11th Capacity Building Programme for Officers of Electricity Regulatory Commissions

Long-term Demand Forecasting & Power Procurement Planning for Distribution Utilities (Uttar Pradesh)

Dr. Anoop Singh
Dept. of IME, IIT Kanpur

Need for Demand Forecasting & Power Procurement Planning (PPP)

- Long-term Forecast
  - Planning for capacity addition/power procurement
  - Upgrade transmission facilities
- Medium-term Forecast
  - Planning for power procurement
  - Design tariff structure
  - Demand-side management
  - Time of use pricing
- Short-term Forecast
  - Merit order dispatch
  - Minimising deviation from schedule
  - Decision making for short-term power procurement
  - Optimising use of renewable energy

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

* - The study was conducted on behalf of UPPCL so as to enable the utilities to meet their obligations under Power for All programme.

Methodology – Four Stages

1. Projection of electrical energy demand
2. Load profile analysis & projection
3. GAMS based optimisation model
4. Choosing power procurement strategy

1. Projection of electrical energy demand

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 analysis & projection

- Inference from historical load profile
- Account for projected solar addition and DSM
- Account for demand profile influenced by supply

Methodology (contd…)

3. GAMS based optimisation model

- Develop optimisation model considering
  1. Existing & candidate plants' quantum and prices
  2. Projected solar capacity addition and DSM activities
  3. With and without short-term procurement
  4. Generator & contract specific constraints
- Defining different power procurement scenarios

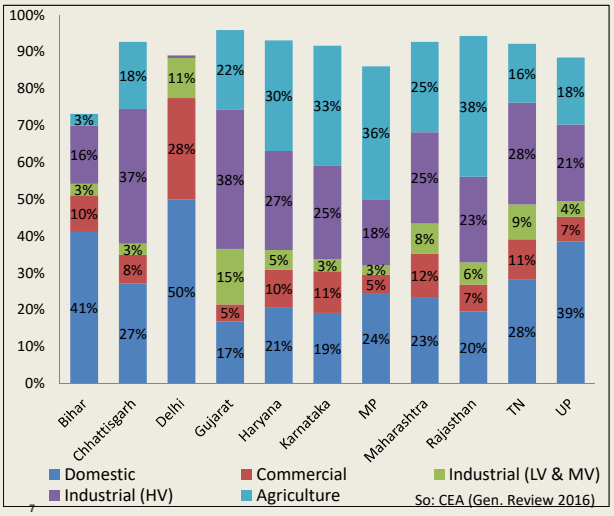
4. Choosing power procurement strategy

- Estimation of social cost and utility cost in different economic and power procurement scenarios
- Identify optimal power procurement strategy

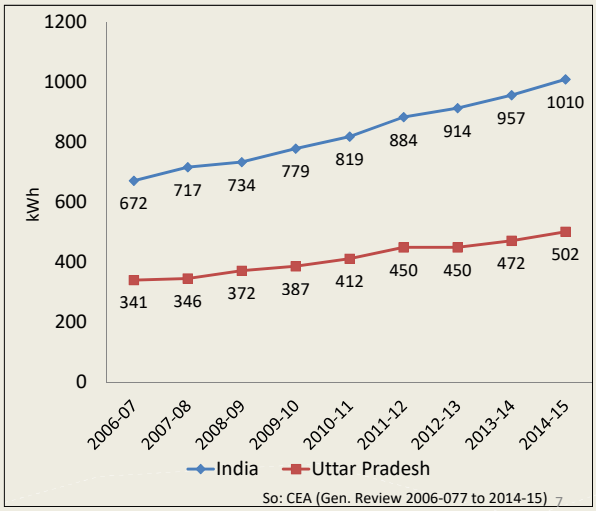
Projection of Electrical Energy Demand

Electricity Demand Pattern Across States

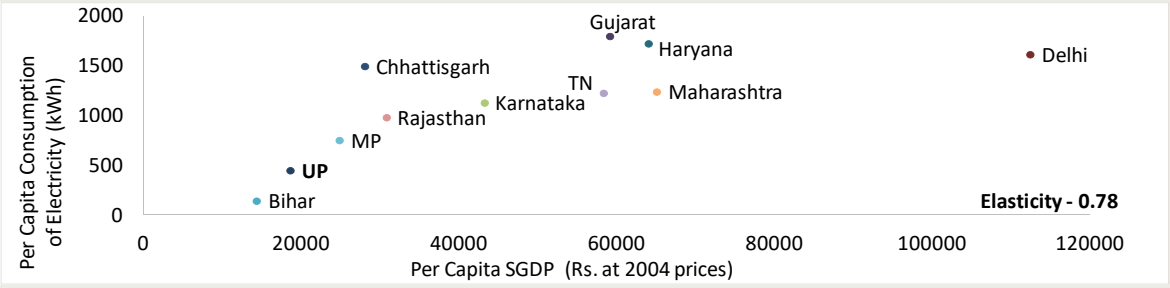
Category-wise Electricity Consumption (2014-15)

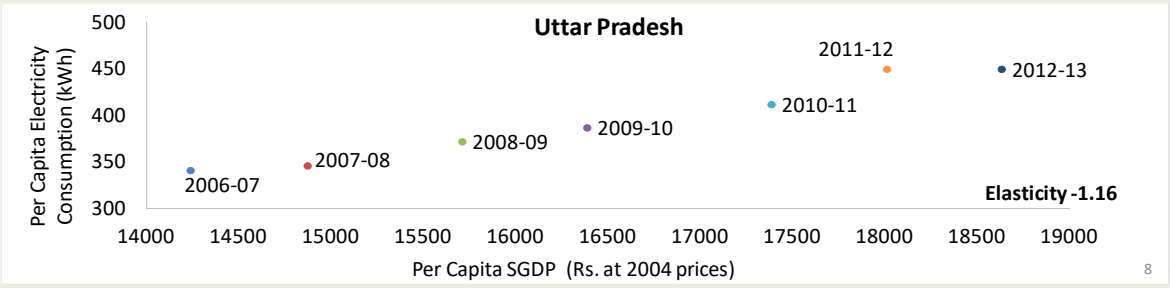


Per Capita Electricity Consumption

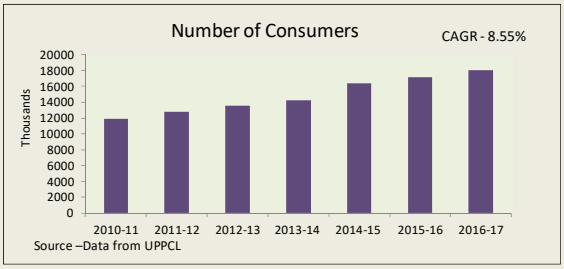


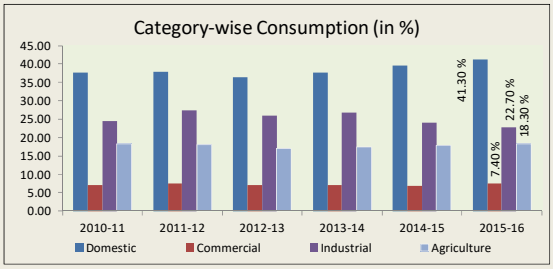
Electricity Consumption vs Economic Activity

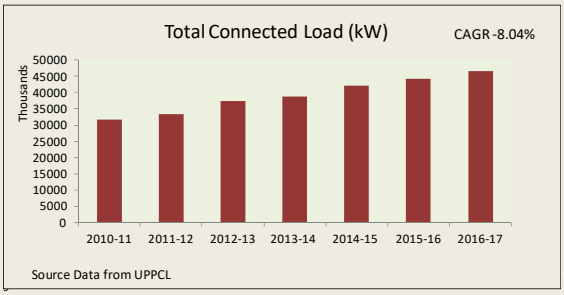


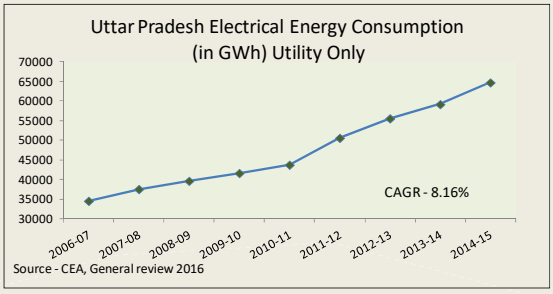


Power Sector Scenario in Uttar Pradesh









9

Forecasting Methods

Trend Analysis

- Useful for preliminary estimate for forecast
- Uses time factor, assuming pattern of demand in the past will continue into future
- Does not explain underlying factors
  - Demographics
  - Economic factors
  - Consumer behaviour and price sensitivity
  - Government initiative, tech. development and RE induction
- Easy to use and understand

10

10

Forecasting Methods (Contd…)

End-use method

- Focuses on various end-uses in the residential, commercial, agriculture and industrial sectors
- Aggregate energy demand is summed over different end-uses in a sectors
- Effective method when there is lack of adequate past data
- This method requires a high level of detail on each of the end-uses
- Does not take in account demographics and socio-economic factors

Forecasting methods (Contd…)

Econometric Analysis

- Utilises information from historical data, along with factors that influence electricity demand
  - Demographic factors (urbanisation, number of households & size, connected load etc.)
  - Economic factors (GDP/per capita income, industrial growth etc.)
  - Consumption behaviour by consumer category
  - Price sensitivity
- Estimate econometric relationship and use it to predict future demand

Econometric Model

Total energy required at bus-bar

$$Q = f(G, U, P, S_p, S_s)$$

Where, Q = Per capita consumption of electricity in kWh

G = Per capita SGDP

U = Urbanisation Ratio in state

P = Price of electricity, ₹s. per kWh

S_p = Share of primary sector (Agri. & Allied services) in SGDP

S_s = Share of Secondary sector (Industries) in SGDP

Data & Data Sources

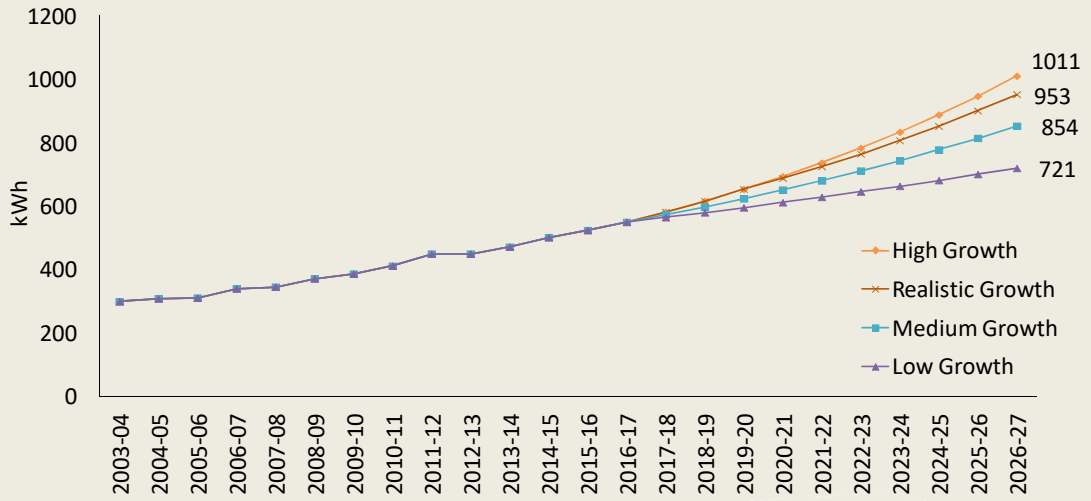
- CEA -General Review (2003-04 to 2014-15)
  - i. Category-wise Connected Load, No. of Consumers and Consumption all states
  - ii. Per capita electricity consumption
  - iii. Number of pump-sets energized, Mid year population
- CSO, MOSPI
  - i. State Gross Domestic Product at constant price (base year 2011)
- PFC Reports
  - i. Weighted average price of electricity (base year 2011)
- Tariff Orders
  - i. Power procurement cost
- UPSLDC
  - i. Unrestricted demand, rostering, emergency rostering, electricity generation etc.
- UPPCL
  - i. U.P. number of consumers, connected load and consumption category-wise
  - ii. PPA Information's and rate of electricity
  - iii. CS3 & CS4 reports

Forecasting Scenarios

- High Growth Scenario
- Realistic Growth Scenario
- Medium Growth Scenario
- Low Growth Scenario

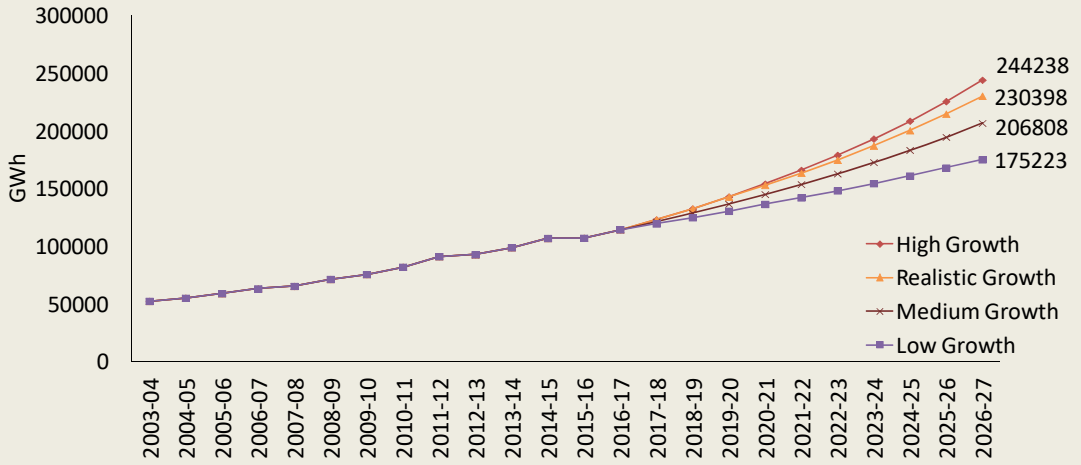
15

Projected Per Capita Electricity Consumption in U.P



16

Projected Electrical Energy at Bus-bar for Utility Only



17

17

Results Comparison With Other Reports

Compassion Projected Energy (19th EPS vs Estimated Value) GWh					
FY	CEA	Econometric model results (IIT Kanpur)			
	19 EPS	Realistic	High	Medium	Low
2016-17	108070	114512	114512	114512	114512
2021-22	150797	163562	166115	153757	142298
2026-27	195323	227838	244238	206808	175223

Note: For utilities only
* Without Captive Generation

Projected Total sales (In MU)			
FY	PFA	Econometric Model	Δ %
2016-17	83789	92882	11%
2017-18	95131	101267	6%
2018-19	103173	110511	7%
2019-20	116385	120706	4%
2020-21	126046	130958	4%
2021-22	136700	141753	4%

Note: Energy sold
* Without Captive and losses

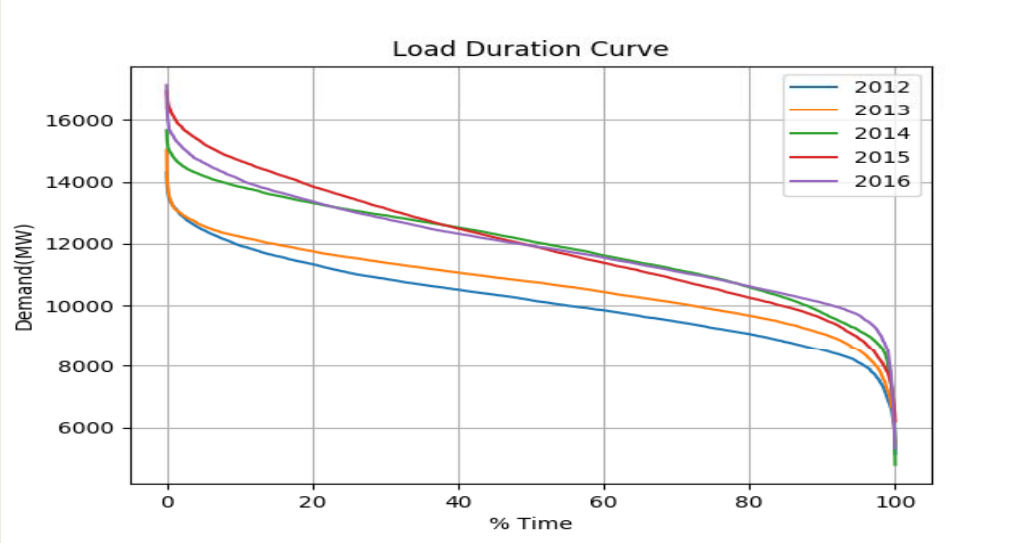
18

18

Load Profile Analysis & Projection

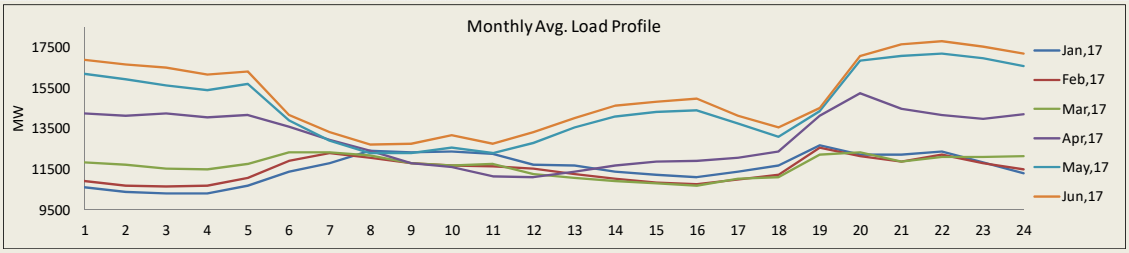
19

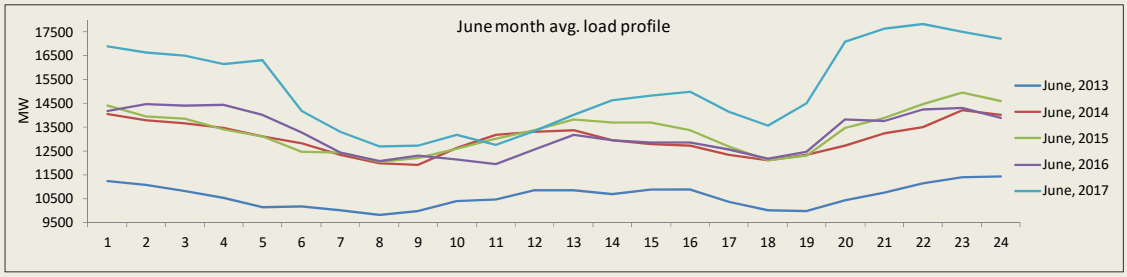
Low Duration Curve



20 Source - Night Report ,UPPCL

Uttar Pradesh – Load profile

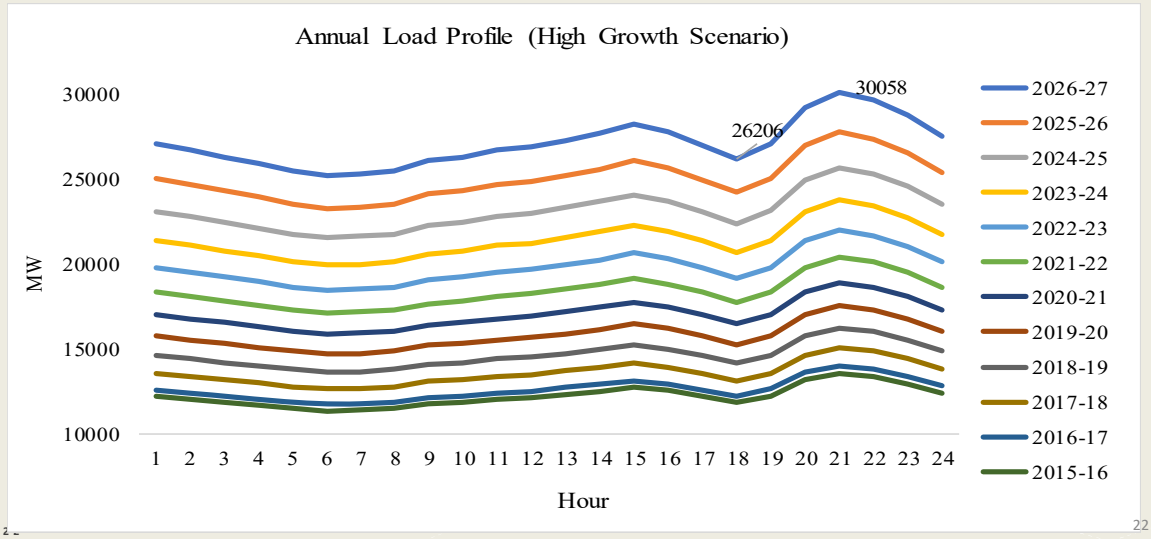




Source - Night Report ,UPPCL

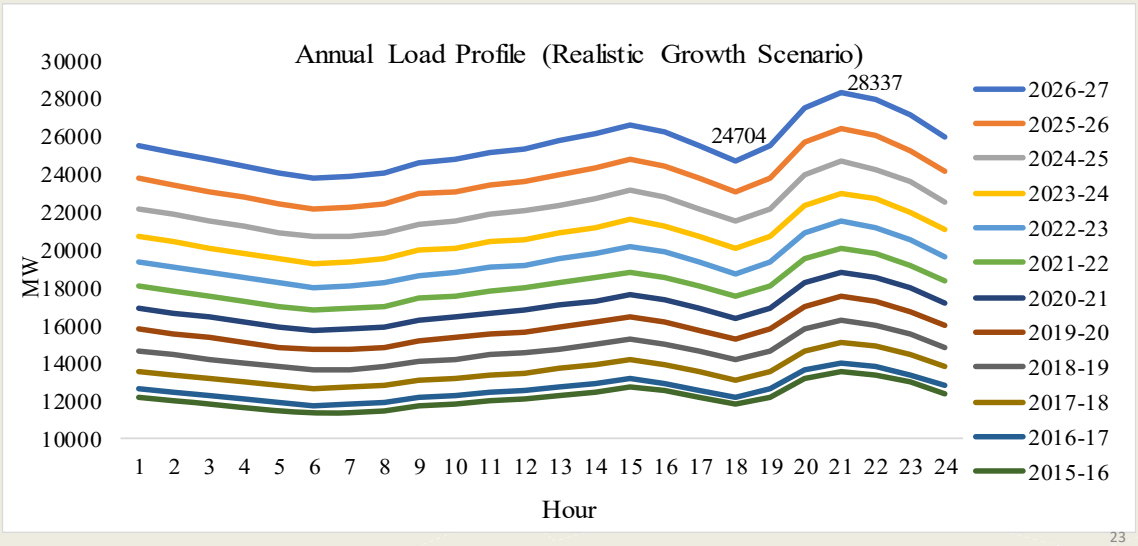
21

Projected Load Profile – High Growth Scenario



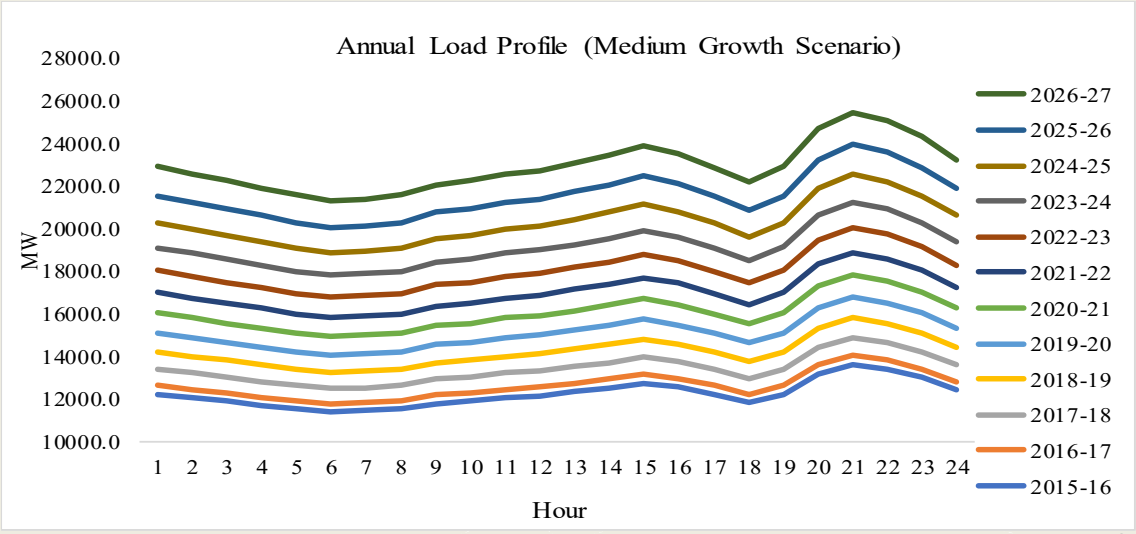
22

Projected Load Profile – Realistic Growth Scenario



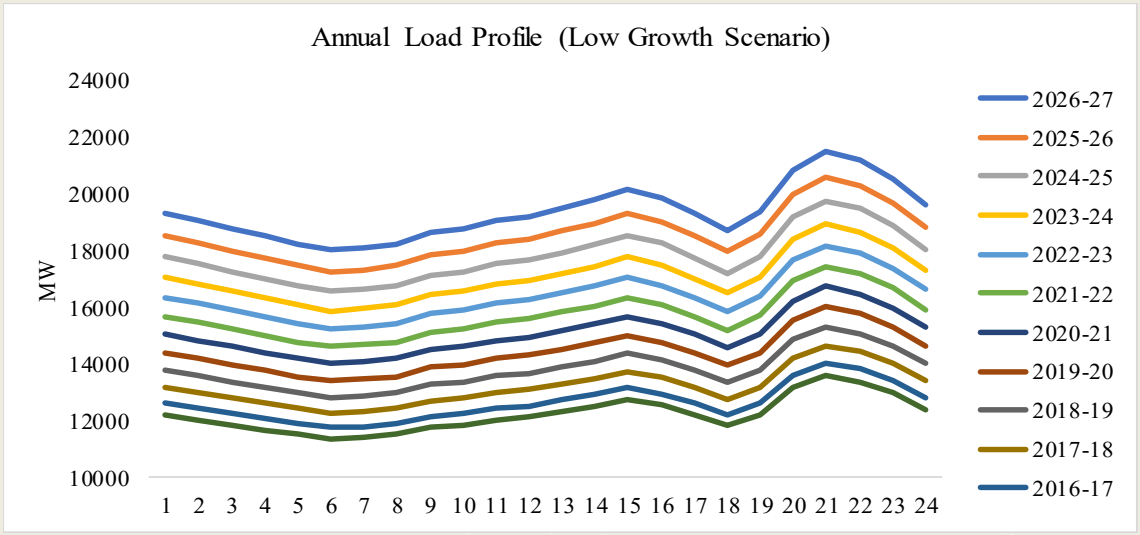
23

Projected Load Profile – Medium Growth Scenario



24

Projected Load Profile – Low Growth Scenario



25

25

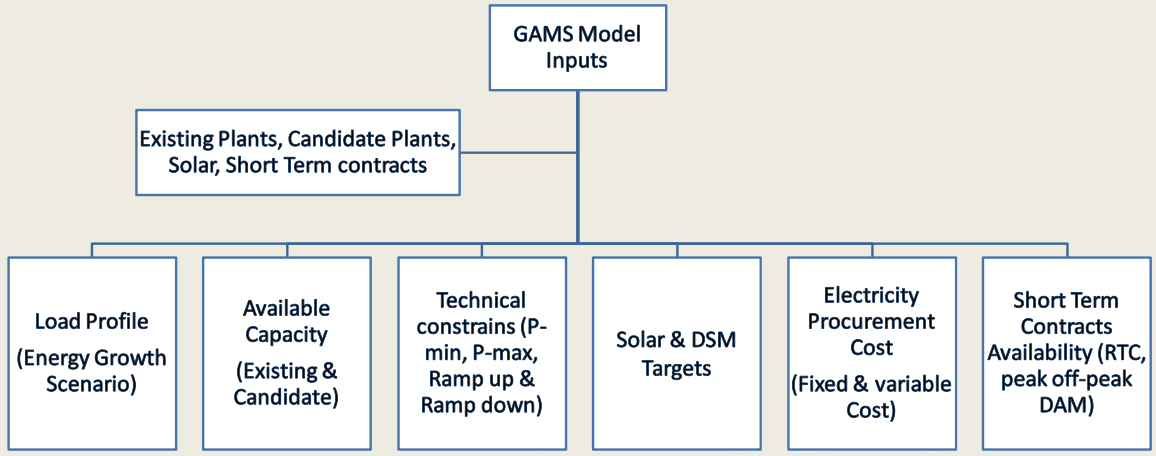
GAMS Based Optimisation Model

26

26

Input Variables

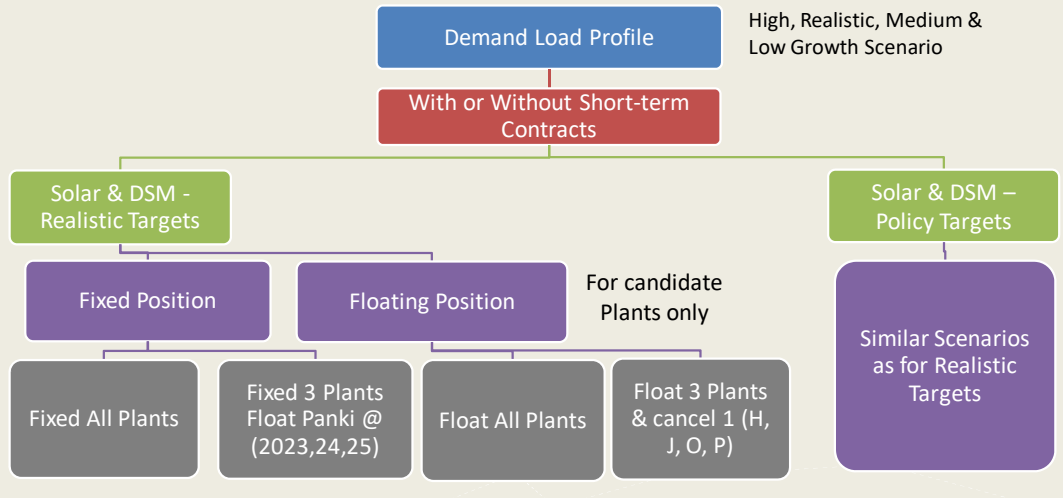
Minimise social cost of power supply



27

27

GAMS Simulation for Different Power Procurement Scenario



28

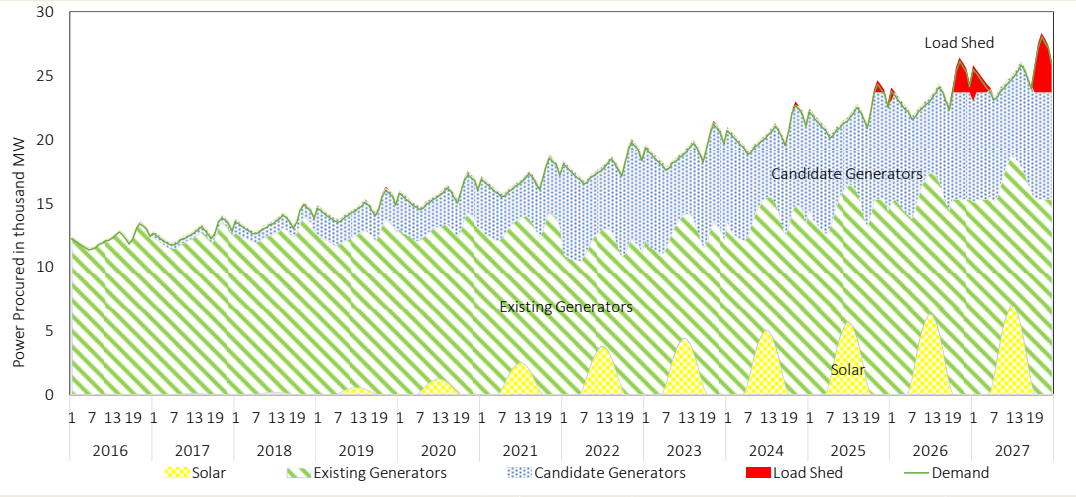
28

GAMS Output

- Demand & Generation Chart
- PLF of Plants
- Optimal position for candidate plants
- Utility Cost & Social Cost

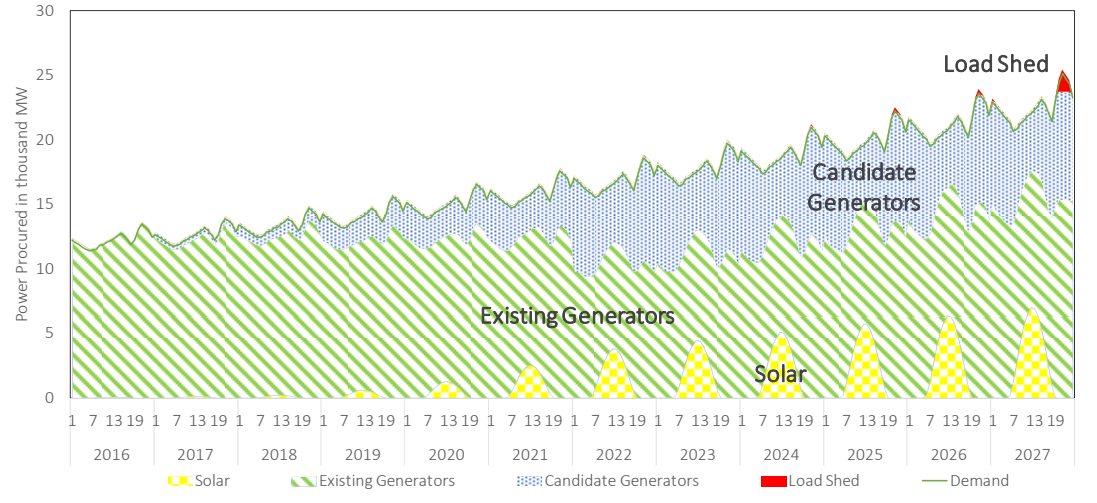
29

Demand & Gen. Curve for Realistic Growth Scenario (Fix All Without Considering STPP)



30

Demand & Gen. Curve for Medium Growth Scenario (Fix All Without Considering STPP)



31

31

Choosing Power Procurement Strategy

32

32

Conclusions & Key Observations

- Most optimal strategy 'All Float' case
- Certain existing plants/PPAs have low PLF
- Progress on DSM and Solar capacity addition should be reviewed for medium-term power procurement
- Planned and effective measures should be in place for metering, meter reading, billing and collection
- Periodical Power Procurement Analysis (at least every three years)
- Extension of Time of Day (ToD) tariff for all large consumers
- fair and transparent competitive bidding
- Adopt a state-level UMPP model

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?)

Thank You

www.iitk.ac.in/ime/anoops

anoops@iitk.ac.in

35