



Demand Forecasting Techniques and Tools

Introduction – Demand forecasting

Prediction of future energy demand requires an intuitive and wise judgment

The forecast needs to be revised at regular intervals to take care of new policies and changes in socio-economic trends.

The demand forecast is used as a basis for system development, and for determining tariffs for the future.

Over-forecasts lead to more plant than is required – Unnecessary capital expenditure

Under-forecasts prevent optimum economic growth – Lead to installation of many costly and expensive to-run generators.

The demand for electricity depends on a number of socio-economic factors

Long-term

- Plays a fundamental role in economic planning of new generating capacity and transmission networks.
- Spans over 5 to 20 years

Medium-term

- Used mainly for the scheduling of fuel supplies, maintenance program, financial planning and tariff formulation
- Spans over 1 month to 5 years

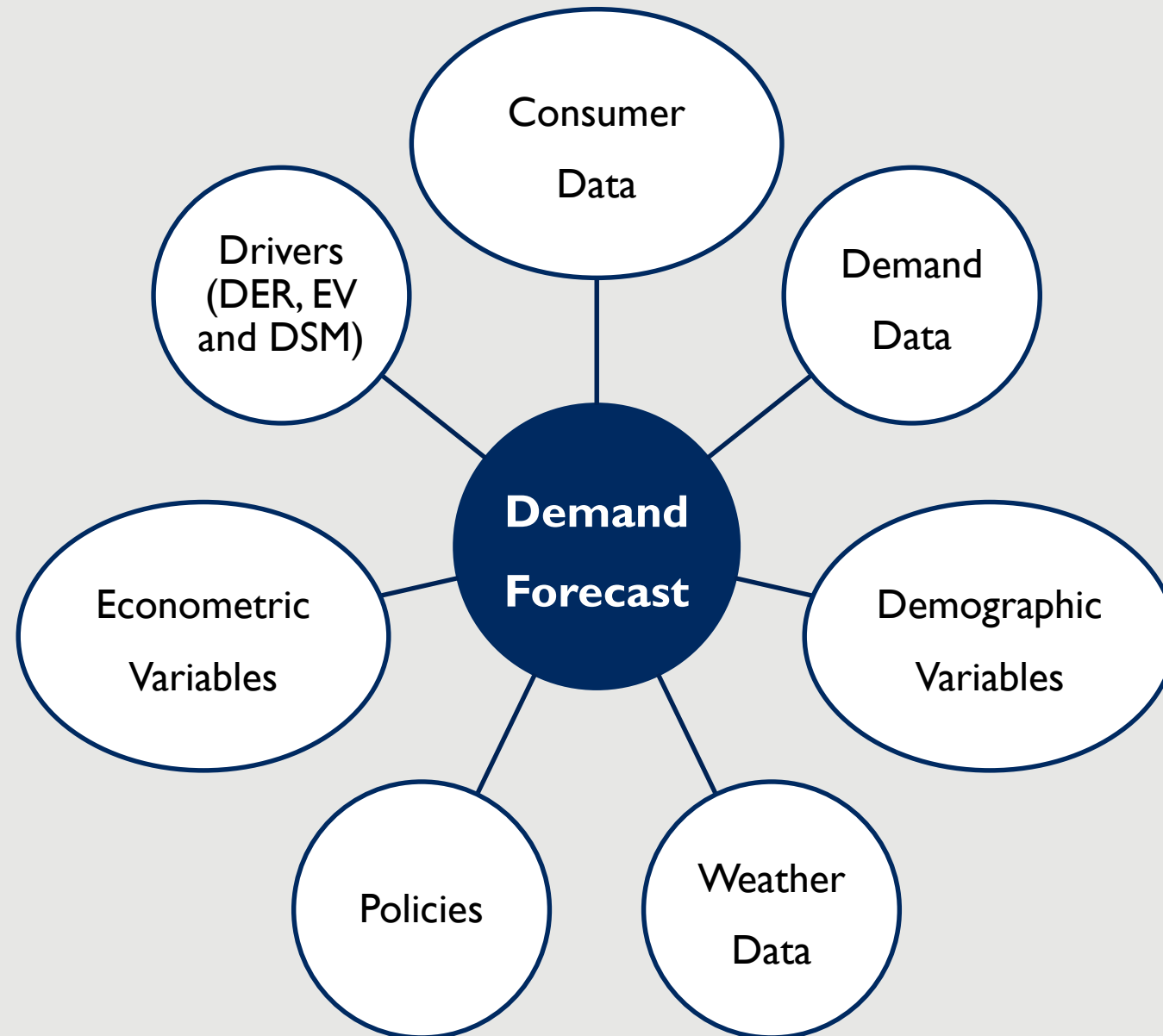
Short term

- Provides the basis for planning start-up and shut down schedules of generating units, reserve planning and the study of transmission constraints
- Spans over 1 day to several weeks

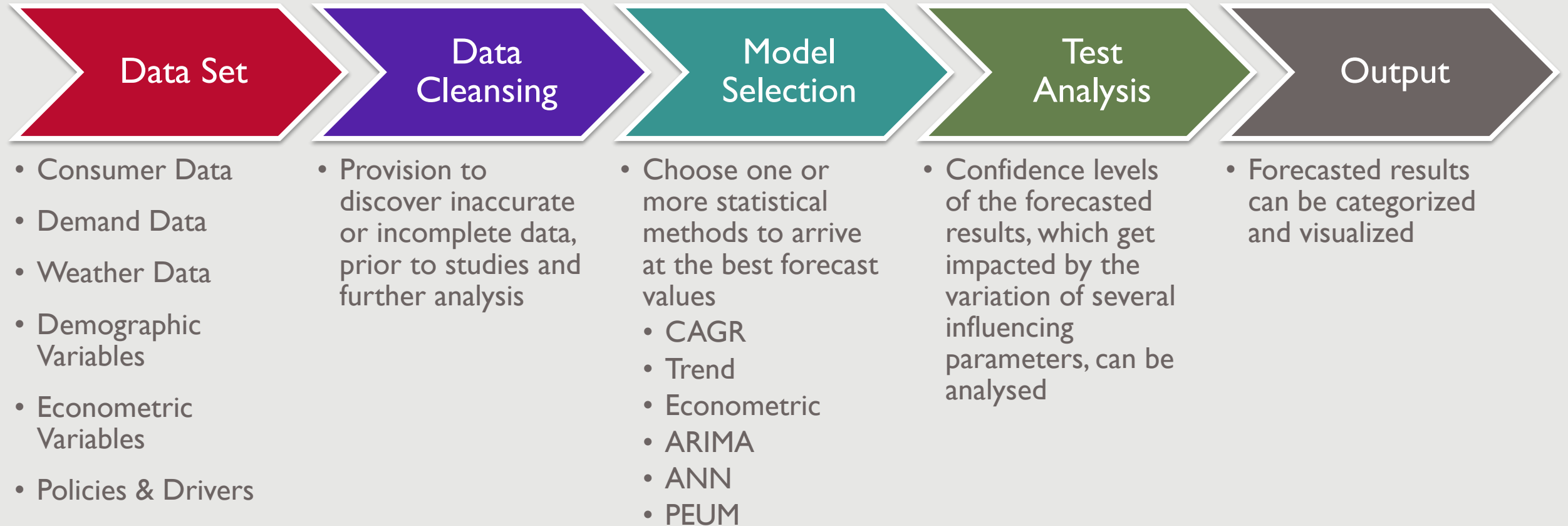
Very short term

- Used in economic load dispatching and security assessment
- Spans over some minutes to several hours

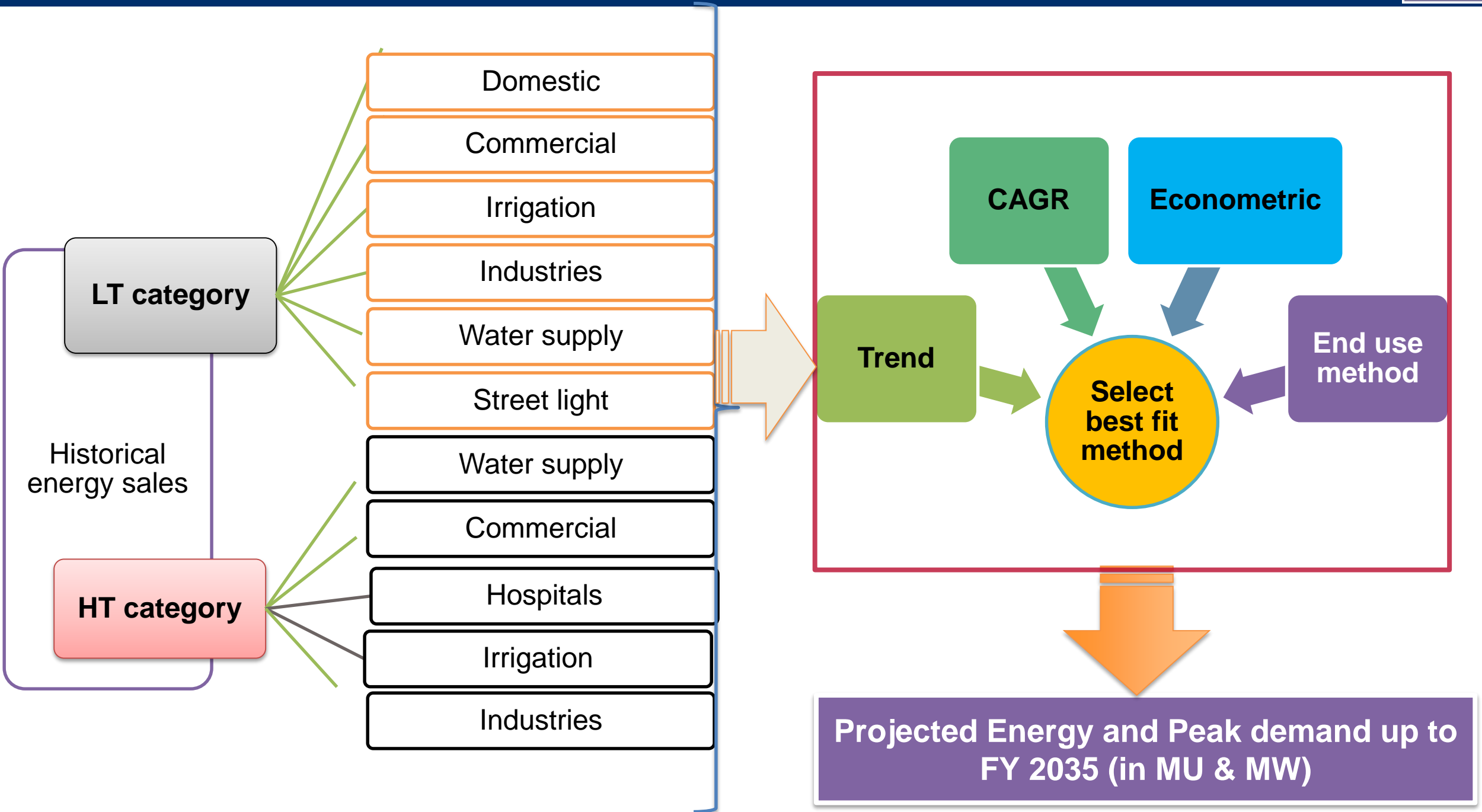
Demand Forecasting in RE Rich Environment: Key Elements



Demand forecasting – Business Process



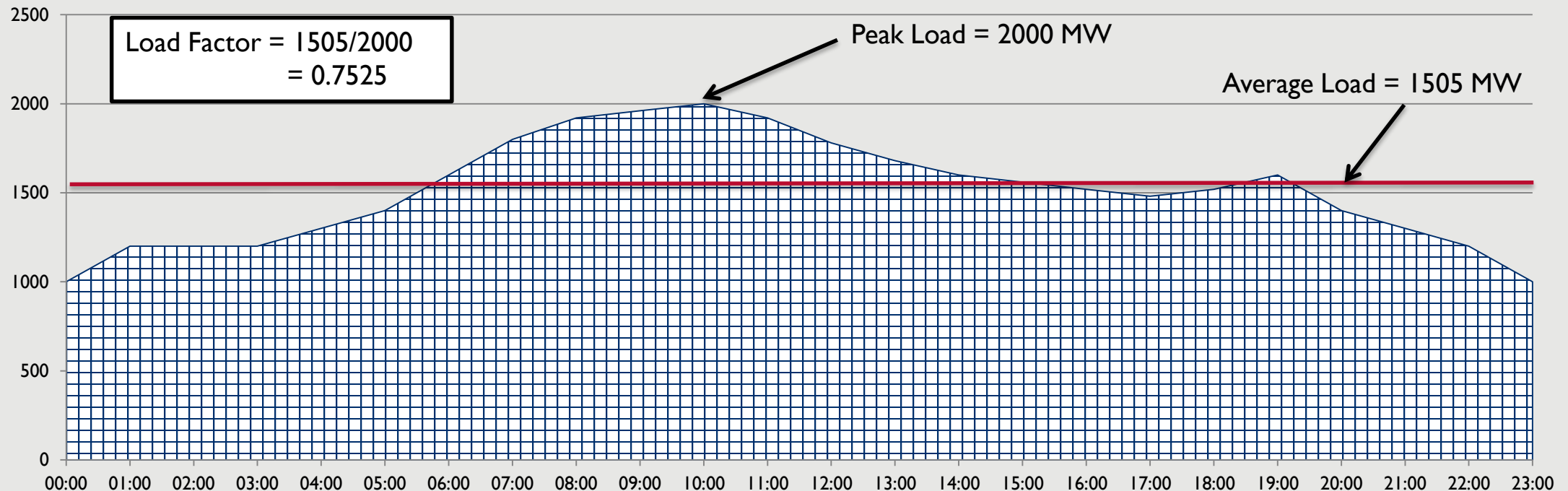
Load Forecasting Approach



Historical Load Factor Computation

Peak Demand Forecasting

- Forecasting should be done for electrical energy.
- Annual peak demand is obtained by annual load factor as –
 - Peak demand MW = (Energy sales in MU * 1000) / (Load factor * 8760)
 - A reliable load factor value is required.



Load Forecasting Features – Sample Independent Variables

Total population

Total number of households

Gross domestic product

Per capita income

Relative price deflator

GDP of registered manufacturing sector

GDP of unregistered manufacturing sector

GDP of tertiary sector

GDP of Agriculture

Production of State specific products like tea, rubber, coal, etc

Seasonal / monthly maximum temperature

Rooftop Solar PV / DER (Number of installations or total generation)

EVs (Number of vehicles or total demand)

Energy efficiency (Total reduction in demand)

Demand Response (Total reduction in demand)

CPP (Total capacity)

Open Access (Total Capacity)

AT&C Loss (Percentage of demand)

Make in India (Total increase in demand)

Power For All (Total increase in demand)

Saubhagya scheme (Total increase in demand)

Demand Forecast – Demographic Variables

State Population

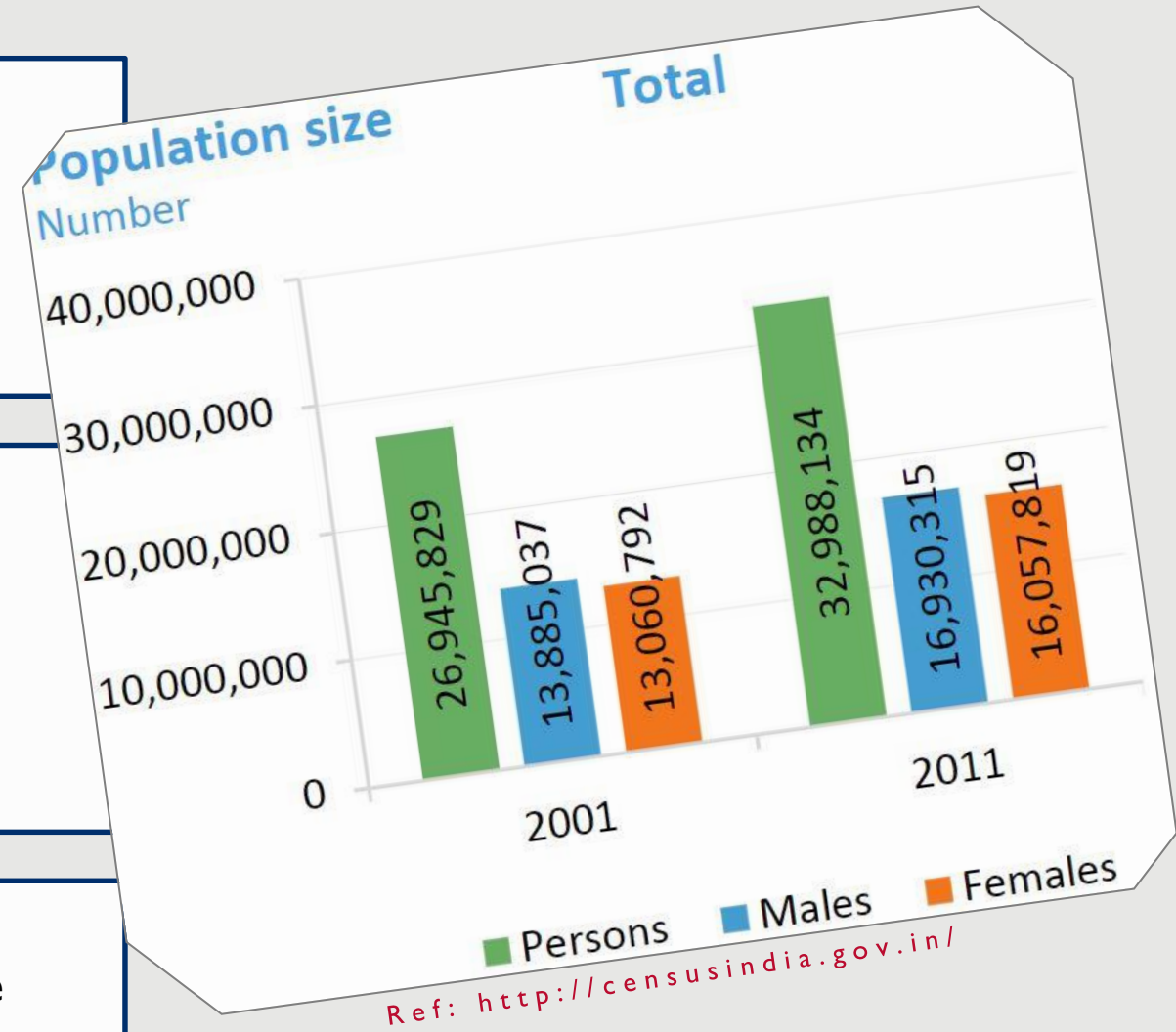
- Population of a region will have a positive correlation with the demand of that region
- With growing per capita consumption, population has a direct impact on demand

Number of households

- Due to socio-economic factors, number of persons per household is coming down, which is also a reason for increase in number of households.
- With continued improvements in quality of life, demand for energy will continue to soar

Number of connections / installations

- From the population growth estimates, the estimates on the number of installations can be apportioned
- This number is a function of the demographic growth



Demand Forecast – Econometric Variables

Gross Domestic Product

Measure of economic growth of the people living in an area

GDP of different sector gives an insight on the possible demand from the corresponding consumer categories

Per Capita Income

Represents the average income of an individual

Calculated based on the GDP value and the population forecasted

Price Deflator

Measure of price inflation/deflation with respect to a specific base year

This variable explains the effect of prices in the demand equation



Jharkhand			
Gross State Value Added by economic activity at current prices			
		2011-12	2012-13
S.No.	Item		
1.	Agriculture, forestry and fishing	2233546	2550211
1.1	Crops	1342099	1611776
1.2	Livestock	477585	459416
1.3	Forestry and logging	357560	399912
1.4	Fishing and aquaculture	56302	79107
2.	Mining and quarrying	1620374	1879069
3.	Manufacturing	3853920	4429280
	Primary	3016583	3797607

Ref: <https://niti.gov.in/content/2011-12-series>

Demand Forecast - Drivers

- Consumer buys power at competitive rates
- Impact captured by projecting Y-o-Y Open Access Sales

Open Access



- Varied types and sizes of CPP exist in the country
- Utilized in process industry and local power consumption

CPP



- Several programs aim at reducing loss
- DISCOMs have developed loss reduction trajectory

T&D Losses



- Impacts customers' level and pattern of electricity usage
- Mainly Energy Efficiency & Demand Response

DSM



- Several GOI initiatives to promote electric vehicles
- Impacts both MU and MW

EV



- Penetration of consumer level DERs reduces load
- DER varies the load profile seen by utility

DER



Electric Vehicles – Assessment of Impact

EV Categories

- 2-wheelers include Motorcycle, Scooter and Moped
- 3-wheelers include personal, passenger and e-rickshaws
- 4-wheelers include private & commercial cars
- Bus includes normal buses and omni bus

Battery Characteristics

- Average battery size (kWh per vehicle)
- Full charging cycle
- Complete charging cycle efficiency
- Energy requirement per km (kWh)

Vehicle Statistics

- Total number of vehicles on road - YoY
- Number of EV as a percent of total vehicles on road – YoY
- Average kms driven per day

Demand Forecasting Methods

Parametric Methods

- **Subjective**
 - Judgment
 - Intuition
 - Commercial knowledge
 - Any other relevant information.
- **Uni-Variate**
 - Based entirely on past observation in a given time series.
 - Naive or projection forecasting technique.
- **Multi-Variate**
 - Establishes casual or explanatory relationship with other variables
 - Whether variables co-relate or move in relation to each other in some clearly established way.
 - Regression models, econometric models
- **End Use**
 - Usage of the electricity in residential, commercial and industrial sectors.
 - Specific energy consumption in lighting, heating, air-conditioning, refrigeration, manufacturing etc.

Artificial Intelligence Based Methods

- **Neural networks**
- Support vector machines
- Genetic algorithms
- Wavelet networks
- Fuzzy logics
- Expert system

Compound Average Growth Rate

- CAGR is a specific term for the geometric progression ration that provides a constant growth rate over the time period.
- It is a useful measure of growth over multiple time periods.
- This method dampens the effect of volatility of periodic changes that can render arithmetic means irrelevant.

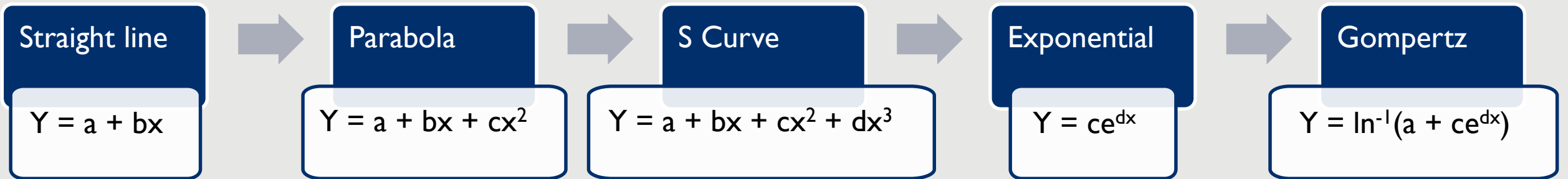
$$Y = \{(\text{Current value}/\text{Base value})^{1/(\text{no of years}-1)}\}-1$$

This method best suits data which has seen a uniform growth / decline over time.

Sudden impacts are not best captured by this method.

Trend Analysis

- Trending methods are widely used as a tool for forecasting which works with historical data, extrapolating past load growth patterns into future.
- Trending techniques involve fitting trend curves to basic historical data adjusted to reflect the growth trend itself.
- With the trend curve the forecast is obtained by evaluating the trend curve function at the desired future point.
- Typical trends

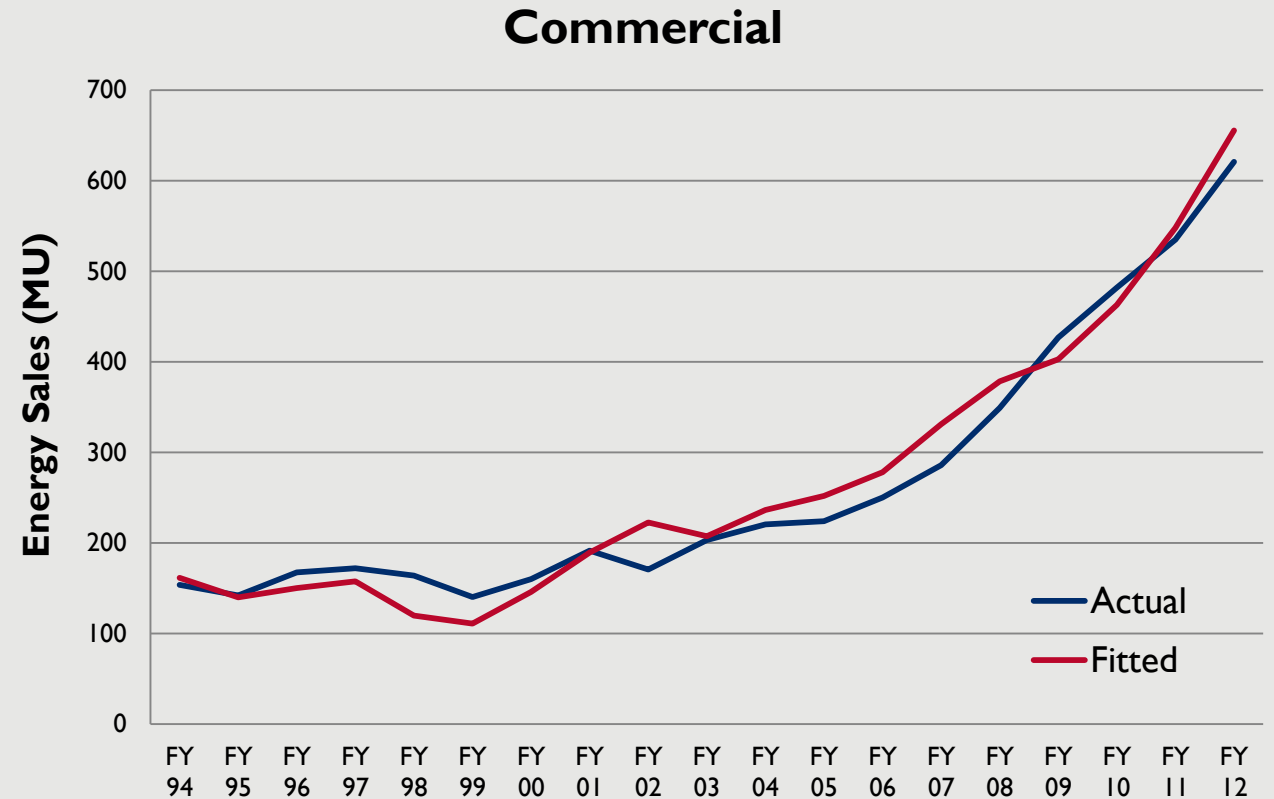


Econometric Method

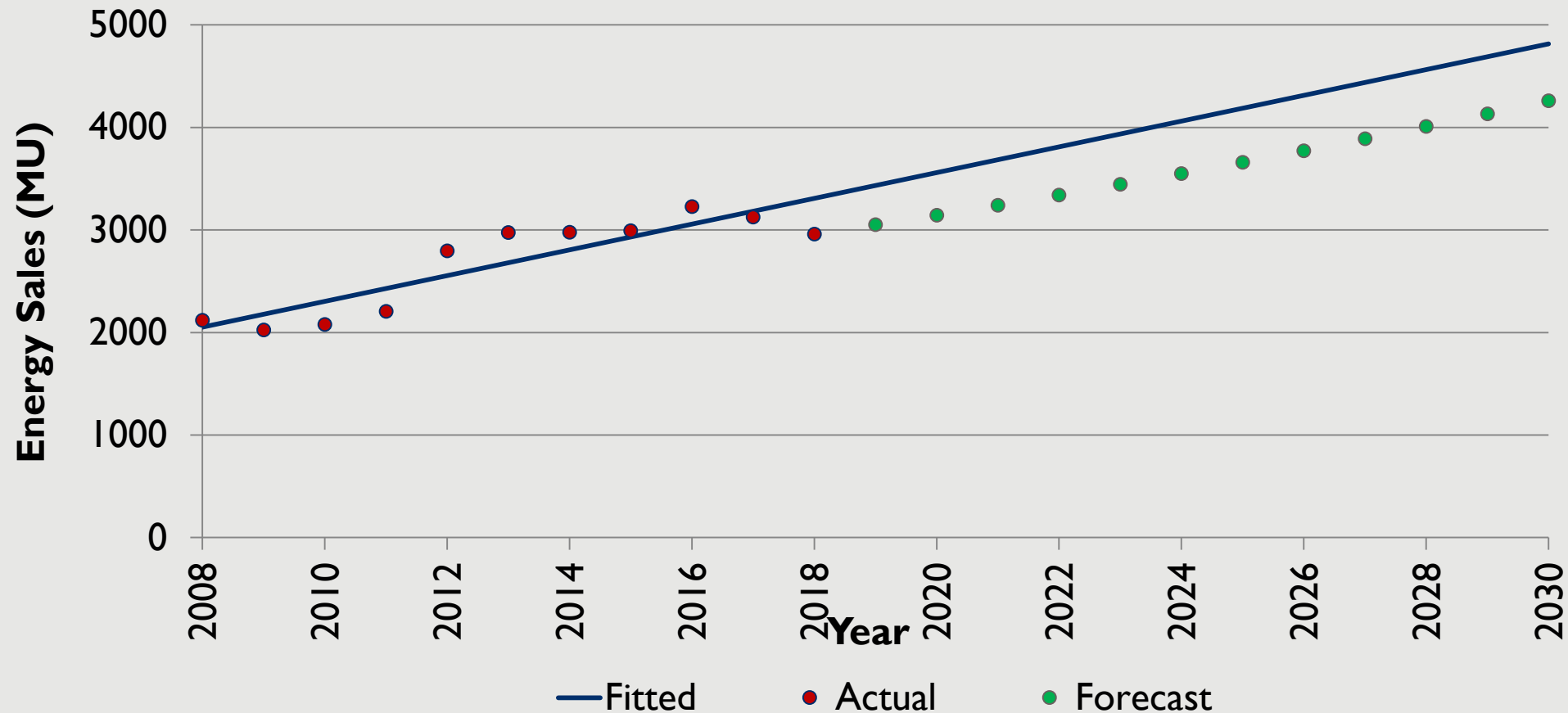
$$Demand_{Commercial} = a * GDP_{Tertiary} + b * Price\ Deflator + c$$

- a: 0.000327
- b: -510.859
- c: -56.4218 (constant term)

- **Gross domestic product: Tertiary at constant prices** – The sum of all the products and services produced in a year at constant prices in tertiary sector.
- **Price deflator:** Calculated based on the ratio of GDP (current prices) and GDP (constant prices).
 - Price deflator is a measure of price inflation/deflation with respect to a specific base year



Historical Energy Consumption (MU) – Curve Fitting



The best fitting curve will be chosen as the one with which the sum of the squares of the differences between the fit values and the corresponding past input sample values is minimum.

This is then used to predict the future trend of the corresponding economic or energy consumption data.

MiPSO – MiPower Power System Scheduling Optimization

27/02/2023 10:38:37

Problems in Power Systems
that needs to be resolved through
Research in MiPSO

admin

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Demand Forecasting Module

Consumer Data

Historical Demand Data

Weather Data

Econometric Variables

Policies

Drivers

- CPP
- Open Access
- DERs
- EVs
- DSM



Input

Selection of method can be **adaptive** based on the best curve fit looking into **R^2 error** and **standard deviation**

Algorithm



- CAGR
- Trend Analysis
- Econometric
- Partial End Use
- ARIMA
- ANN

Long Term Forecast (Upto 16 yrs.)

- Annual Energy Consumption (MU)
- Annual Peak Demand (MW)

Medium Term (3 to 5 yrs.)

- Seasonal/Monthly Energy Forecast (MU)
- Seasonal/Monthly Peak Demand (MW)

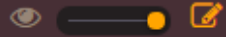
Load Profile (Medium & Long Term Horizon)

- Hourly load profile (MW)
- Weekday / Weekend Demand (MW & MU)
- Demand statistics



Output

Category



Drivers

Licensee

Category

Variables

+ Category

C Commercial/ Non-domestic (CS)

D Domestic (DS)

I Industrial HT (HTS)

I Industrial LT (LTIS)

I Irrigation (IAS)

P Public Lighting (SS)

R Railways (RTS)



Commercial/ Non-domestic (CS)







Name

Commercial/ Non-domestic (CS)

Code

CS

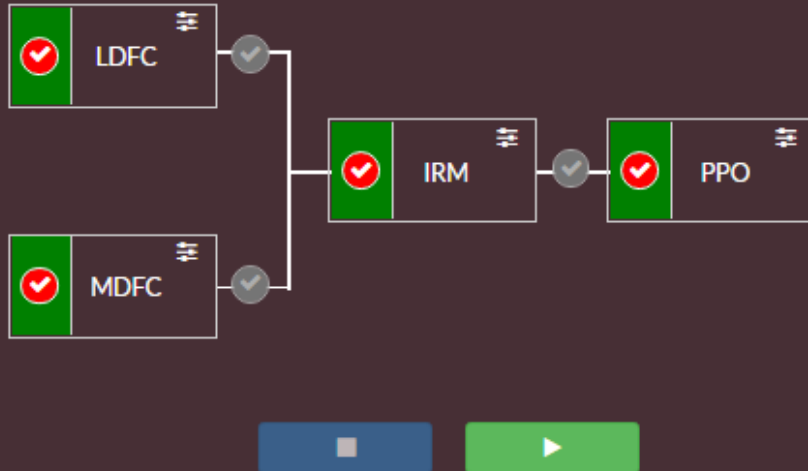
Mapped Variables

Name	Unit		+
Energy sales	MU	Dependent	 
GDP-Constant	Lakhs	Independent	 
Price Deflator	-	Independent	 
Commercial - Installations	No	Independent	 
Commercial - Specific energy	kWh	Independent	 



Mapping
variables to
category

EXECUTION



SCENARIO SETTINGS

Scenario Name

Scenario with drivers

Manage Demand Forecast Data +

- Licensee Projection Data
- State Projection Data
- T & D Loss
- Open Access
- Captive Power Plant
- Distributed Energy Resources
- Electric Vehicle

Manage Resource Mapping Data +

Manage Power Procurement Data +

Configuration

LDFC

MDFC

Annual IRM

Weekly IRM

PPO

Method Type : CAGR, ECONOMETRIC, PEUM, TREND

History Period From: 2015

History Period To: 2019

Forecast Period From: 2020

Forecast Period To: 2040

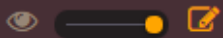
Compute Load Profile: Yes

Option to configure
input data for
demand forecast

Option to choose different
methods and define study
period for demand forecast

UPDATE CANCEL

Distribution Licensee



- Drivers
- Licensee
- Category
- Variables

+

H

Distribution Licensee

Jharkhand Bijli Vitran Nigam Limited

Jharkhand Bijli Vitran Nigam Limited

JBVNL

Distribution Licensee Information

Name

Jharkhand Bijli Vitran Nigam Limited

Code

JBVNL

Licensee type

State Distribution Utility

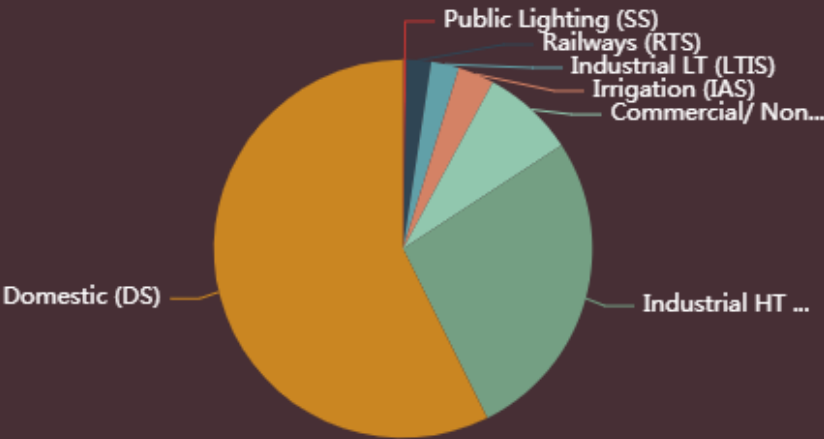
- Energy
- Load Profile
- Policies

Mapped Categories

Name	Upload	+
Domestic (DS)		
Commercial/ Non-domestic (CS)		
Public Lighting (SS)		
Irrigation (IAS)		
Industrial LT (LTIS)		
Industrial HT (HTS)		
Railways (RTS)		

Energy Sales (MU)

Select Year : 2019



Addition of Distribution Licensee

Drivers



- Drivers
- Licensee
- Category
- Variables

Electric Vehicle

OA CPP DER EV

EV Configuration Details

H

Jharkhand Bijli Vitran Nigam Limited

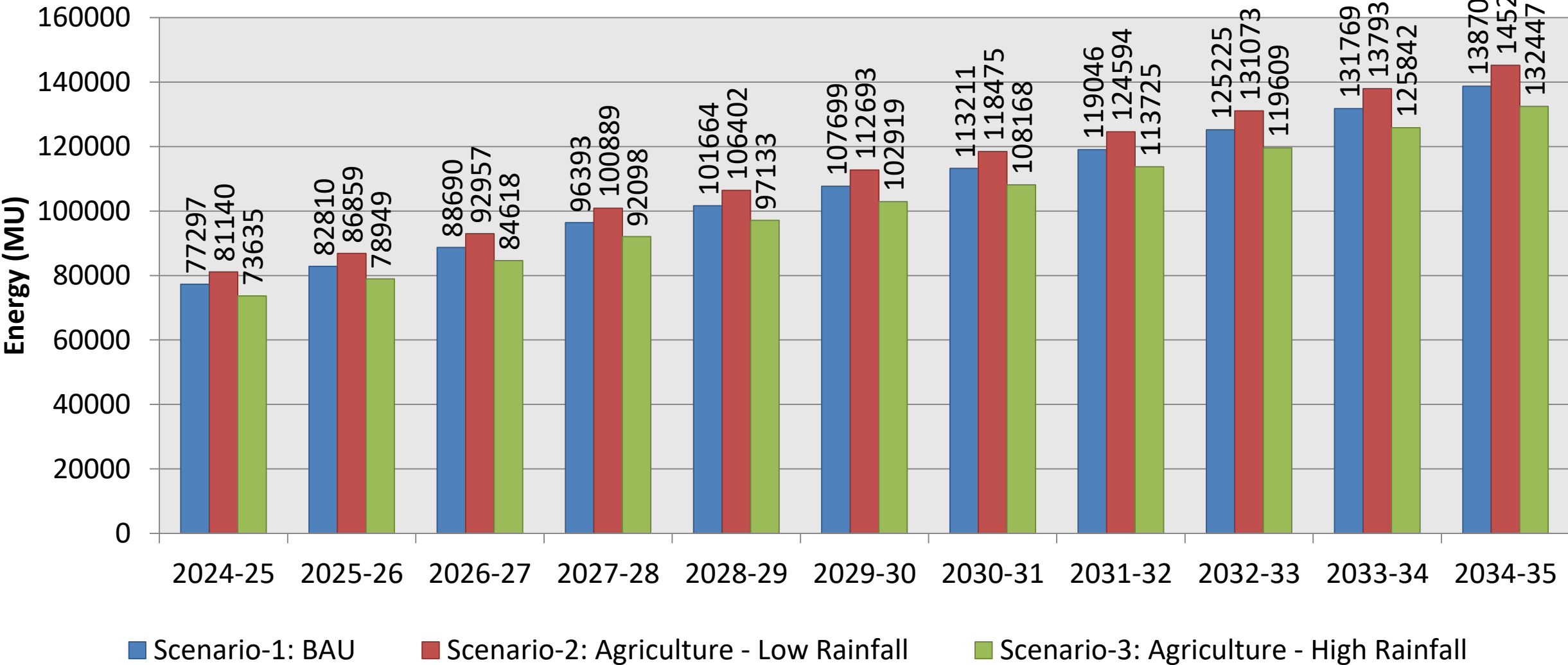
Electric Vehicle Specifications

Electric Vehicles

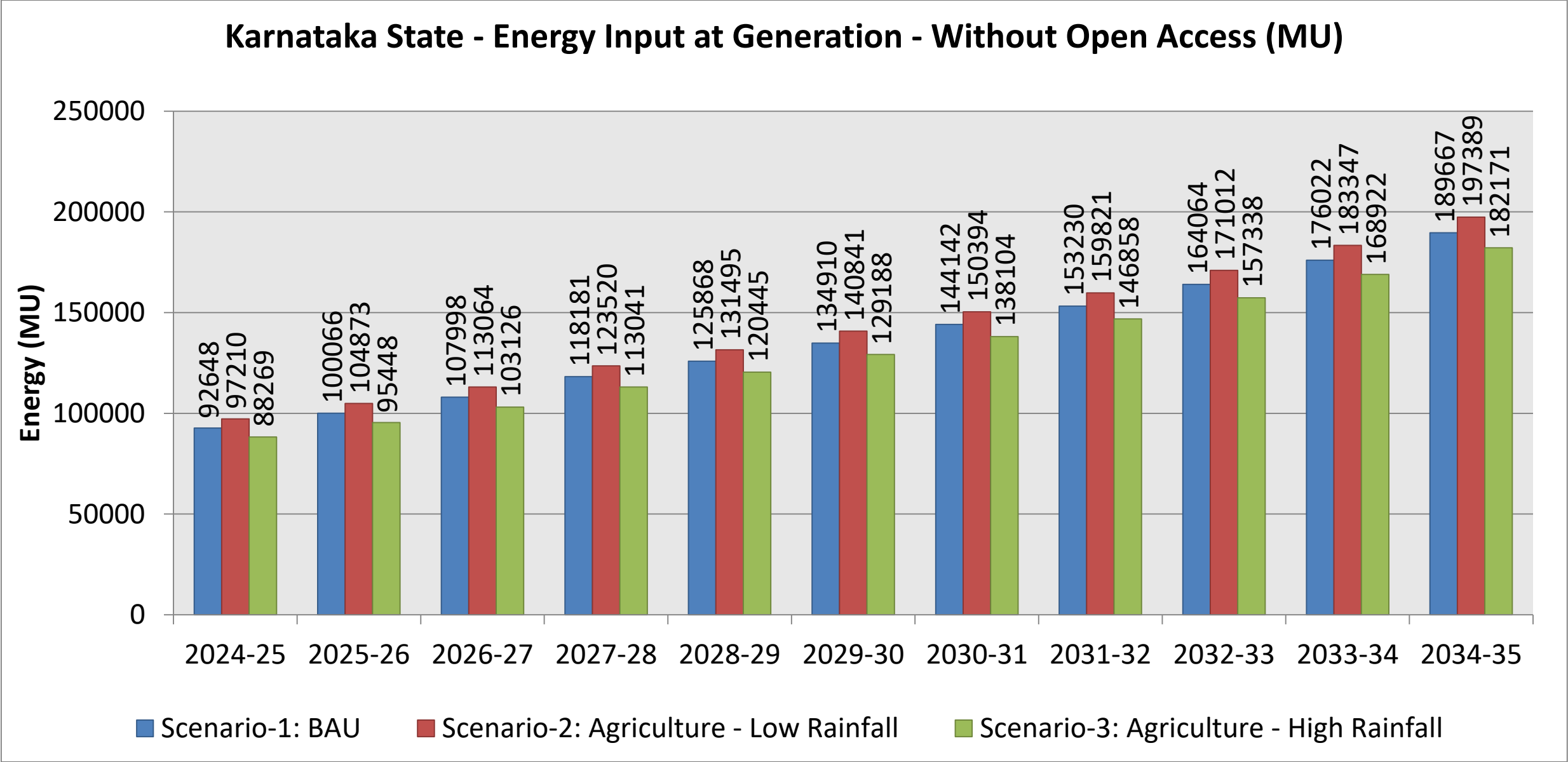
EV Configuration EV Category

Vehicle Category	Avg. Battery Size (kWh / vehicle)	Complete charging cycle efficiency	Avg. km run / day	Energy requirement per km (Wh)	Charging Cycles per Hour
2W	1.500	72.000	20.000	20.000	1.330
3W	7.000	72.000	80.000	50.000	1.330
4W	15.000	72.000	35.000	130.000	1.330
BUS	120.000	72.000	200.000	1000.000	0.500

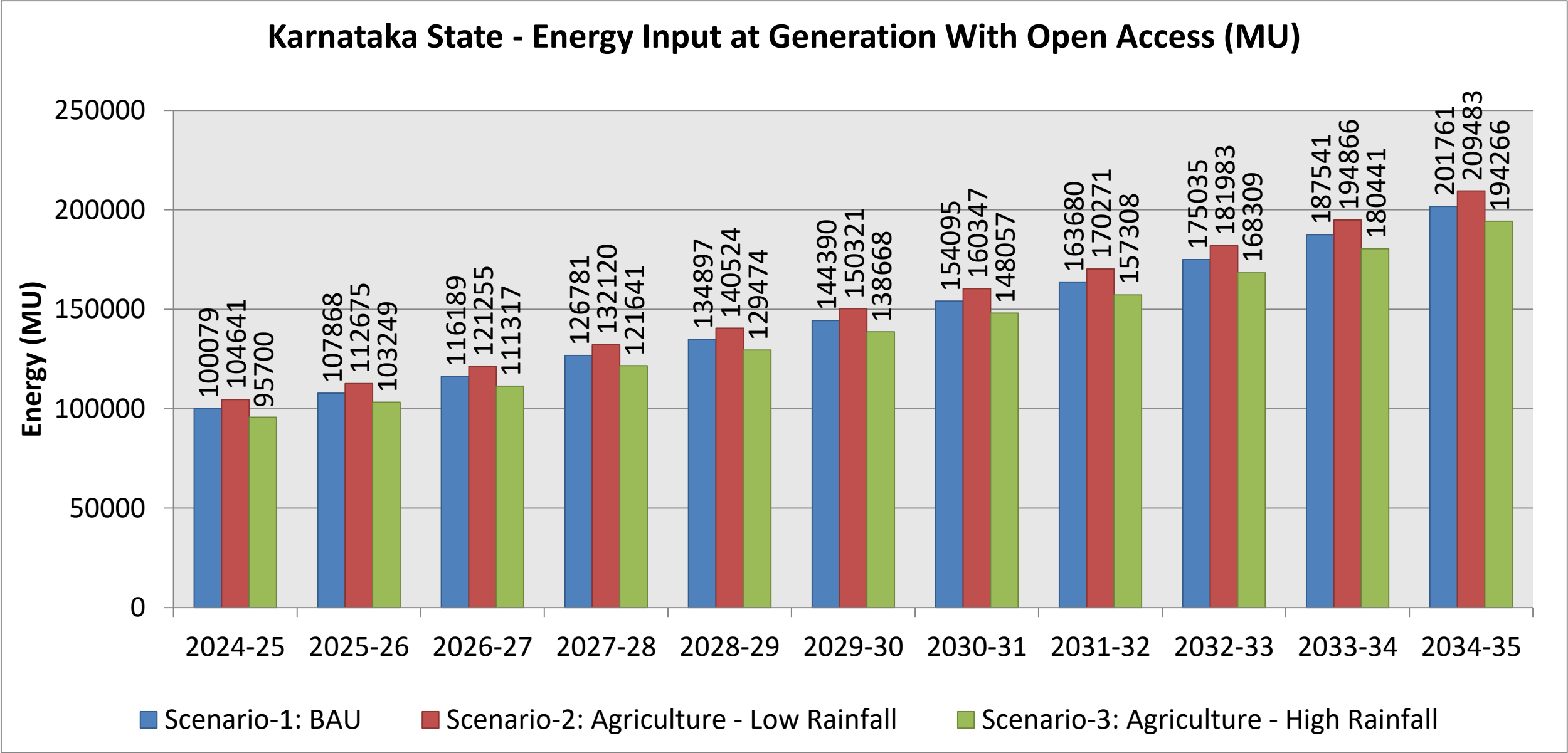
Karnataka State - Energy Sales (Without Open Access) (MU)



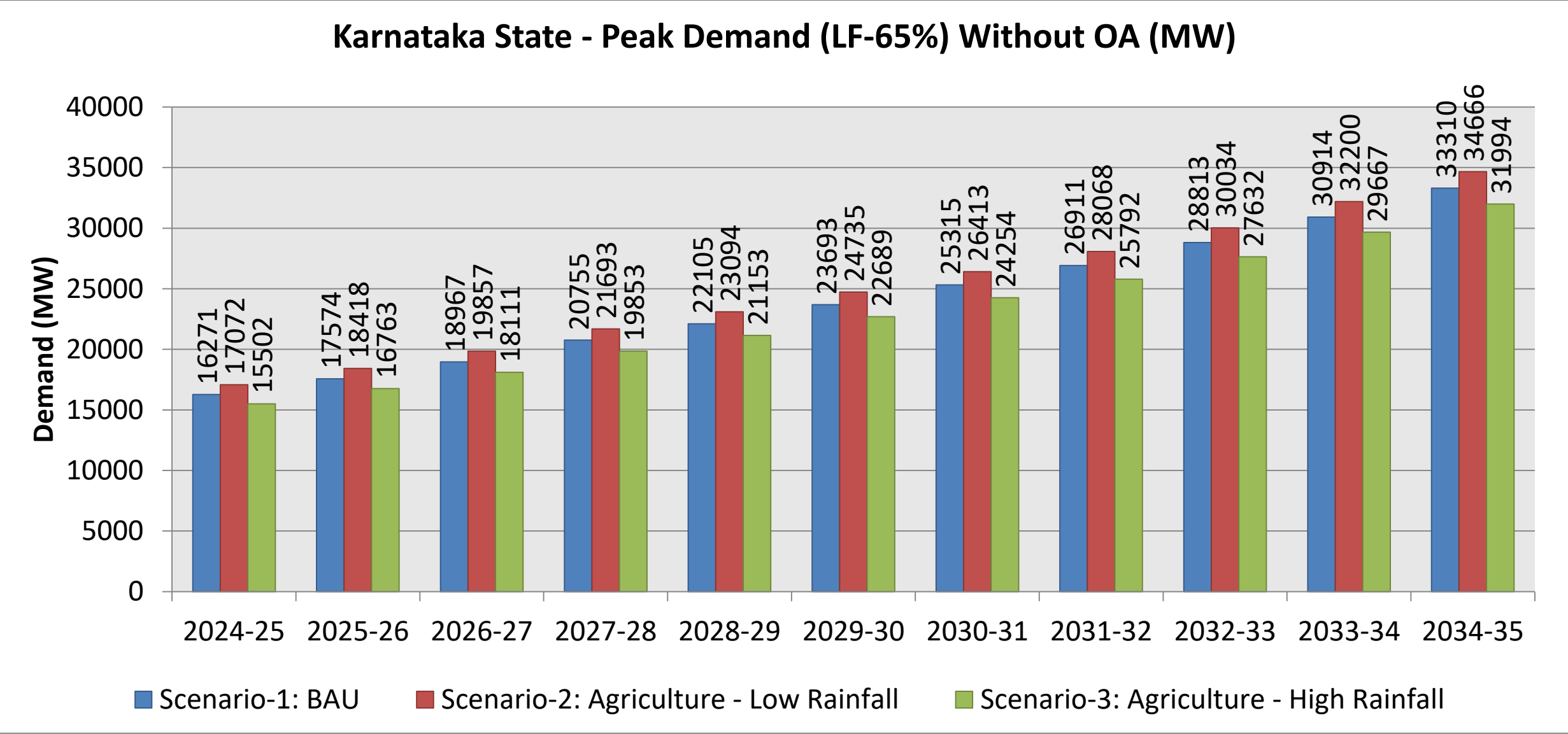
Scenarios – Energy Input - Without OA



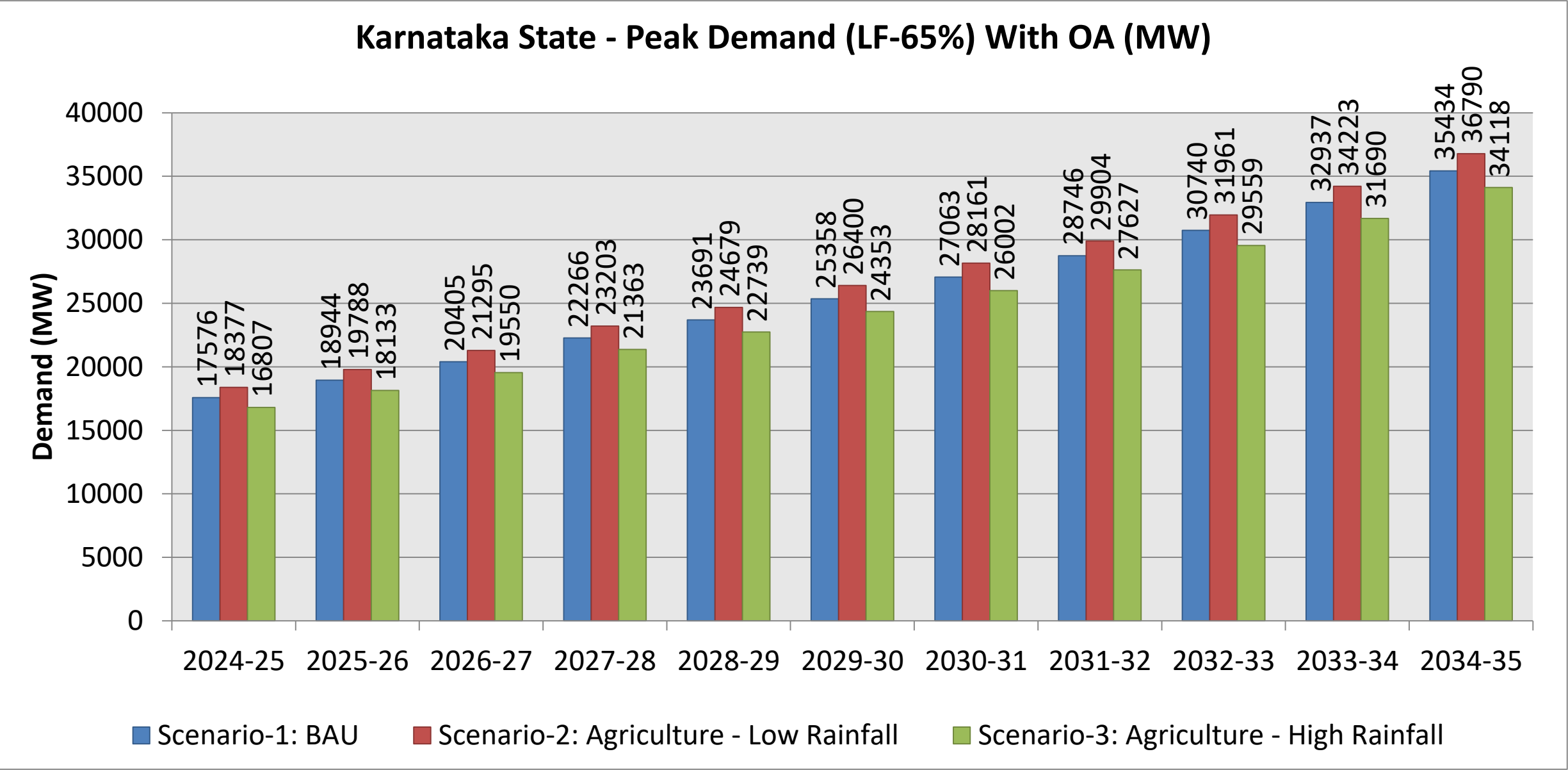
Scenarios – Energy Input – With OA



Scenarios – Peak Demand (LF = 65%) – Without OA



Scenarios – Peak Demand (LF = 65%) – With OA



Energy and peak demand to be contracted by all the ESCOMs is presented under 3 scenarios viz., average rainfall, low rainfall, and high rainfall.

Energy and peak demand to be handled by the Karnataka transmission network is provided for 3 scenarios viz., average rainfall, low rainfall, and high rainfall considering the open access.

The demand projection at Ex-bus generation is carried out with load factor of 62.5%, 65%, and 67.5%.

Thank you