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Indian Institute of Technology Kanpur (IITK) and Indian Energy Exchange (IEX) are delighted to announce

Training Program on

"Power Procurement Strategy and Power Exchanges"

28-30 July, 2014

SHORT TERM LOAD FORECASTING

"Power Procurement Strategies and Power Exchanges"

Agenda

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- Need for Load Forecasting
- Definition of Load Forecasting
- India Power Market Context
- Portfolio Management
- Types of Load Forecasting
- Short Term Load Forecasting
- Forecasting Process
- Forecasting Challenges

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Load Forecasting is critical in Indian Scenario

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- Energy Deficit Market
- Significant Growth
- Continuous shift of growth pattern
- Technical and Commercial Losses
- Distribution Infrastructure
- Metering Infrastructure
- Nascent Market Mechanism
- Regulatory Policies
- Renewable / Distributed Generation

Benefits of Load Forecasting

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- Efficient Power Procurement
- Capacity Planning
- Selling of Excess Power
- Optimum Supply Schedule
- Network Planning
- Demand Side Management
- Fuel Mix Selection
- Renewable Planning

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What is Load Forecasting

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Load forecasting is about estimating future consumptions based on various data and information available and as per consumer behavior

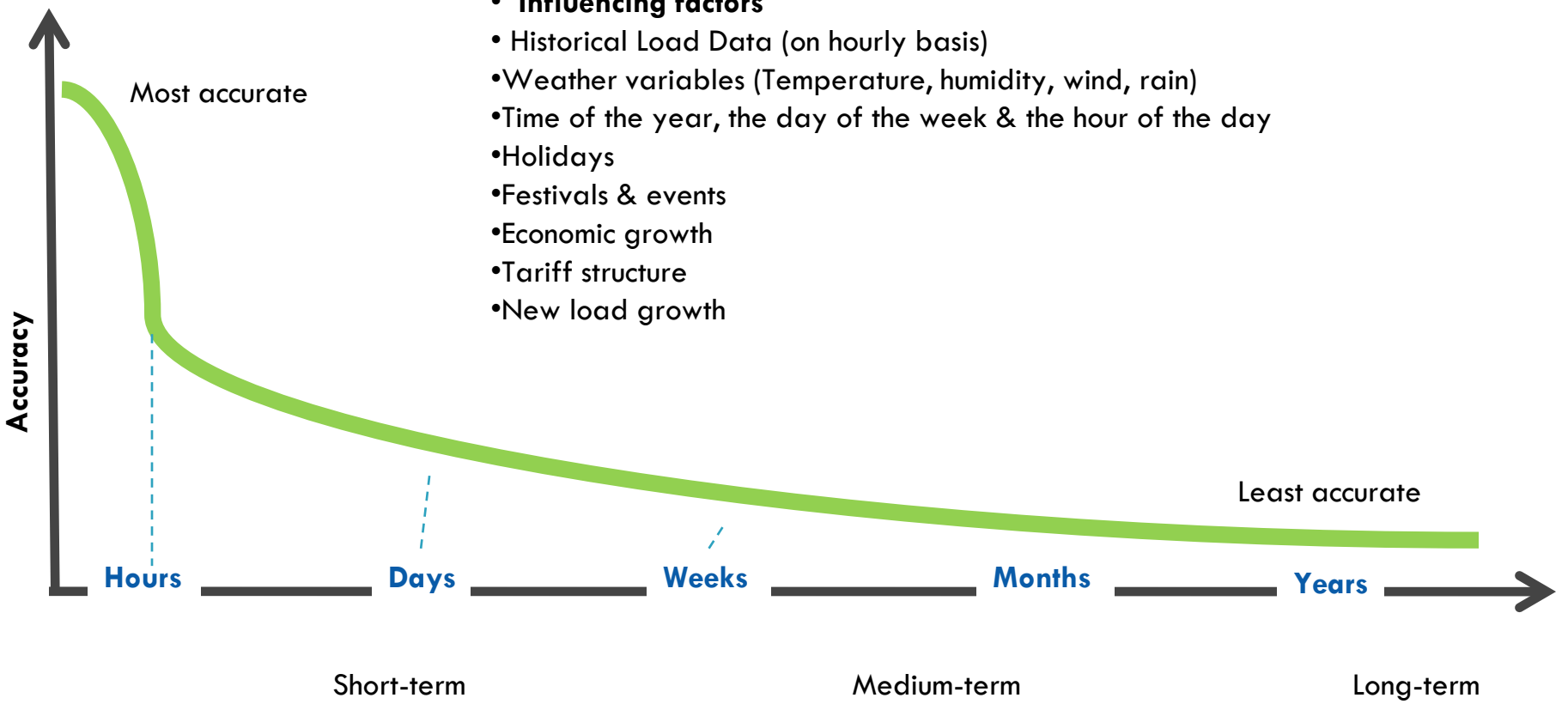
Load Forecasting mean forecasting average load in kW or total load in kWh for blocks of 15', 30', hour, day, week, month or year for a daily forecast, weekly forecast, monthly forecast, yearly or multi-year forecast

There are different tools and techniques for load forecasting

It is possible to forecast load for unconstraint demand. Load Forecasting of constraint demand is trivial.

Load Forecasting Accuracy

- **Influencing factors**
- Historical Load Data (on hourly basis)
- Weather variables (Temperature, humidity, wind, rain)
- Time of the year, the day of the week & the hour of the day
- Holidays
- Festivals & events
- Economic growth
- Tariff structure
- New load growth



Forecast periods and accuracy levels

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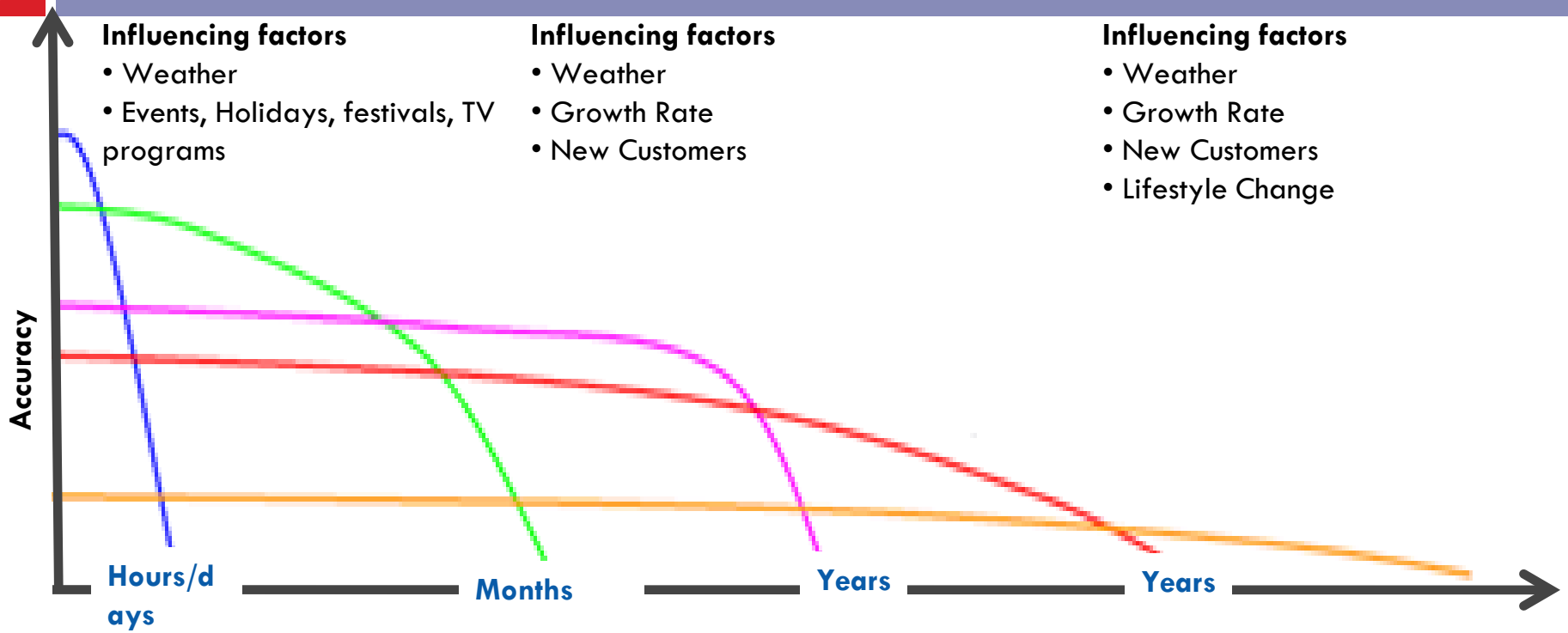

Influencing factors
- Weather
- Events, Holidays, festivals, TV programs

Short Term

Benefits
- Network Planning
- Supply /Demand Matching
- Spot Power Procurement
- Load Shedding Strategy
- Interaction with SLDC

Influencing factors
- Weather
- Growth Rate
- New Customers

Medium Term

Benefits
- Network Planning
- Supply /Demand Matching
- Power Procurement
- Rate Case Development

Influencing factors
- Weather
- Growth Rate
- New Customers
- Lifestyle Change

Long Term

Benefits
- Capacity / Investment Planning
- Fuel Mix Decision

Factor Affecting Load

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- Weather Data
  - Temperature
  - Humidity / Rain Fall
  - Wind Speed
- Hour of the day, Day of the Week, Month of the Year
- Econometric Factor
  - Residential Growth
  - Agricultural Growth
  - Commercial Growth
  - Industrial Growth
- Events / Special Events
- Life Style Changes
- Power Tariffs

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Sources of Power for Distribution Company

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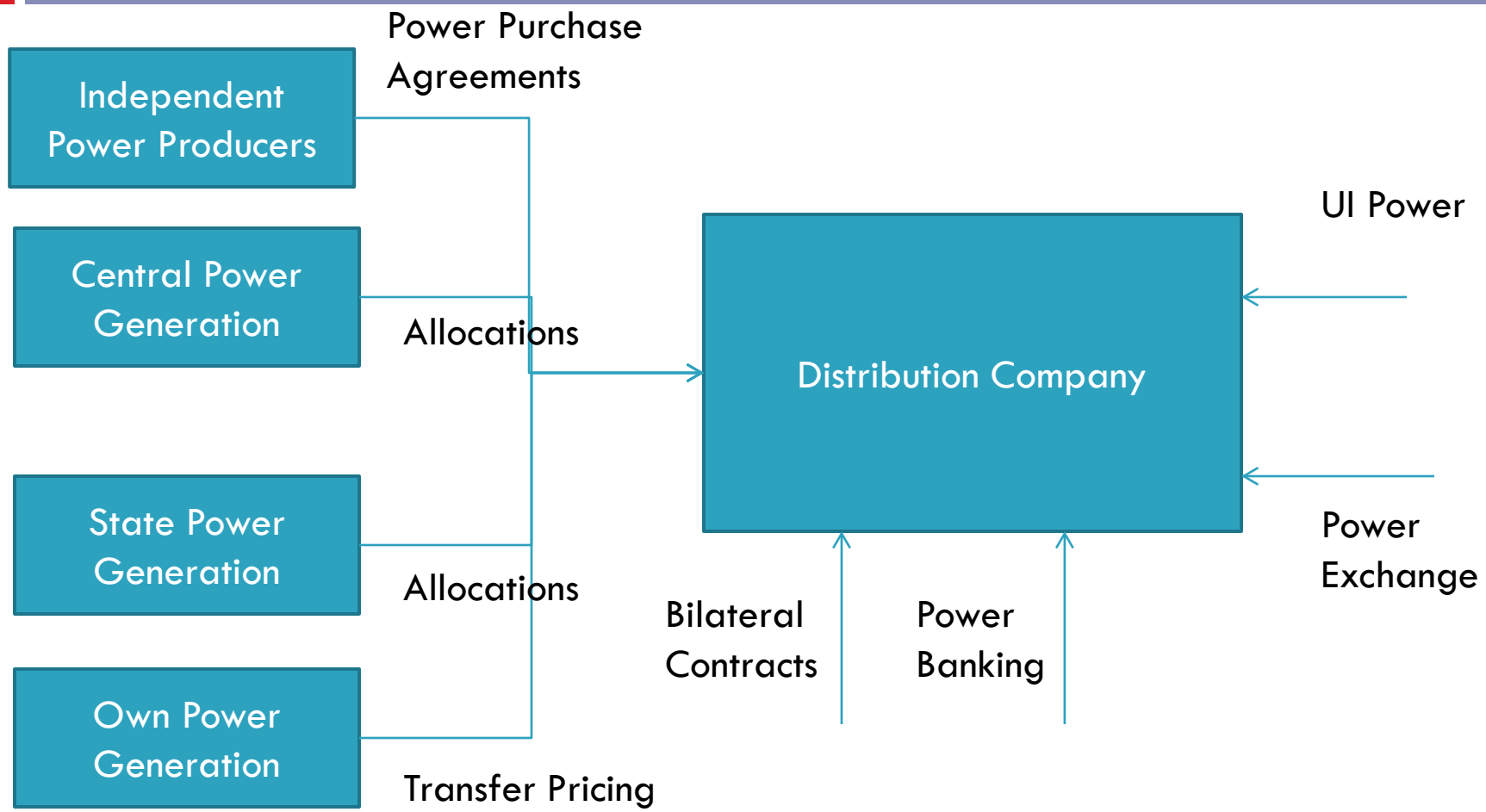

Source of Power for Distribution Company

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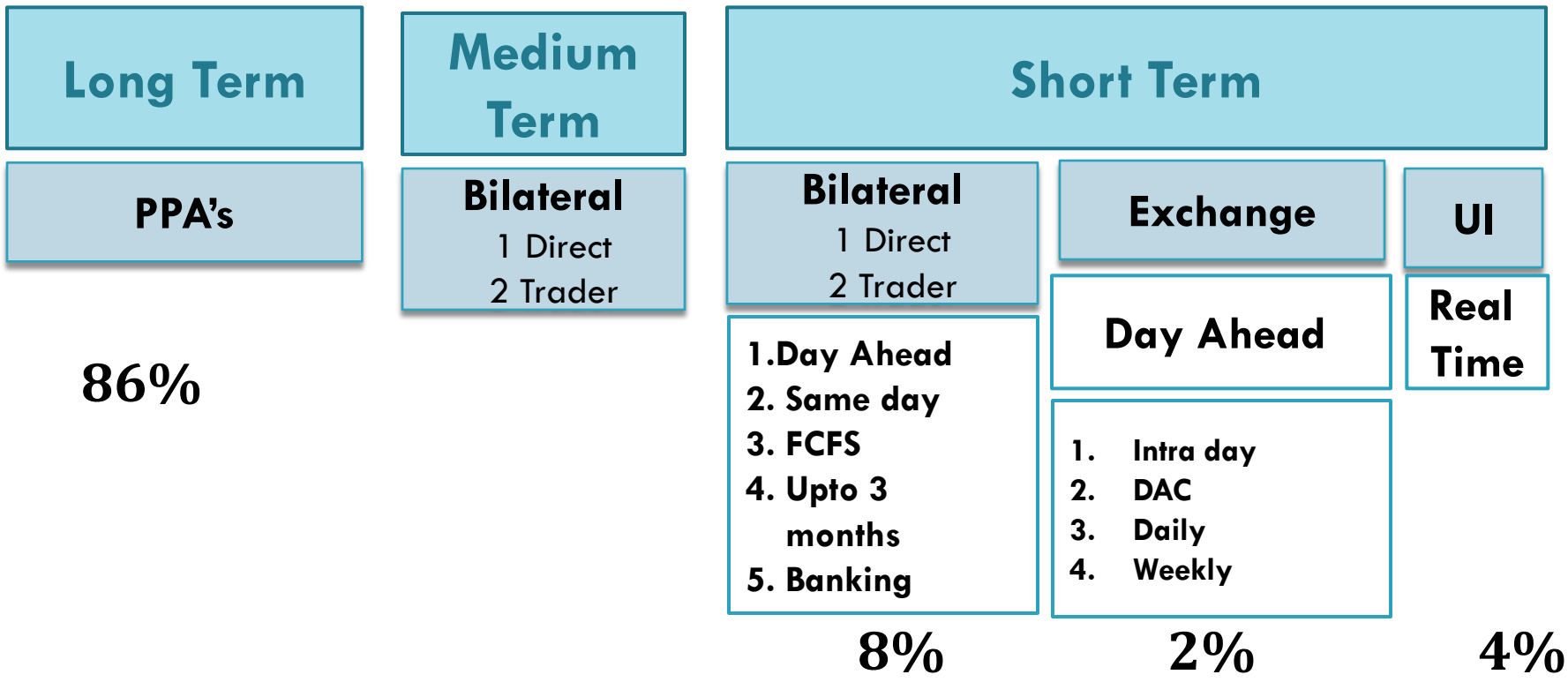

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Portfolio Management Process

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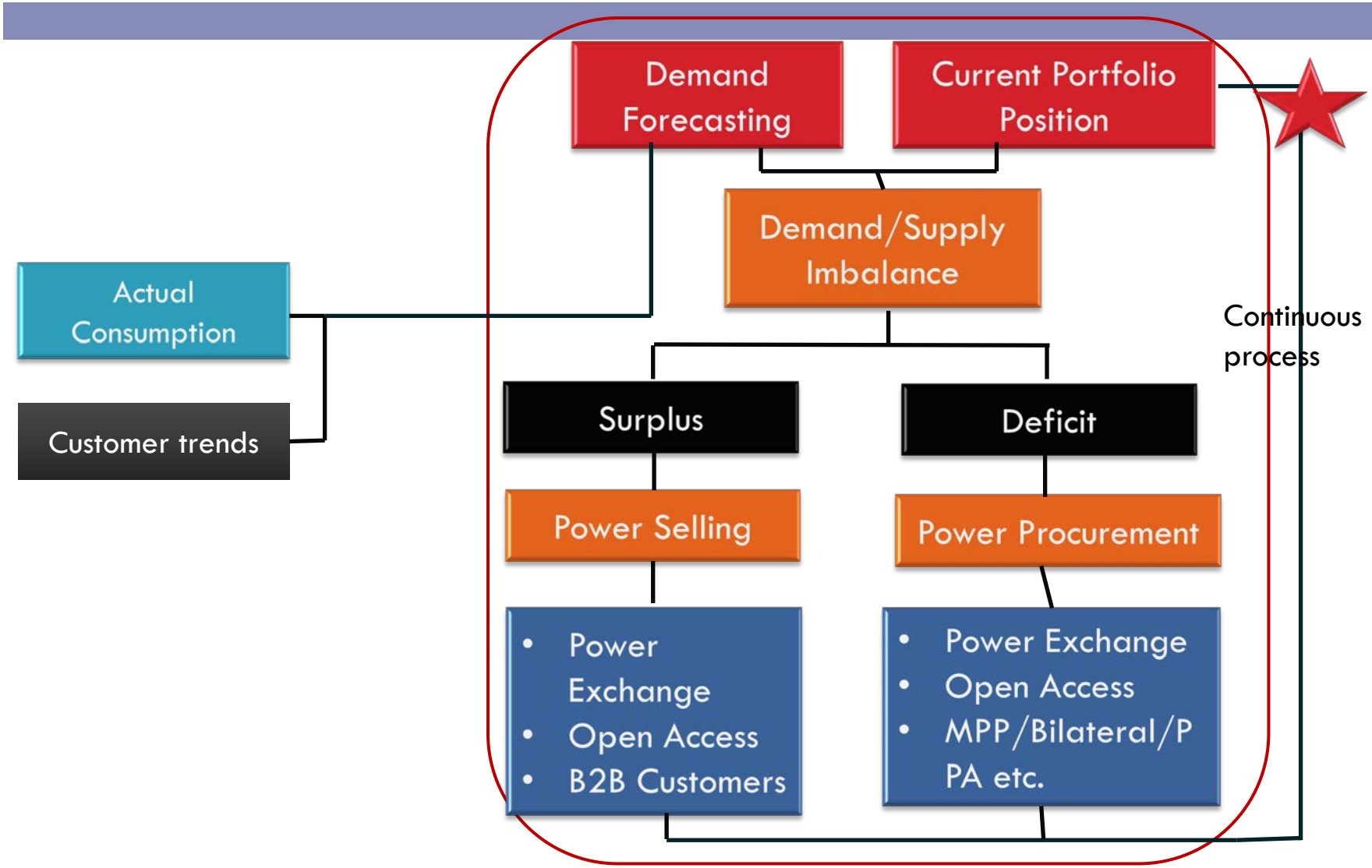

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Forecasting Horizons

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Horizons	Forecast Granularity	Forecast Run Frequency
Near Real Time	15’	Every Few Hours
Day Ahead	15’	Daily
Week Ahead	15’	Daily
Month Ahead	15’/ Daily	Weekly
Year Ahead	Daily/ Monthly	Monthly
Multi-Year Ahead	Monthly	Monthly

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Demand Forecast Models Levels

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Maturity model	Strengths	Weakness
Optimized Demand Forecasting model	✓ High forecast accuracy ✓ More parameters and metrics involved ✓ More interactive solution	✓ Expensive solutions ✓ Need of dedicated support staff ✓ Business users need to understand model ✓ Integration issues
Defined/ Managed forecasting	✓ Scalable and Extensible ✓ Improved forecast accuracy due to statistical techniques ✓ Easy and fast generation of multiple forecasts ✓ Exceptions handling and alerts mechanism	✓ Slightly Expensive solutions ✓ Need of special software applications ✓ Need of significant amounts of accurate data from multiple sources ✓ Limited parameters and Integration issues ✓ More of statistical analysis tool
Basic demand forecasting	✓ Less cost of ownership ✓ Existing applications are mainly used ✓ Easy to implement and understand	✓ Normally low forecast accuracy ✓ Highly manual processes (prone to errors, time consuming) ✓ Less parameters and analysis of data ✓ Not able to incorporate: ✓ Complexity in demand ✓ various metrics

Forecasting Methodologies

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- Simple Time Series Models
- Regression Models
- Similar Day Approach/ Seasonal
- Neural Networks

Examples of Models

- Moving Average
- Exponential Smoothening
- Trend Projection
- ARIMA (Auto Regressive Integrated Moving Average)

Example of Similar Day Approach

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- Factors: Amongst several factors which impact consumption, there are two high level components which are highly significant:
  - Seasonality
  - Weather
- These factors can be expressed as:

$$C = F(S, W) + \varepsilon$$

C = consumption,

S = season/TOD

W= weather

ε = error or residue

Seasonal Component

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- ARIMA along with components such as AR, MA etc. is generally used to account for the seasonality
- If the consumption is to be forecasted one year in advance on granularity such as 1 hr, ARIMA can not be used. Seasonality is accounted by finding the Normal Seasonal Curve.
- The normal seasonal curve would reflect the consumption assuming that all weather parameters were at their normal values and that there are no other factors influencing the consumption. This normal curve reflects the periodic component of the consumption time series and covers the auto regressive components.
- There are three major seasonal components considered:
  - Time of the day
  - Day of the week
  - Day of the year

Shifting Peaks

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- The moment of peak consumption may change with season
- The magnitude of the peak changes with season

DoW Seasonal Component

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- This seasonality could be reflected as a ratio

$$\left(\frac{7 * C_d}{C_w} \middle| DOW\right)$$

Cd is the consumption of a given Day

Cw is the consumption of the day.

DoW is day of the week

Weather Component

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- This component accounts for the variance in consumption due to a change in weather conditions.
- This component is made up of a number of sub components which play together to constitute the total weather impact. These components could be Humidity, Wind, Rainfall Atmospheric Pressure etc.
- There are a number of possibilities to evaluate the impact of these weather components on the consumption. We have found the optimal values of these coefficients using OLS (Ordinary Least Square)

$$y_t = \beta_1 T_t + \beta_2 H_t + \beta_3 W_t + \beta_4 R_t + \cdots + \beta_n X_t + \varepsilon$$

T, H, W etc. are weather parameters such as temperature, wind, rainfall etc.

β_i are regression coefficients and

ε Is the residue term

Events

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- Certain events have significant impact on Consumption
- For these events, the forecast adjust the forecast accordingly.
- The events impact is calculated and automatically used in the forecast
- Only the events are used where the impact standard deviation is less than 60% of the mean

Model Testing

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- There are various approaches of Model Testing:
  - Scatter plot of the actual load versus the model.
  - Correlation between the actual load and the model.
  - R- square between the actual load and the model.

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Load Forecasting Implementation Process

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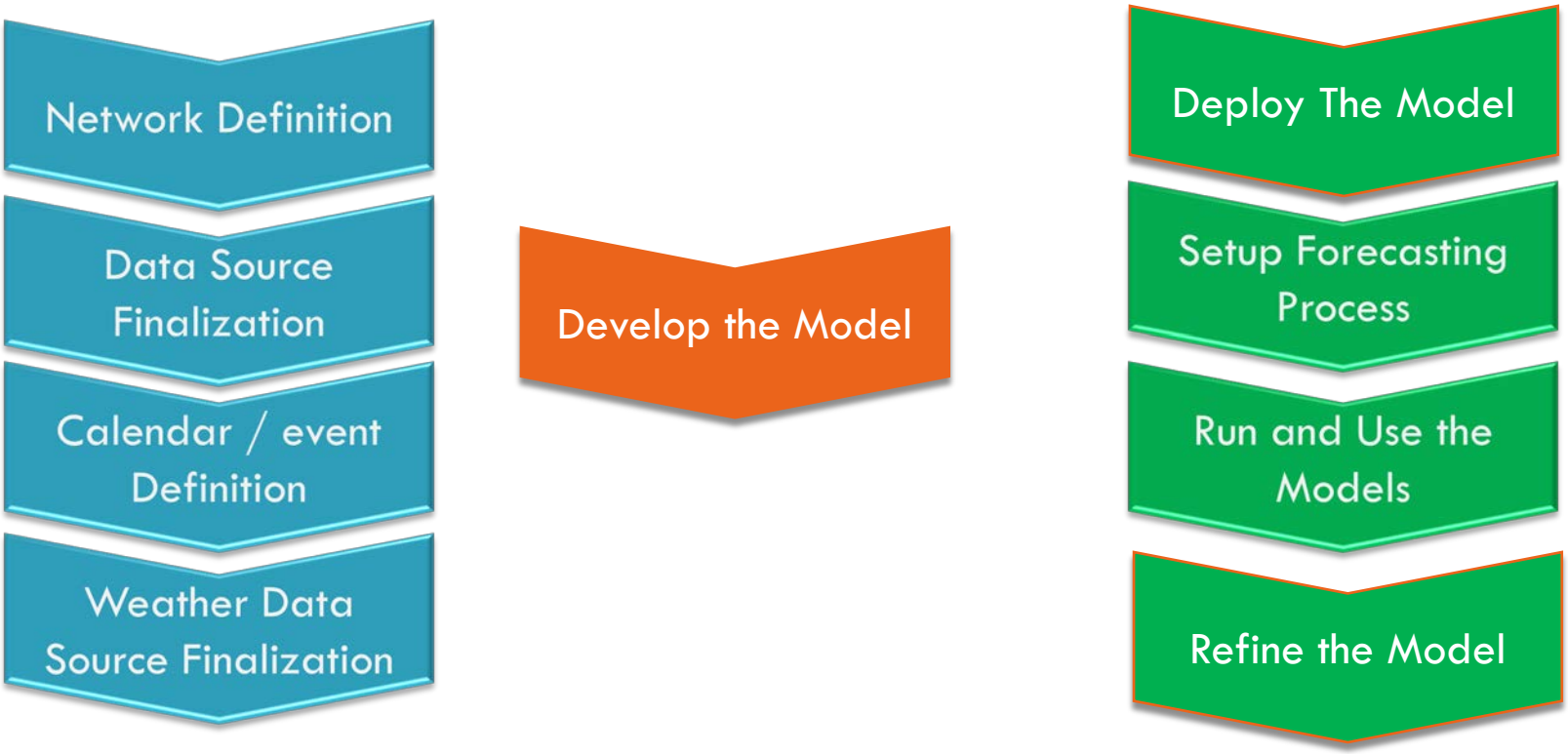

Load Forecasting Model Development

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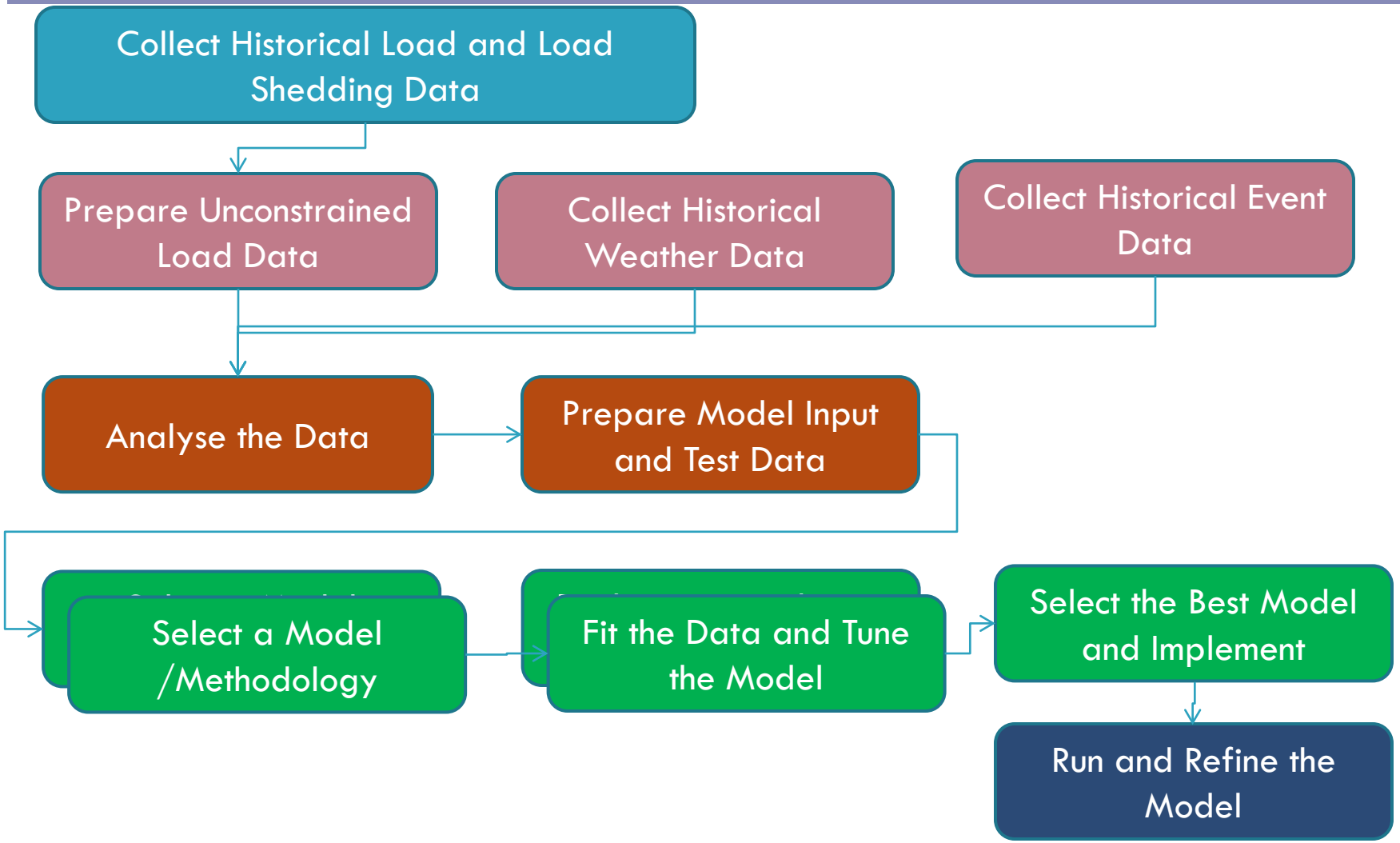

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Forecasting Challenges

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- Data Related Challenges
  - Lack of good data is the biggest challenge in load forecasting
  - Forecasting requires clean
- Process and Methodology Challenges
- Governance Challenges
- Technology Challenges
- Eternal Data Challenges

Pitfalls in Forecasting

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- Forecasting is a statistical process. It is not expected to forecast demand of each consumer and then roll it up.
- Forecasting needs to be done of unconstrained load
- Forecasting involves both profile forecasting and total forecasting. Quite a few times, the profile forecasting is done more accurately while total forecasting is done less accurately
- The forecasting accuracy is a combination of good data, good process and good model. A good model alone or a good software alone can not give good accuracy
- Accuracy Improvement is a gradual process and involves significant human intervention. An automated process does not provide good accuracy on regular basis
- More data does not necessarily mean better forecast. It is important to select optimum data size
- One model does not fit all

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THANK YOU

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