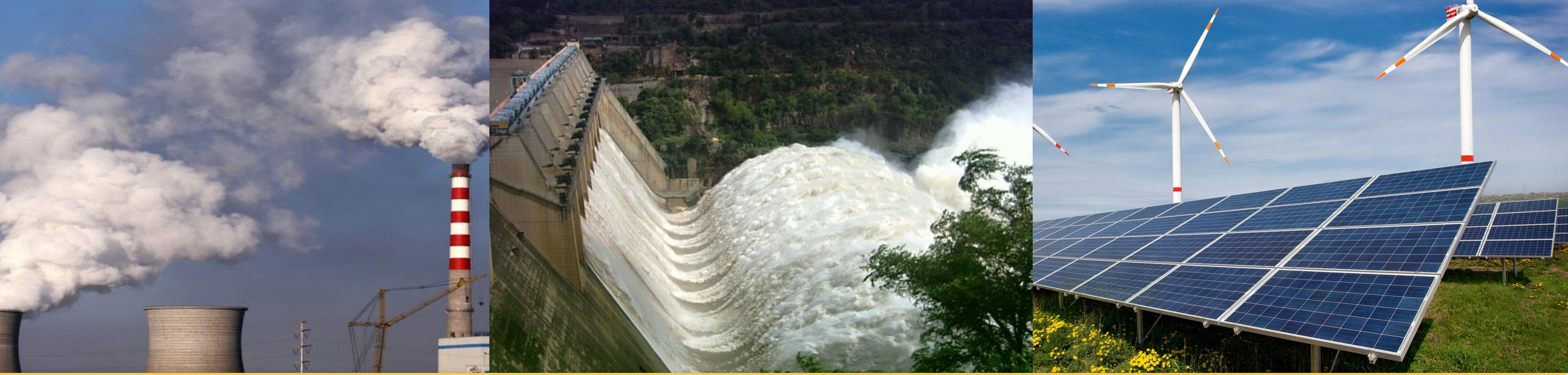

Load Forecasting: Methods & Techniques

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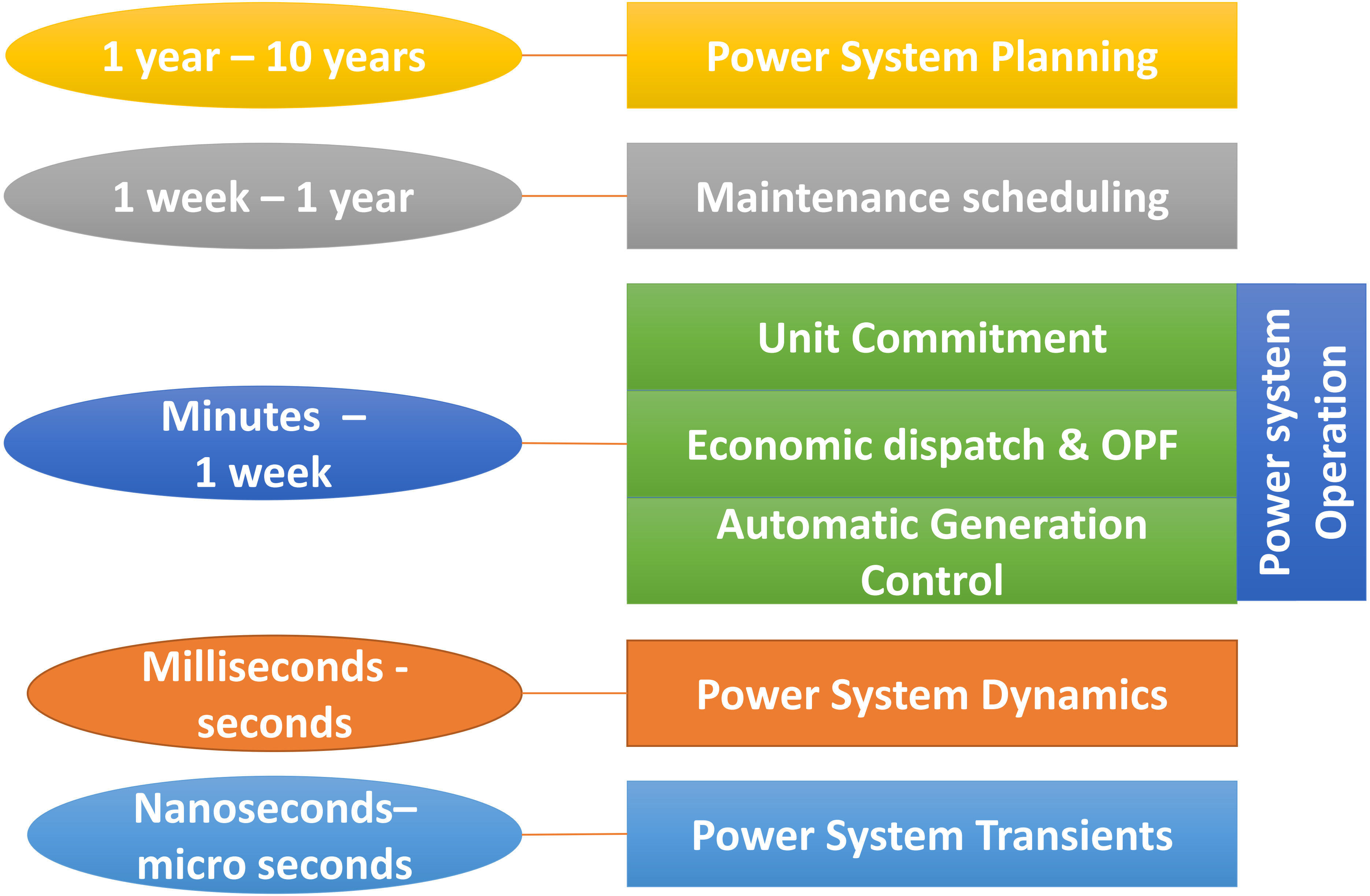
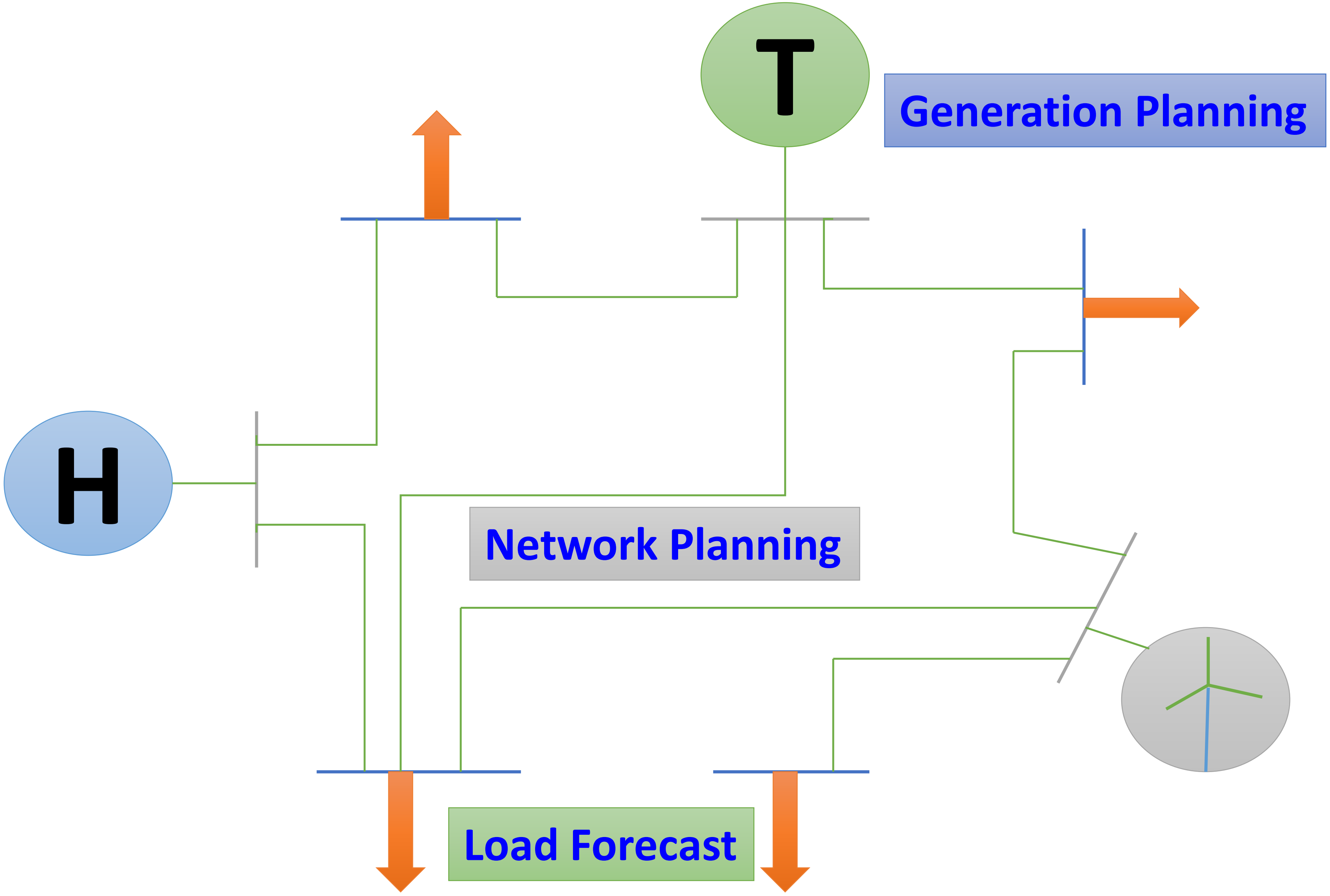
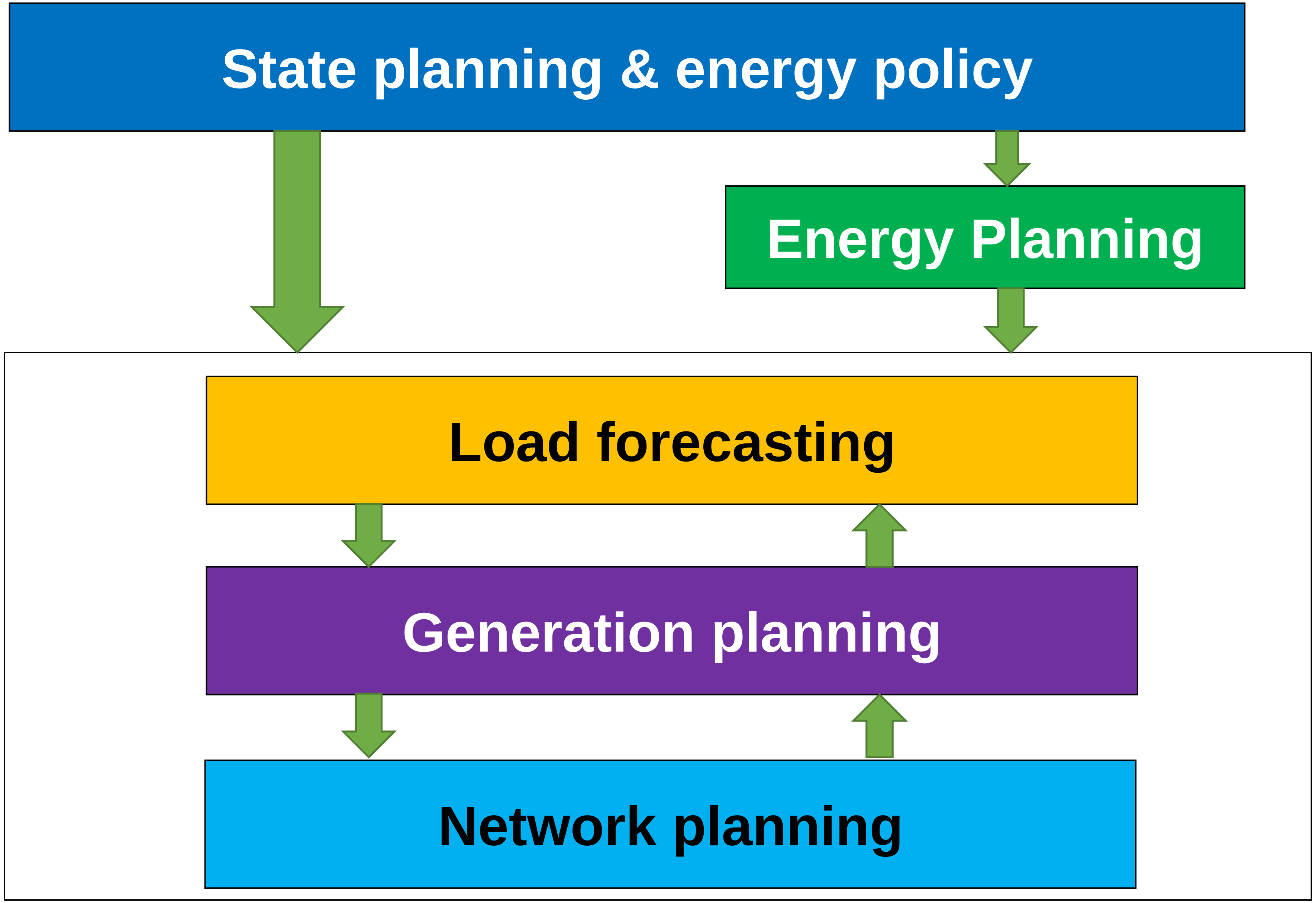


Power System Planning



Structure of power system planning



Load Forecasting: Introduction

- The term forecast refers to projected load requirements, determined using a systematic process of defining future loads in sufficient quantitative detail to permit important system expansion decisions to be made.

Required for

- Capacity planning
- Network Planning
- Generation and transmission capital investment
- Financial forecasting
- Efficient Power Procurement
- Selling of Excess Power
- Planning of fuel ordering
- Optimum Supply Schedule
- Renewable Planning
- Fuel Mix Selection

Forecasting: Introduction

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

- Economic growth,
- Industrial production
- New technological developments that influence the life styles,
- Governmental policies etc.

Prediction of future energy demand requires an intuitive and wise judgment

The ability to forecast the long-term demand for electricity is a fundamental prerequisite for the development of a secure and economic power system.

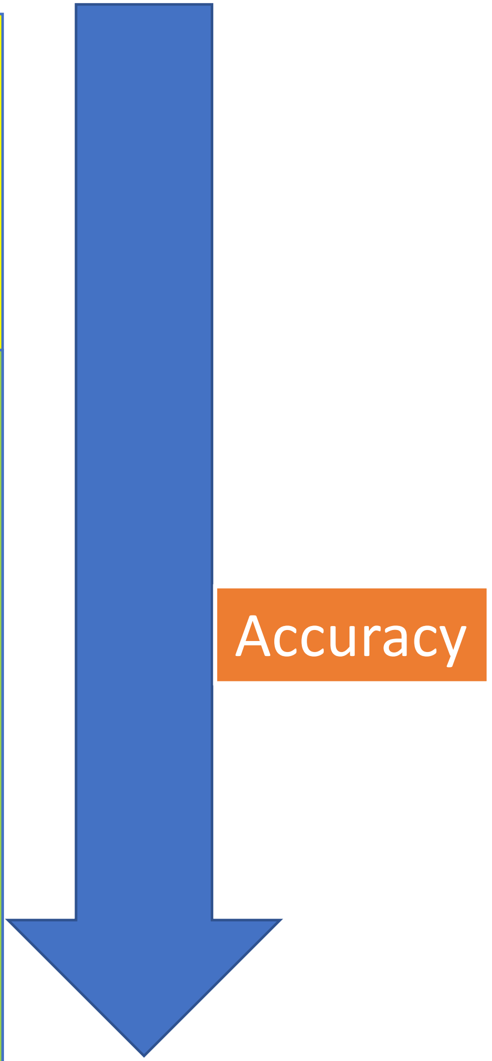
The demand forecast is used as a basis for system development, and for determining tariffs for the future.

Load Forecasting: Time spans

Long term (1 -20 years): Plays a fundamental role in economic planning of new generating capacity and transmission networks.

Medium term (1 week to 1 years): used mainly for the scheduling of fuel supplies, maintenance programme, financial planning and tariff formulations.

Short term (1 hour to week): provides the basis for planning start-up and shut down schedules of generating units, spinning reserve planning and the study of transmission constraints. Used in economic load dispatching and security assessment.



Load Forecasting: Why ?

Forecasting ensures the availability of supply of electricity

Provides the means of avoiding over and under utilization of generating capacity

Helps to make use of best possible use of capacity

Too high forecasts lead to more plants than is required – Unnecessary capital expenditure

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

Load Forecasting : Uncertainties

Forecasting the future needs for electricity is a difficult task

Electricity production and distribution are highly capital intensive

Projects are large and lead times are long

Forecasting can not be an isolated activity

Role of electrical energy in the society should be reflected

Government policy and strategic decisions taken by utility are important factors

Forecasting should view that the future is open to the effects of many human actions.

Load Forecasting : Uncertainties

Uncertainties arise from the impact of the changes in public perceptions, viewpoints and policies.

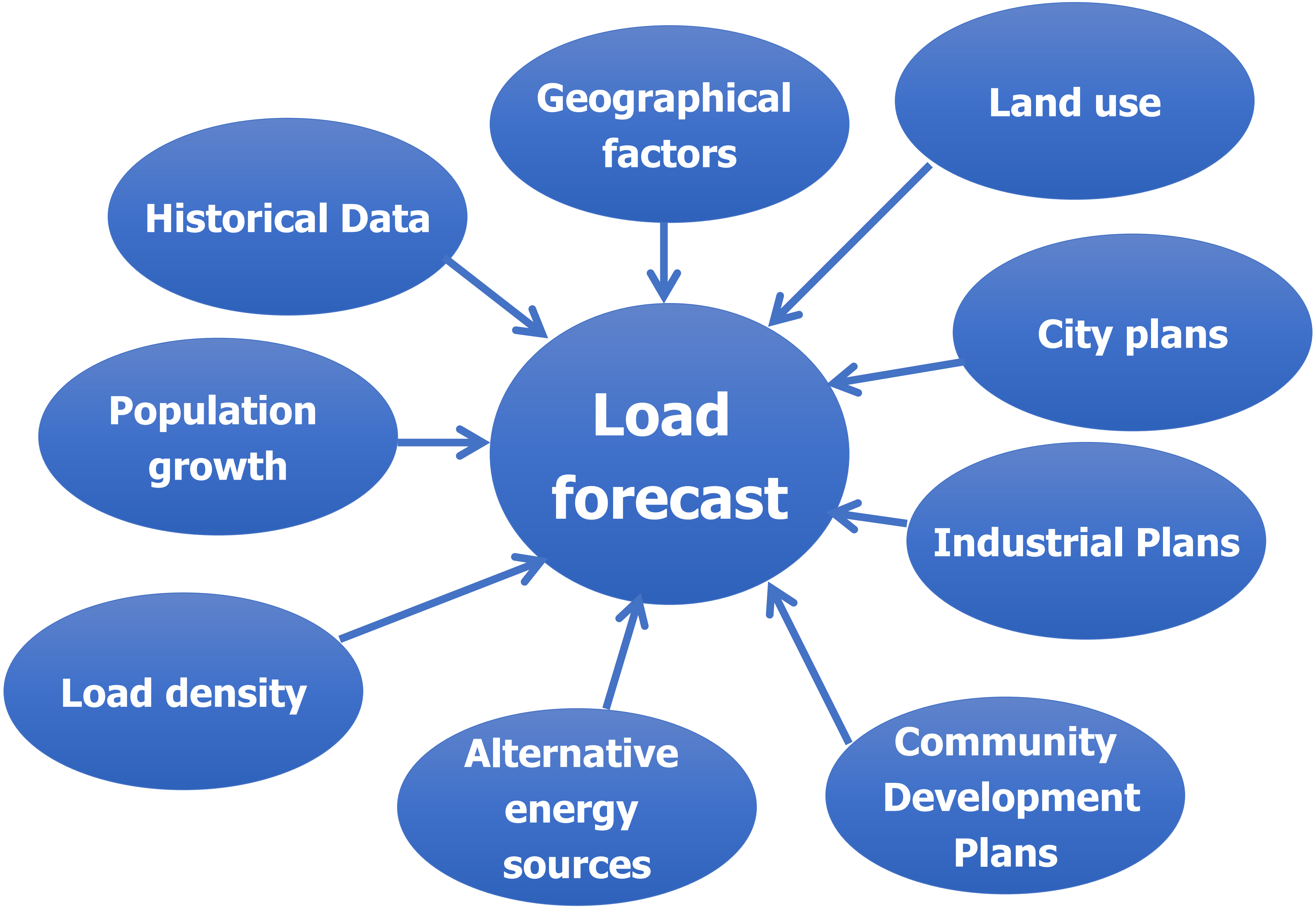
Demand Side Management and conservation policies give additional requirements on load forecasting.

Precise forecasting is impossible

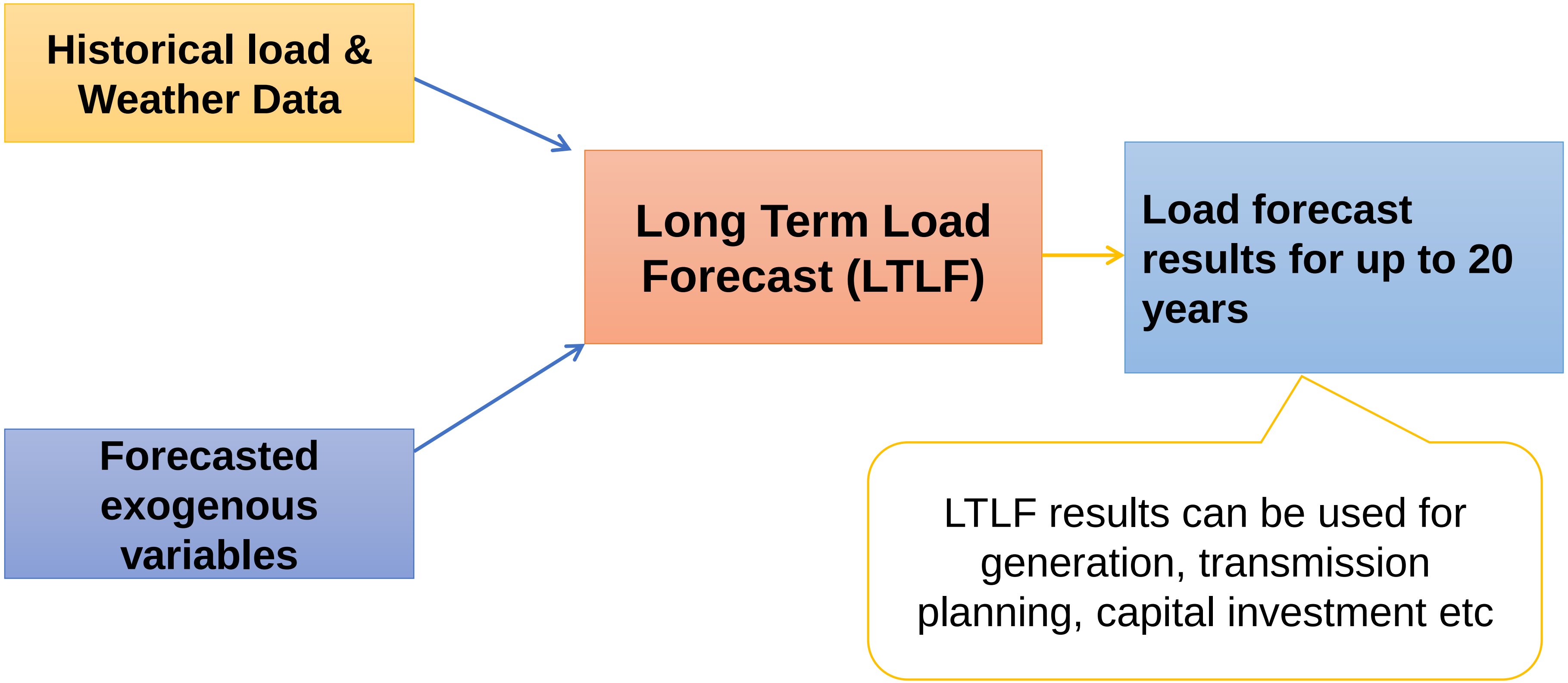
To tie future plans too rigidly to a single load forecast projection is too risky.

By incorporating the role of uncertainty into the analysis techniques, the emphasis of planning moves from making an accurate forecast to constructing a system that can adapt readily to changes.

Load Forecasting: Factors affecting



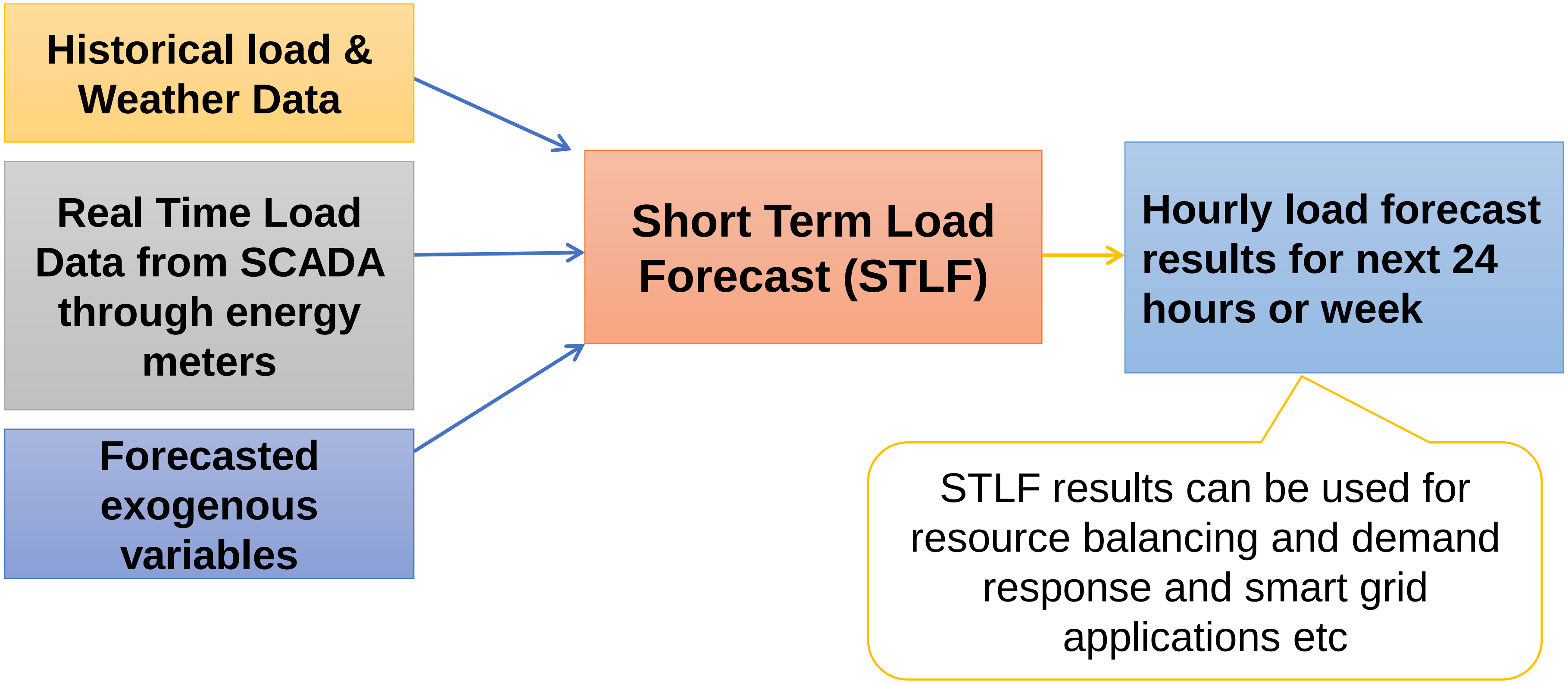
Long Term Load Forecasting : Structure



Modeling techniques used for long term load forecasting are:

- Trend Analysis
- Linear Multi-Variable Regression
- Partial end use method
- Scenario approach

Short Term Load Forecasting : Structure



The most important modeling techniques used for short term load forecasting can be categorized into 3 groups such as:

- Time Series Analysis (AR, ARX, ARMA etc.)
- Multiple linear regression
- Expert systems approach (like Neural networks, Fuzzy logic)

Load Forecasting : Methods

Energy demand forecasting has developed over time from a very basic and simplistic exercise into a complex procedure

Numerous methods have been developed over the history of energy forecasting.

The types of forecasting procedure can be classified into five broad categories:

- Subjective
- Univariate
- Multivariate
- End use
- Combination of the above

Load Forecasting : Methods - Subjective

In this approach, forecasts is made on a subjective basis using

- Judgment,
- Intuition,
- Commercial knowledge and
- any other relevant information.

Forecasters may or may not take the past information into consideration.

Load Forecasting : Methods - Univariate

Univariate forecasts are based entirely on past observation in a given time series.

This approach is also known as naive or projection forecasting technique.

Many forecasting procedures fall into this group, such as

- extrapolation of trend curves,
- exponential smoothing,
- Holt-Winters and
- Box-Jenkins techniques.

Load Forecasting : Methods - Multivariate

This approach attempt to establish casual or explanatory relationship with other variables

It depends on methods of measuring whether variables co-relate or move in relation to each other in some clearly established way.

As an example, electricity sales may depend on other variables such as price and income.

Regression models as well as econometric models fall into this category.

Multivariate models are sometimes called ‘casual’ or ‘prediction’ models.

Load Forecasting : Methods – End Use

This methodology is based on specifying those activities that give rise to sales or consumption of electricity demand.

This method, decomposes the sales of electricity into its elemental component of consumption,

For example, in the case of domestic, the demand is decomposed into

- space heating,
- water heating,
- cooking,
- refrigeration and others.

These components are explained in terms of physical and technical parameters as economic factors.

End user models are sometimes called ‘ disaggregated’ or ‘bottom-up’ or physically based modeling approaches.

Load Forecasting : Methods – Combination

Different techniques are used in combination to produce new and in many cases better forecasting results.

Obtained by combining two or more forecasts, following various combination procedures.

Load Forecasting : 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.

The trend analysis may be

- Linear trend
- Non-linear trend (Quadratic)
- Exponential trend
- Cumulative average growth rate (CAGR)

Load Forecasting : Multi Variable Regression

The econometric method determined energy demand by considering the influence of independent variables, such as

- Population,
- Income,
- Economic growth,
- Cost, industrial
- Commercial activity and also other economic variables.

Multi-variable regression analysis is used to establish the correlation between selected socio-economic-energy variables and energy consumption data using the past sample data.

Load Forecasting : Trend & CAGR

	Trend	Equation
1	Linear trend	$Y = C_0 + C_1*.X$
2	Non-linear trend (Quadratic)	$Y = C_0 + C_1*.X + C_2*X^2$
3	Exponential trend	$Y = e^{(C_0 + C_1.X)}$
4	CAGR (Compound Average Growth Rate)	Y={(Current value/Base value) ^1/(no of years-1)}-1

Load Forecasting : Multi Variable Regression

The following linear regression model can be used for the regression analysis

$$Y = C_0 + C_1 * X_1 + C_2 * X_2 + C_3 * X_3 + \ldots\ldots\ldots + C_n * X_n$$

where

- Y denotes the dependent energy consumption variable
- X_1 to X_n denote the independent regression variables.
- C_0, C_1, ... C_n are the constants of the linear multi-variable regression model

Load Forecasting : Multi Variable Regression

The econometric method determine energy demand by considering the influence of independent variables, such as

- Total population
- Total number of households
- Gross domestic product
- Per capita income
- Relative price deflator (Electricity)
- GDP of registered manufacturing sector
- GDP of unregistered manufacturing sector
- GDP of tertiary sector
- GDP of Agriculture

Multi-variable regression analysis is used to establish the correlation between selected socio-economic-energy variables and energy consumption data using the past sample data.

Category wise regression variables

- Domestic (Lighting & Heating)
- Commercial
- LT-Power
- HT-Power
  - HT commercial Installations
  - HT Industries
  - LIS …
- Irrigation Pump sets
  - Agricultural consumers
  - Horticultural consumers …
- Water Works
  - HT
  - LT
- Street Light

Load Forecasting : Partial End Use

The end-use method determines energy demand through total kWh use from all of the electrical appliances used.

In the basic form, this model is simple accounting procedure that enumerates the end uses and adds the electricity use for each end use of its components.

In view of practical difficulties in assessing the end usage of equipment's, the method of partial end use model is being increasingly used.

This method is being followed by CEA in its forecasting methodology in the EPS. Presently also working for Econometric models

In this methodology the specific consumption of each of the category is being assessed based on the past sample and correction is made to account for changing scenario.

Load Forecasting : Scenario Approach

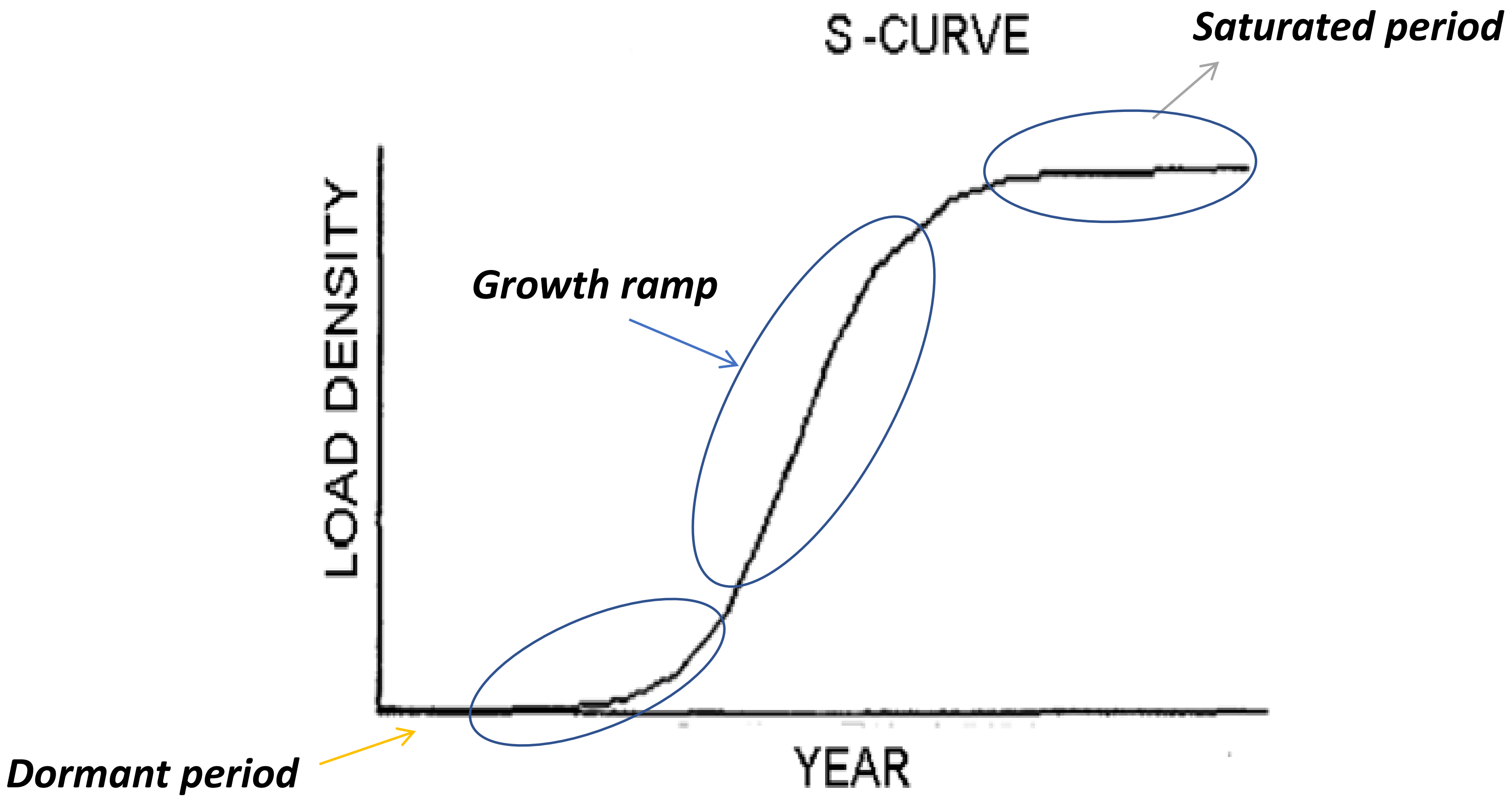
A scenario is a time – ordered sequence of events bearing cause effect relationship with one another and modeled to simulate a future situation.

Scenario approach captures the effect of policy changes and other guidelines of the government to meet specific goal or an objective to the energy consumption.

Scenario analysis is a means by which "decision makers understand the uncertainty created by multiple combinations of input factor values; they sometimes investigate the results of scenarios in which combinations of variables are changed".

Scenario analysis uses groupings to determine which causes a particular output value to change.

Load Forecasting : Spatial Load Forecasting



S curve behavior is used to identify the overall dynamics of what happens at the distribution /small area level.

Load Forecasting : Spatial Load Forecasting

how much power must be delivered, and where and when it will be needed.

A spatial forecast involves the coordinated forecast of all small areas in a region.

The amount of "where information" (spatial resolution) in a forecast must match the T&D planning needs.

A point stressed in spatial forecasting is that when viewed at the small area level, load growth trends can look substantially different than when viewed at the system level.

Analysis of load in terms of MW/sq.km or MU/sq.km is a convenient way of relating it to local T&D capacity needs and is often used in power delivery planning.

Peak Demand Forecasting

Forecasting should be done for both electrical energy and demand levels.

Annual peak demand is obtained by annual load factor as:

- Peak demand = Energy sales /(Load factor * 8760)

A reliable load factor value is required.

Thank You