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Long Term Load Forecasting in Power Systems

(SAARC Prospective)

Dr. Muhammad Tariq
Associate Professor and Head
Department of Electrical Engineering
FAST National University of Computer & Emerging Sciences, Pakistan

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Forecasting

"Prediction is very difficult,
especially if it's about the future."

Nils Bohr

Introduction

Forecasting is the process of making predictions of the future based on past and present data

A forecast is only as good as the information included in the forecast (past and data)

History is not a perfect predictor of the future (i.e., there is no such thing as a perfect forecast

Forecasts are always wrong and no substitute for the calculated demand

Every forecast includes an error estimate

- mean squared error, mean average percentage error, mean absolute deviation etc.

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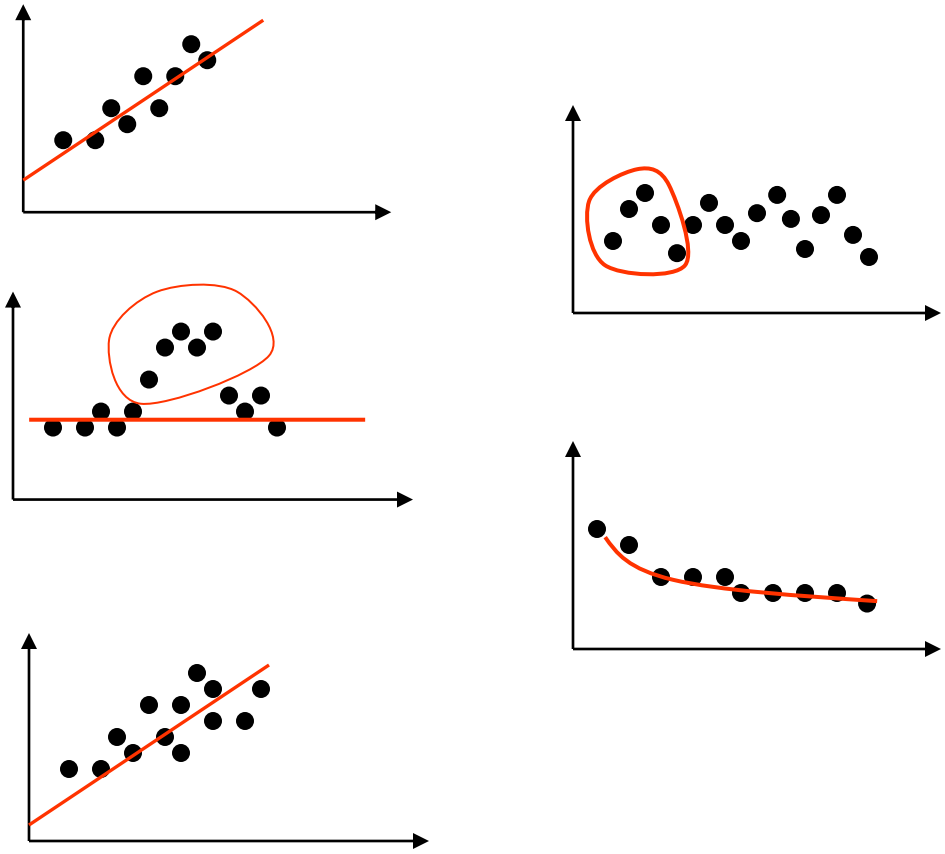
Introduction (contd.)

What should we consider when looking at past and present demand data?

- Trends
- Seasonality
- Cyclical elements
- Autocorrelation
- Random variation



Introduction (contd.)

Load forecasting is a technique used by power companies to predict the power or energy needed to balance the supply and **load demand** at all the times.

It can be classified in terms of time like:

- Short-term load forecasting (STLF)
- Medium-term load forecasting (MTLF)
- Long-term load forecasting (LTLF)

Forecasts are more accurate for shorter time periods and getting degraded with the duration

Introduction (contd.)

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.

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

Introduction (contd.)

Why load forecasting?

- Optimum utilization of the generation resources
- Capacity and network planning
- Capital investment
- Efficient financial planning
- Efficient power procurement
- Selling of excess power
- Optimum fuel supply schedule
- Renewable and alternative energy planning and installation

Introduction (contd.)

- Ensuring the availability of supply of electricity and type of sources that can be used
  - Expensive-immediate, Cheap-long term
- Avoiding over and under utilization of generating capacity
- Ensuring best possible use of capacity
- Unnecessary capital expenditure
  - i.e., too high forecasts lead to more plants than is not required
- Too low forecasts prevent optimum economic growth
  - Lead to installation of many costly and expensive to-run generators and resources

Why Forecasting is difficult? Uncertainties

- Electricity production and distribution are highly capital intensive
- Projects are large and lead times are long
- Uncertainties due to changes in public perceptions, viewpoints and policies, unavoidable circumstances (COVID-19).
- 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.

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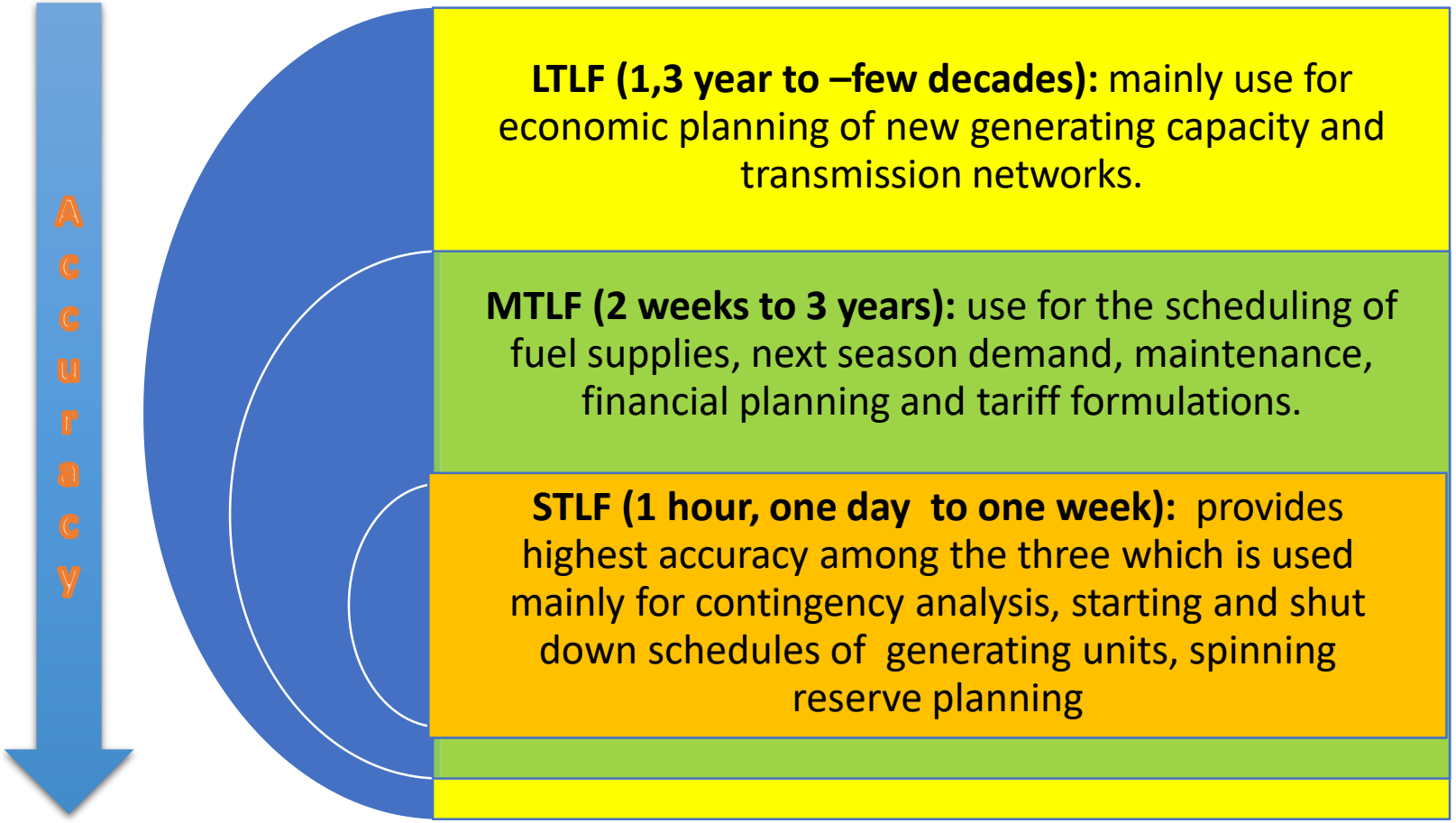
Timeline of Load Forecasting



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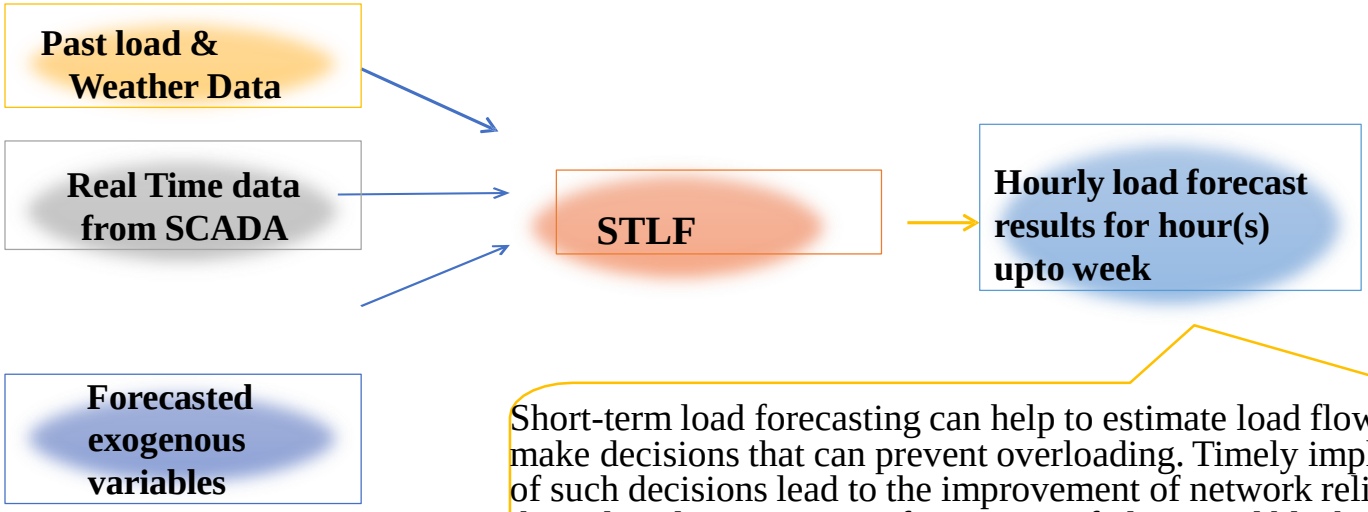
Short Term Load Forecasting



Short-term load forecasting can help to estimate load flows and to make decisions that can prevent overloading. Timely implementations of such decisions lead to the improvement of network reliability and to the reduced occurrences of equipment failures and blackouts.

The most important modeling techniques for STLF are

- Time Series Analysis (AR, ARX, ARMA ARIMA, ARIMAX etc.)
- Multiple linear regression (MLR)
- Artificial Intelligence (expert system based techniques like, Machine learning, Neural networks, Fuzzy logic)

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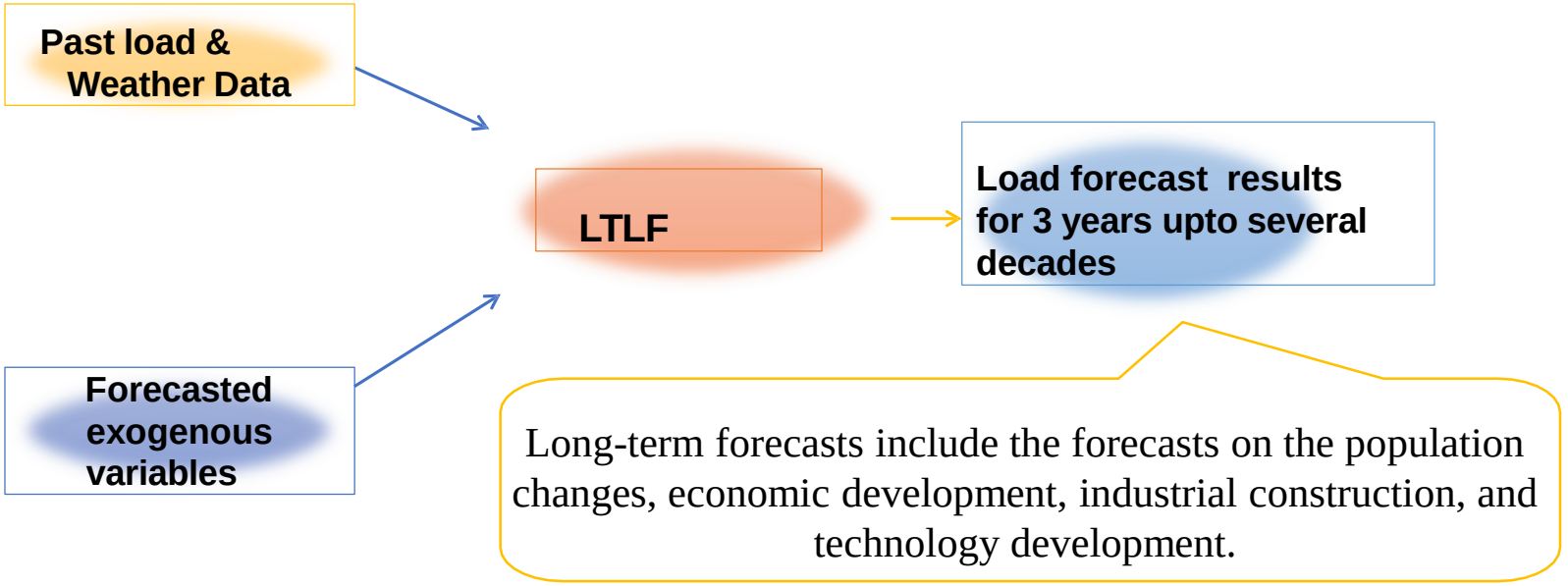
Long Term Load Forecasting



Modeling techniques used for long term load forecasting are:

- Trend Analysis
- Linear Multi-Variable Regression
- End-use and econometric approach (GDP growth, Industrial growth, telecom infrastructure, Co2 emission)
- Partial end use method
- Scenario approach

LTLF Forecasting based on 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)

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Load Forecasting based on Multi Variable Regression

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

- Population,
- Income,
- Economic growth,
- Cost, industrial
- Gross domestic product (GDP)
- Per capita income
- Relative price deflator (Electricity)
- GDP of registered manufacturing sector
- GDP of unregistered manufacturing sector
- GDP of tertiary sector
- 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.

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Load Forecasting based on Partial End Use Approach

- The partial End Use technique is a combination of End Use technique for the sectors where sufficient data for the past is available and the programme for the future is well defined and trend analysis in the case of others (non – industrial bulk consumers like Research Establishments etc).

Load Forecasting based on 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”.

General Load Forecasting Techniques

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Load Forecasting Techniques

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

1. Subjective
2. Univariate
3. Multivariate
4. End-use and econometric approach
5. Combination of the above

Load Forecasting based on Subjective Approach

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 based on Univariate Approach

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
- Box-Jenkins techniques.

Load Forecasting based on Multivariate Approach

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.

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

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Load Forecasting based on Econometric Approach

The econometric approach combines economic theory and statistical techniques for forecasting electricity demand.

The approach estimates the relationships between energy consumption (dependent variables) and factors influencing consumption.

The relationships are estimated by the least-squares method or time series methods.

One of the options in this framework is to aggregate the econometric approach, when consumption in different sectors (residential, commercial, industrial, etc.) is calculated as a function of weather, economic and other variables

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Load Forecasting based on End Use Approach

Descriptions of appliances used by customers, the sizes of the houses, the age of equipment, technology changes, customer behavior, population dynamics are usually included in the statistical and simulation models based on the so-called end-use approach

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

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

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Load Forecasting based on Hybrid Approach

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.

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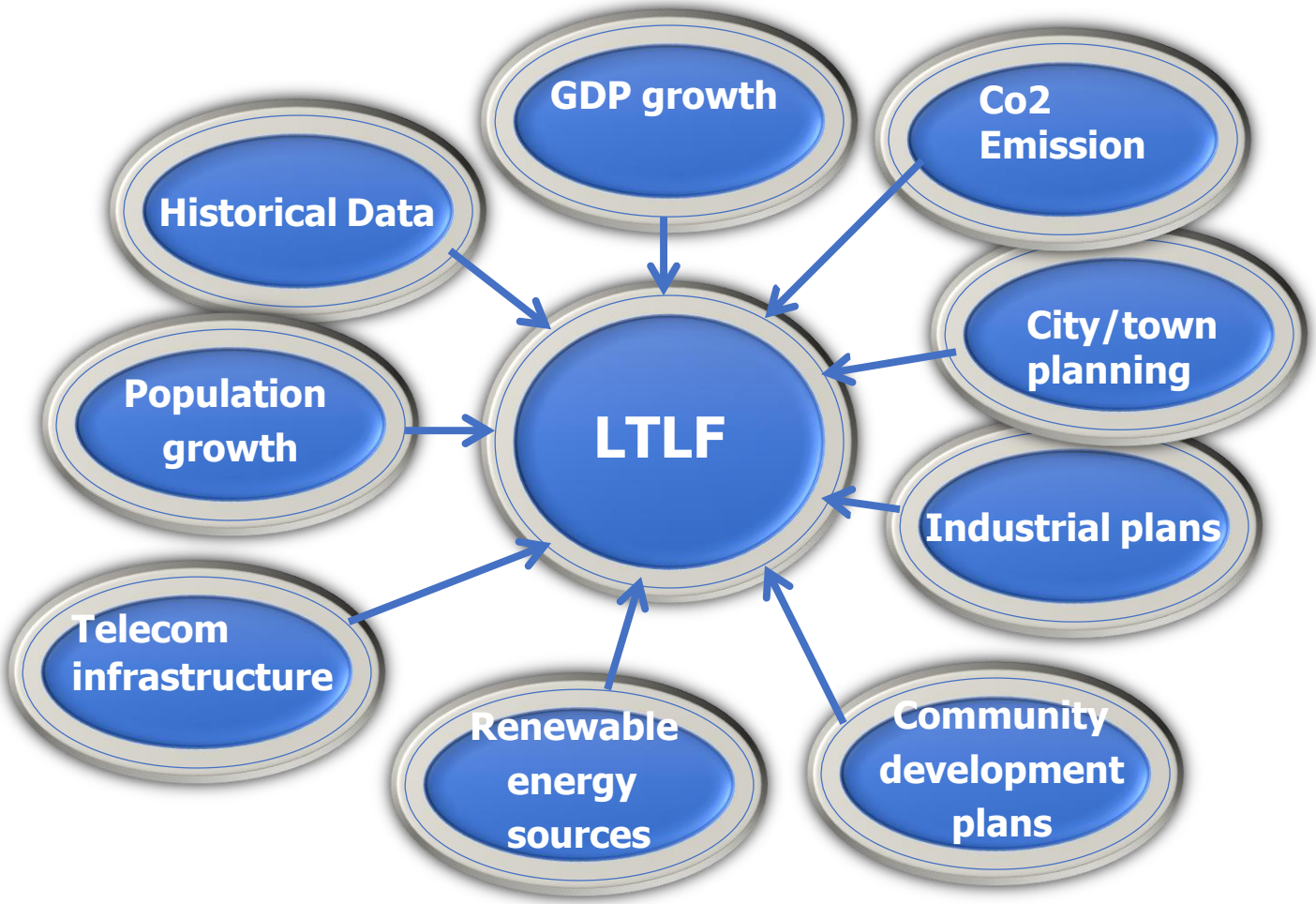
Factors affecting LTLF



REAL GDP GROWTH AT CONSTANT MARKET PRICES, 2019 AND FORECASTS

		Real GDP forecasts (percent)				Revisions to forecasts from October 2019 (percentage point)	
		2019	2020(e)	2021(f)	2022(f)	2020(f)	2021(f)
South Asia		**4.1**	**-7.7**	**4.5**	**4.6**	**-14.0**	**-2.2**
Afghanistan	December to December	3.9	-5.5	2.5	3.3	-8.5	-1.0
Maldives	January to December	5.9	-19.5	9.5	12.5	-25.0	3.9
Sri Lanka	January to December	2.3	-6.7	3.3	2.0	-10.0	-0.4
Fiscal year basis		**18/19**	**19/20(e)**	**20/21(f)**	**21/22(f)**	**19/20(f)**	**20/21(f)**
Bangladesh	July to June	8.1	2.0	1.6	3.4	-5.2	-5.7
Bhutan	July to June	3.8	1.5	1.8	2.0	-5.9	-4.1
Nepal	mid-July to mid-July	7.0	0.2	0.6	2.5	-6.2	-5.9
Pakistan	July to June	1.9	-1.5	0.5	2.0	-3.9	-2.5
		19/20	**20/21(e)**	**21/22(f)**	**22/23(f)**	**20/21(f)**	**21/22(f)**
India	April to March	4.2	-9.6	5.4	5.2	-16.5	-1.8

Note: (e)=estimate, (f)=forecast. For India, FY2020/21(e) runs from April 2020 through March 2021. June 2020 forecasts are from World Bank (2020a) and October 2019 forecasts are from World Bank South Asia Economic Focus Fall 2019. Pakistan is reported at factor cost. **Source:** World Bank

Conclusion

History is not a perfect predictor of the future (i.e., there is no such thing as a perfect forecast and there is no silver bullet)

Forecasts are more accurate for shorter time periods and getting degraded with the duration

An overestimate of long-term electricity load will result in substantial wasted investment on the construction of excess power facilities, while an underestimate of the future load will result in insufficient generation and inadequate demand

Long-term electricity load forecasting plays a vital role for utilities and planners in terms of grid development and expansion planning

The end-use modeling, econometric modeling, and their combinations are the most often used methods for medium- and long-term load forecasting.

Selected Publications in 2020

Impact Factor Journals (Combined Impact Factor Score = 135)
RESEARCH INTERESTS: CYBER PHYSICAL SYSTEMS, SMART GRIDS,
Tariq Research Group: PhD students: 5, PhD graduated: 4, MS students: 7

1. M. Tariq, F. Naeem, M. Ali, and H. V. Poor, "Vulnerability Assessment of 6G Enabled Smart Grids," accepted in IEEE Internet of Things Journal, Nov. 2020, IF 9.94

2. M. Ali, A. Jolfaei, and M. Tariq, "Fuzzy Controller based Early Detection and Prevention of Asymmetrical Faults in Smart Grids," in IEEE Transaction on Industry Applications, vol.-, pp.-, July 2020, IF= 3.488

3. M. Ali, M. Adnan, M. Tariq, and H. V. Poor, "Load Forecasting through Estimated Parameterized based Fuzzy Inference System in Smart Grids," accepted in IEEE Transactions on Fuzzy Systems, April, 2020, IF=9.518

4. M. Tariq, M. Adnan, G. Srivastava, and H. V. Poor, "Instability detection and prevention in smart grids under asymmetric faults," accepted in IEEE Transaction on Industry Applications, vol.-, pp.-, Feb. 2020, IF= 3.488

5. M. Adnan and M. Tariq*, "Cascading Overload Failure Analysis in Renewable Integrated Power Grids," in Elsevier Journal of Reliability Engineering and System Safety, vol.pp.- Jan. 2020, IF = 5.04 Q1

6 . F. Naeem, M. Tariq* and H. V. Poor, "SDN-enabled Energy-Efficient Routing Optimization Framework for Industrial Internet of Things," in IEEE Transactions on Industrial Informatics, DOI: 10.1109/TII.2020.3006885, June, 2020, IF = 9.112 Q1

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