CEYLON ELECTRICITY BOARD

Determination of Electricity Demand Forecast by combining Medium Term Time Trend and Long Term Econometric Modelling

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OUTLINE OF THE PRESENTATION

- **Introduction**
- **Methods of Electricity Demand Forecasting**
- **Methodology adopted for Electricity Demand Forecast 2018-2042**
- **Medium Term Time Trend Forecast 2017-2020**
- **Medium Term Time Trend Forecast comparison with Distribution Division Forecast**
- **Long Term Econometric Forecast 2021-2042**
  - Limitations/assumptions on Socio-Economic Variables
  - Regression equations of model
  - Forecast of significant variables
- **Combination of Medium Term Time Trend and Long Term Econometric Results**
- **Analysis of changes in demand profile**
- **Base Demand Forecast 2018-2042**

INTRODUCTION

- **Ceylon Electricity Board Act : Section 11 - 1**

  "It shall be the duty of the Ceylon Electricity Board to develop and maintain an efficient, coordinated and economical system of electricity supply in accordance with any appropriate license issued by the Public Utilities Commission of Sri Lanka (PUCSL)"

- **Policies and Guidelines for Electricity Demand Forecast**
  - National Energy Policy and Strategies of Sri Lanka in 2008
  - General Policy Guidelines on the Electricity Industry for the Public Utilities Commission of Sri Lanka (PUCSL) in 2009

- **Electricity Demand Forecast for Long Term Generation Expansion Plan (LTGEP) 2018-2037**
  - **Time Trend Modelling ⟹ Medium Term (Year 2017 to 2020)**
  - **Econometric Modelling ⟹ Long Term (Year 2021 to 2042)**

METHODS OF ELECTRICITY DEMAND FORECASTING

- **Time Trend Analysis**
  - Analysis of historical demand data and trends

- **Econometric Analysis**
  - Statistically quantify the relationship between the electricity demand and significant factors that affect the demand

- **End Use (Bottom Up) Approach**
  - Looking at individual users, their operating patterns, end used devices, efficiencies etc.

METHODOLOGY ADOPTED FOR ELECTRICITY DEMAND FORECAST 2018 - 2042

- **Combination of Time Trend modelling and Econometric approach for the preparation of 25 year electricity demand forecast**

Time Trend Modelling → Medium Term Forecast (Year 2017 to 2020)

Econometric Modelling → Long Term Forecast (Year 2021 to 2042)

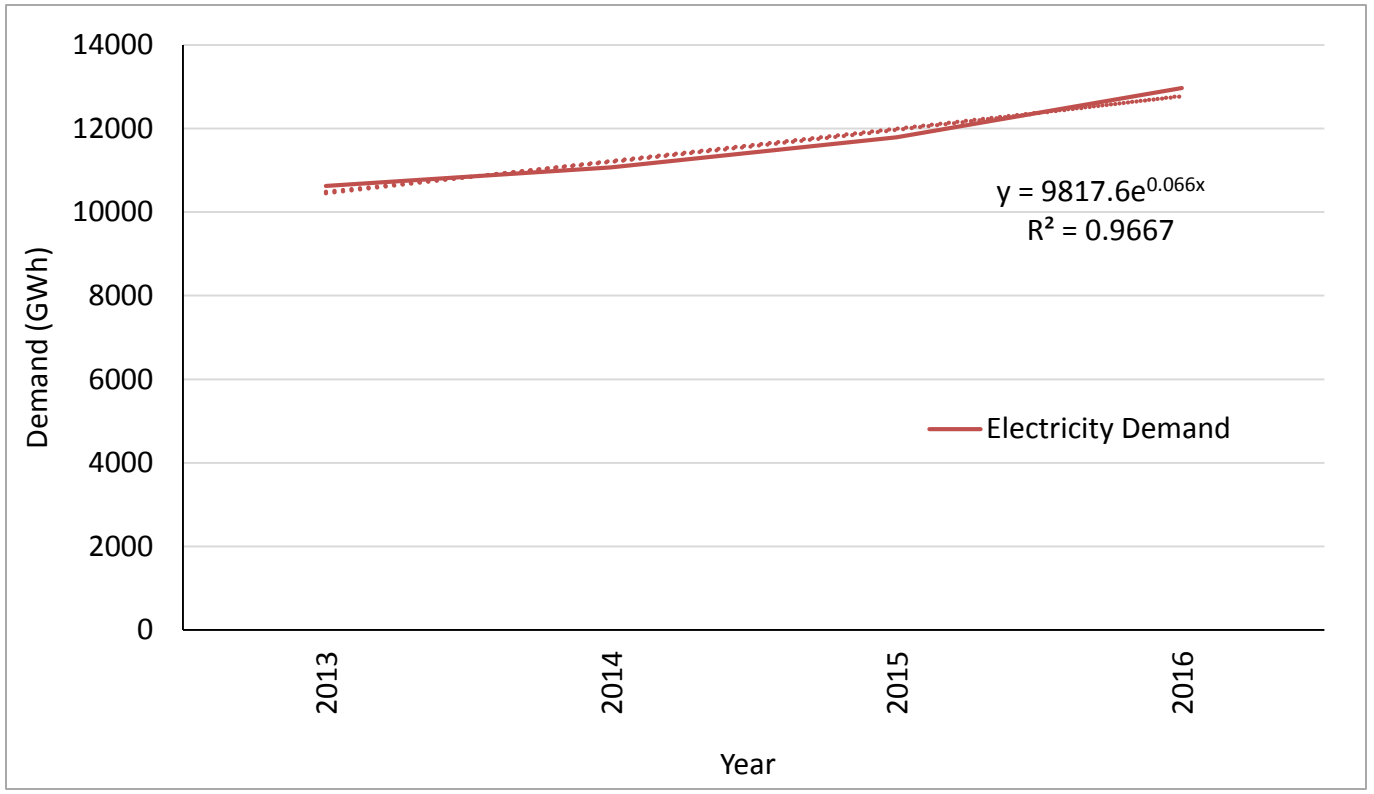
MEDIUM TERM TIME TREND FORECAST 2017 - 2020

MEDIUM TERM TIME TREND FORECAST

- Fit the best curve to the historical demand data (Last 4 years from 2013 to 2016) and assume that the future will follow that line
- Considered the coefficient of determination for the regression equation (R^2)
- Captures the **recent variations in the electricity demand with the present socio economic factors of the country**

MEDIUM TERM TIME TREND FORECAST

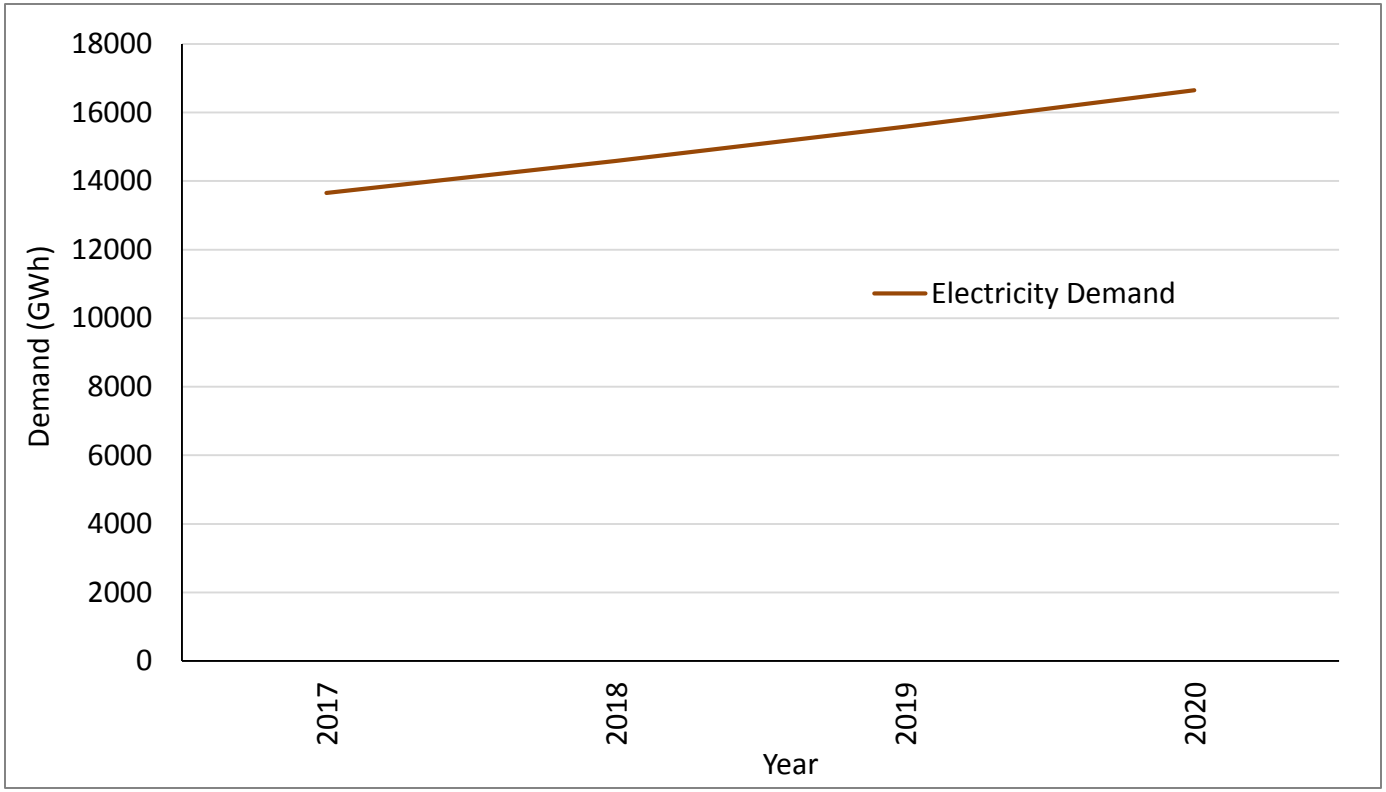
Determination of best fit curve



Coefficient of determination is 0.97 and exponential trend reflects the recent demand variation

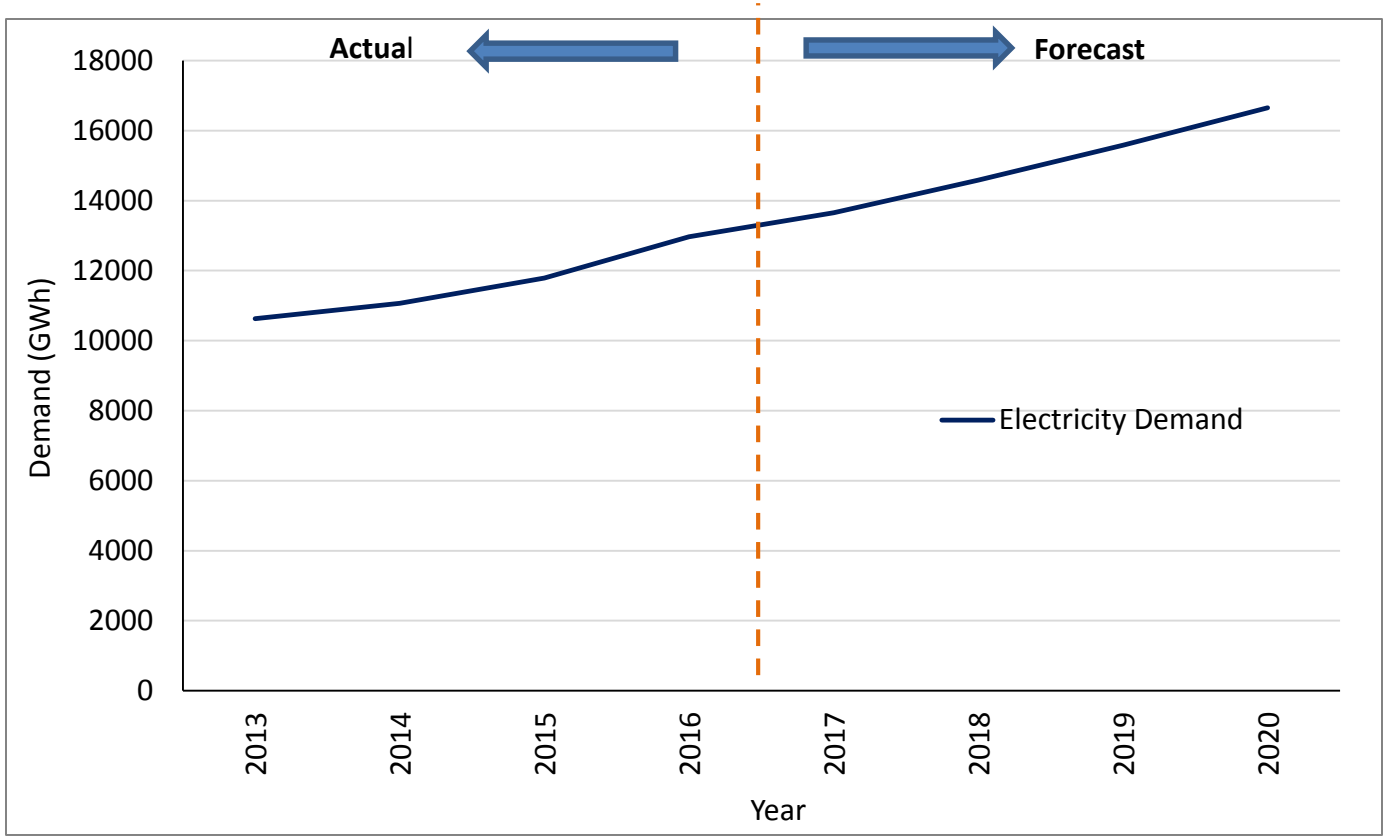
MEDIUM TERM TIME TREND FORECAST

Electricity Demand Forecast 2017-2020 from Time Trend Analysis



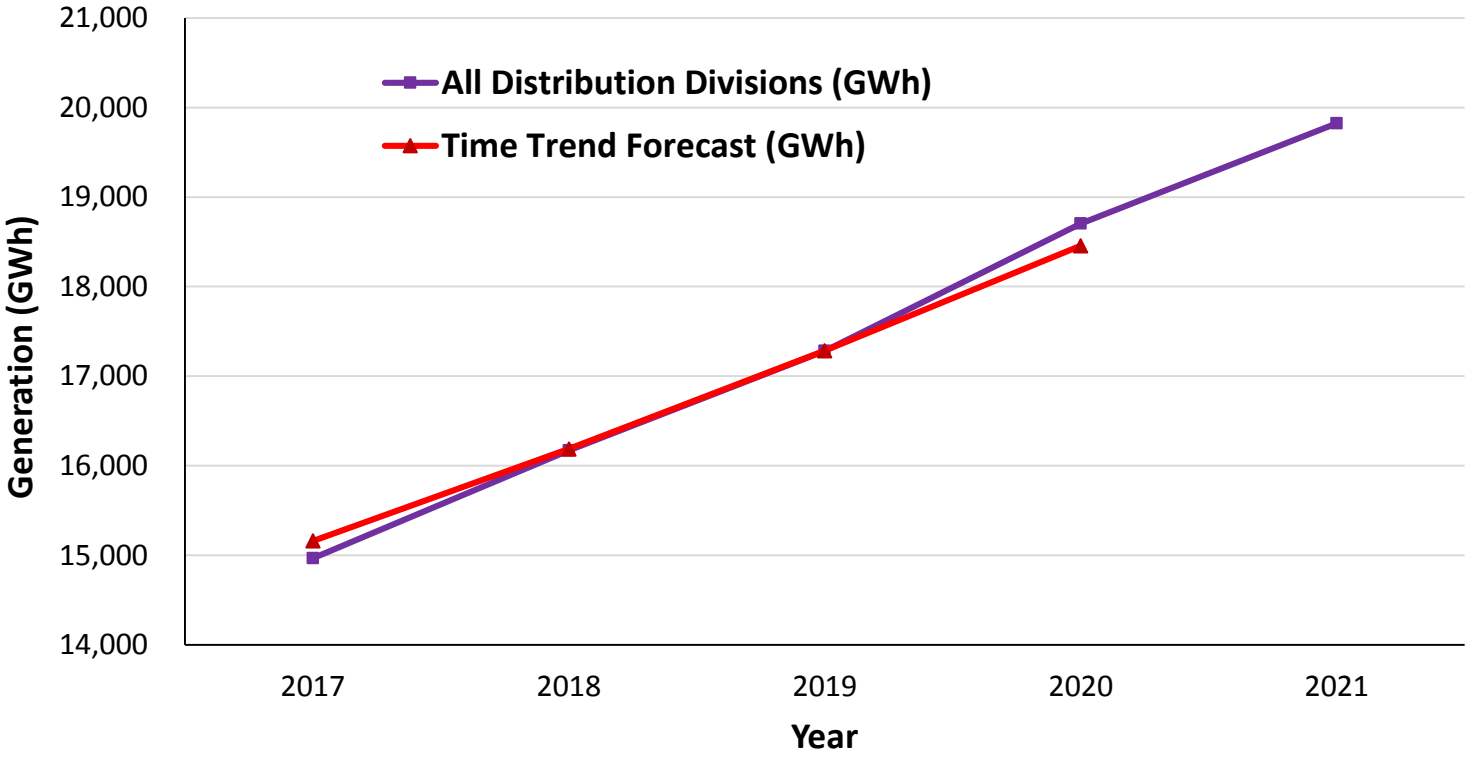
MEDIUM TERM TIME TREND FORECAST

- Average annual demand growth rate : 6.8%



MEDIUM TERM TIME TREND FORECAST COMPARISON WITH DISTRIBUTION DIVISION FORECAST

- Compared the immediate 5 year sales forecasts from CEB Distribution Divisions and LECO (Private Distribution Company) with Time Trend Forecast



MEDIUM TERM TIME TREND FORECAST COMPARISON WITH DISTRIBUTION DIVISION FORECAST

- Year 2020 shows the deviation between two forecasts due to;
  - Distribution divisions have considered full demand requirement of Megapolis Projects and Other new developments in Sri Lanka
  - Consideration of full demand (MW) and load factor (%) will result for **overestimated energy demand**

Average 6.8 % growth will be reasonable to represent medium term demand growth of Sri Lanka

LONG TERM ECONOMETRIC FORECAST 2021 - 2042

LONG TERM ECONOMETRIC FORECAST

- Statistical analysis of the relationship between the electricity demand and several factors which affect to the demand
- Consider sector wise electricity demand :
  - Domestic
  - Industrial
  - Commercial (General Purpose + Hotel + Government)
- Equation for Econometric model;

$$Yi = b_1 + b_2 X_{2i} + \ldots\ldots\ldots\ldots + b_{ki} X_{ki} + e_i$$

Where,

b_1 = Constant , Y_i = Dependent variable (Electricity Demand),

X_i = Independent variables, e_i = Error term

LONG TERM ECONOMETRIC FORECAST

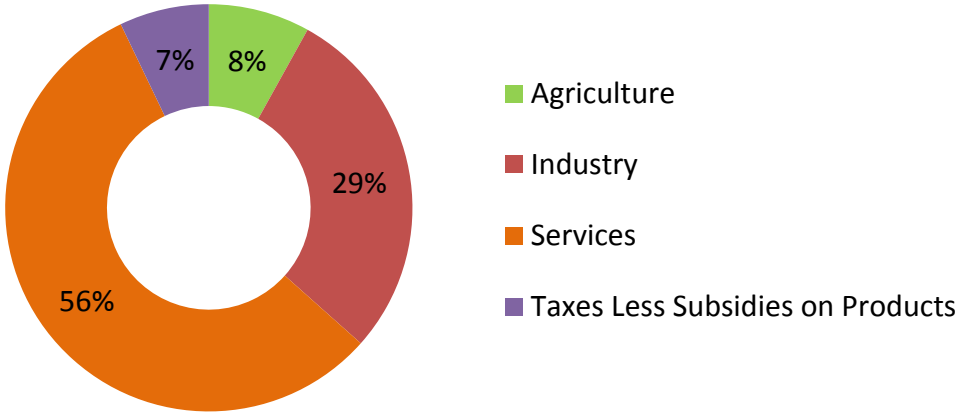
- Variables/factors considered for the econometric modelling:

Sector	Domestic	Industrial	Commercial
Variables	GDP	GDP	GDP
	GDP Per Capita	Previous Year GDP	Previous Year GDP
	Population	Population	Population
	Avg. Electricity Price	Avg. Electricity Price	Avg. Electricity Price
	Previous Year Demand	Previous Year Demand	Previous Year Demand
	Domestic Consumer Accounts	Agriculture Sector GDP	Agriculture Sector GDP
	Previous Year Dom. Consumer Accounts	Industrial Sector GDP	Industrial Sector GDP
		Service Sector GDP	Service Sector GDP

LONG TERM ECONOMETRIC FORECAST

Limitations/assumptions on Socio-Economic Variables

- **Consideration of Total GDP and Sector wise GDP as variables**
  - Total GDP is the combination of following main four sectors



  - Electricity consumption for the agriculture sector in Sri Lanka is very low and therefore the consideration of total GDP doesn't reflect the actual situation
  - Therefore, additionally considered the main two sectorial GDP for the analysis;
    - Industrial Sector GDP
    - Service Sector GDP

LONG TERM ECONOMETRIC FORECAST

- **Analysis of Industrial and Service Sector GDP with CEB Tariff categories**
  - Industrial and Service Sector GDP further analyzed to investigate the discrepancies between CEB tariff categories

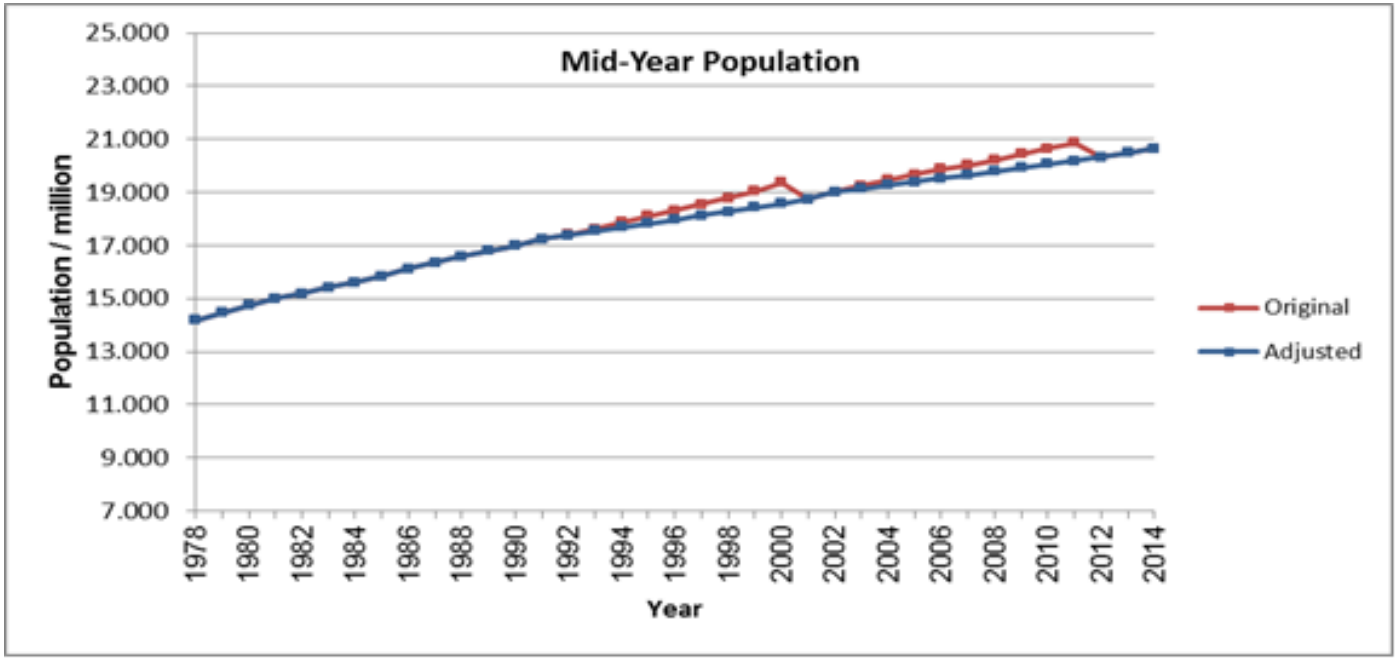
Industries	Mining and Quarrying
	Manufacture of Food, Beverages & Tobacco Products
	Manufacture of Textiles, Wearing Apparel and Leather Related Products
	Manufacture of Wood and of Products of Wood and Cork
	Manufacture of Paper Products, Printing and Reproduction of Media Products
	Manufacture of Coke and Refined Petroleum Products
	Manufacture of Chemical Products and Basic Pharmaceutical Products
	Manufacture of Rubber and Plastic Products
	Manufacture of Other Non- metallic Mineral Products
	Manufacture of Basic Metals and Fabricated Metal Products
	Manufacture of Machinery and Equipment
	Manufacture of Furniture
	Other Manufacturing, and Repair and Installation of Machinery and Equipment
	Electricity, Gas, Steam and Air Conditioning Supply
	Water Collection, Treatment and Supply
	Sewerage, Waste, Treatment and Disposal Activities
	Construction
Services	Wholesale and Retail Trade
	Transportation of Goods and Passengers including Warehousing
	Postal and Courier Activities
	Accommodation, Food and Beverage Service Activities
	Programming and Broadcasting Activities and Audio Video Productions
	Telecommunication
	IT Programming Consultancy and Related Activities
	Financial Service Activities and Auxiliary Financial Services
	Insurance, Reinsurance and Pension Funding
	Real Estate Activities, including Ownership of Dwelling
	Professional Services
	Public Administration and Defence; Compulsory Social Security
	Education
	Human Health Activities, Residential Care and Social Work Activities
	Other Personal Service Activities

In line with Industrial Tariff

In line with Commercial Tariff

LONG TERM ECONOMETRIC FORECAST

- **Past population variation in Sri Lanka**
  - Considered end year population and drop was observed in 2001 and 2011, where **actual census** was carried out
  - Analyzed and adjusted based on **avg. annual growth rate**



LONG TERM ECONOMETRIC FORECAST

- Derive the Regression equations for each sector using SPSS (Statistical Package for Social Science) software

- Considered statistical tests;
  - T statistic
  - Durbin Watson test
  - Coefficient of determination (R^2)
  - F value

LONG TERM ECONOMETRIC FORECAST

Regression equations with most significant variables

Domestic Sector

Ddom (t) I = 203.55 + 1.36 GDPPC (t) i + 0.71 CAdom (t-1)

Where,

Ddom (t) - Electricity demand in domestic consumer category (GWh)

GDPPC (t)- Gross Domestic Product Per Capita (’000s LKR)

CAdom (t-1)- Domestic Consumer Accounts in previous year (in ’000s)

Industrial Sector

Di (t) i = 11.35 + 0.29 GDPi (t) i + 0.87 Di (t-1)

Where,

Di (t) -Electricity demand in Industrial consumer categories (GWh)

GDPi -Industrial Sector Gross Domestic Product (in ’000 LKR)

Di (t-1) - Previous year Electricity demand in Industrial consumer category (GWh)

LONG TERM ECONOMETRIC FORECAST

Regression equations with most significant variables

Commercial Sector (General Purpose, Hotel & Government)

$$Dcom(t)\,i = -104.41 + 0.16\,GDPser(t)\,i + 0.83\,Dcom(t-1)$$

Where,

Dcom (t) - Electricity demand in Commercial consumer categories (GWh)

GDPser - Service Sector Gross Domestic Product (in '000 LKR)

Dcom (t-1)- Previous year Electricity demand in Commercial consumer category (GWh)

Religious purpose and Street Lighting were considered in the 'Other Sector'. This category was analysed without any links to social or demographic variables due to the diverse nature of the consumers included in this category, . Hence, the time-trend analysis was performed to predict the demand in this sector.

$$\ln(Dos(t)) = -103.30 + 0.055\,t$$

Where,

t - Year

LONG TERM ECONOMETRIC FORECAST

Forecast of significant variables

- **GDP Growth Rate**
  - GDP growth rate projection based on the Annual Reports of Central Bank of Sri Lanka (CBSL) and discussions had with them
  - Higher growth up to 7.5% and saturate in 5% beyond 2032

Year	Source	GDP Growth Projection (%)
2016	Annual Report 2015, Central Bank of Sri Lanka	5.8
2017		6.3
2018		7.0
2019		7.0
2020-2024	Assumptions	7.5
2025-2026		7.0
2027-2029		6.5
2030		6.0
2031		5.5
2032-2042		5.0

LONG TERM ECONOMETRIC FORECAST

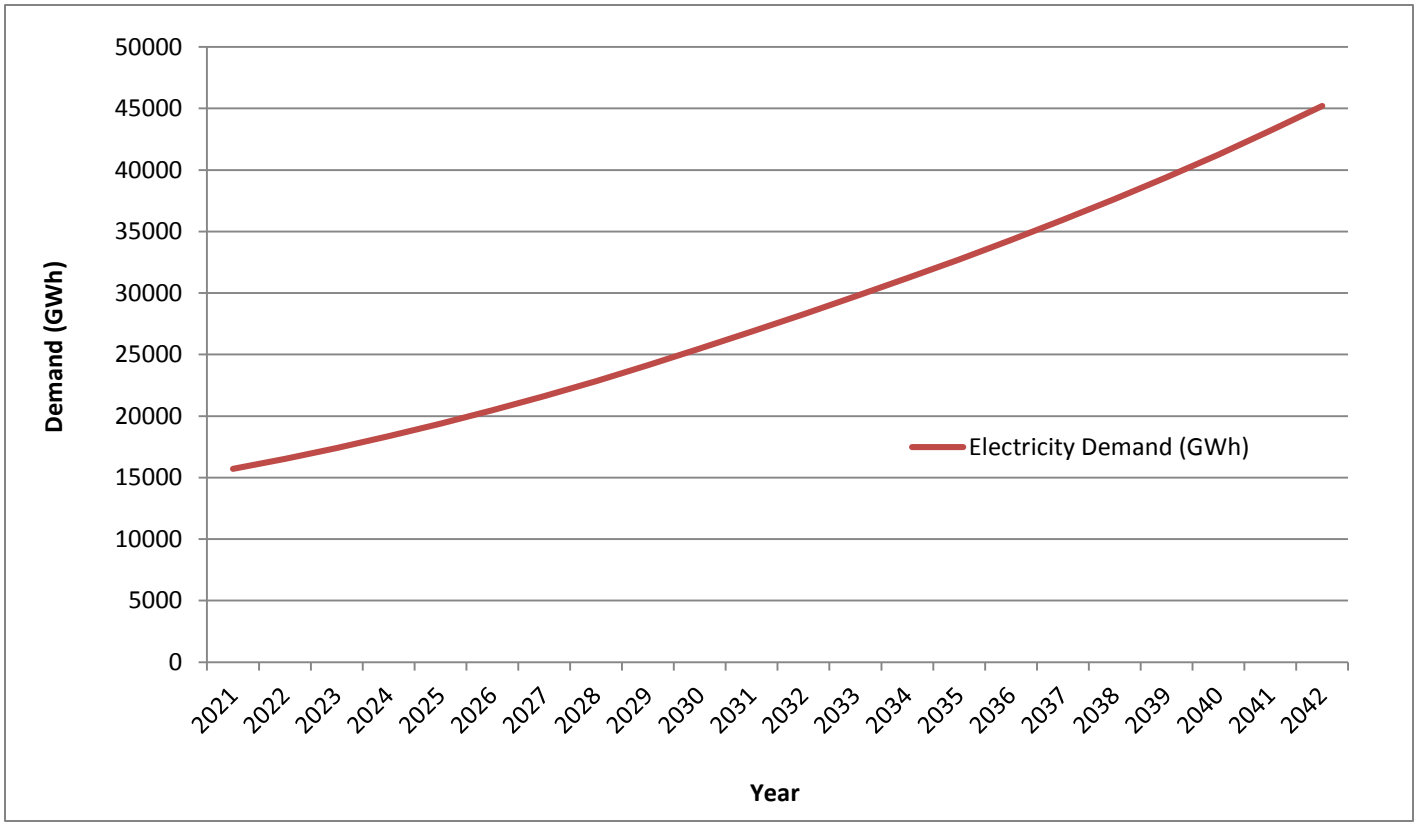
Forecast of significant variables

- **GDP Structure Change and Sector wise GDP**
  - change in the GDP sector percentage was considered by assuming **Industrial sector development inline with proposed government developments** by compensating the Service and Agriculture sectors throughout the forecasting period

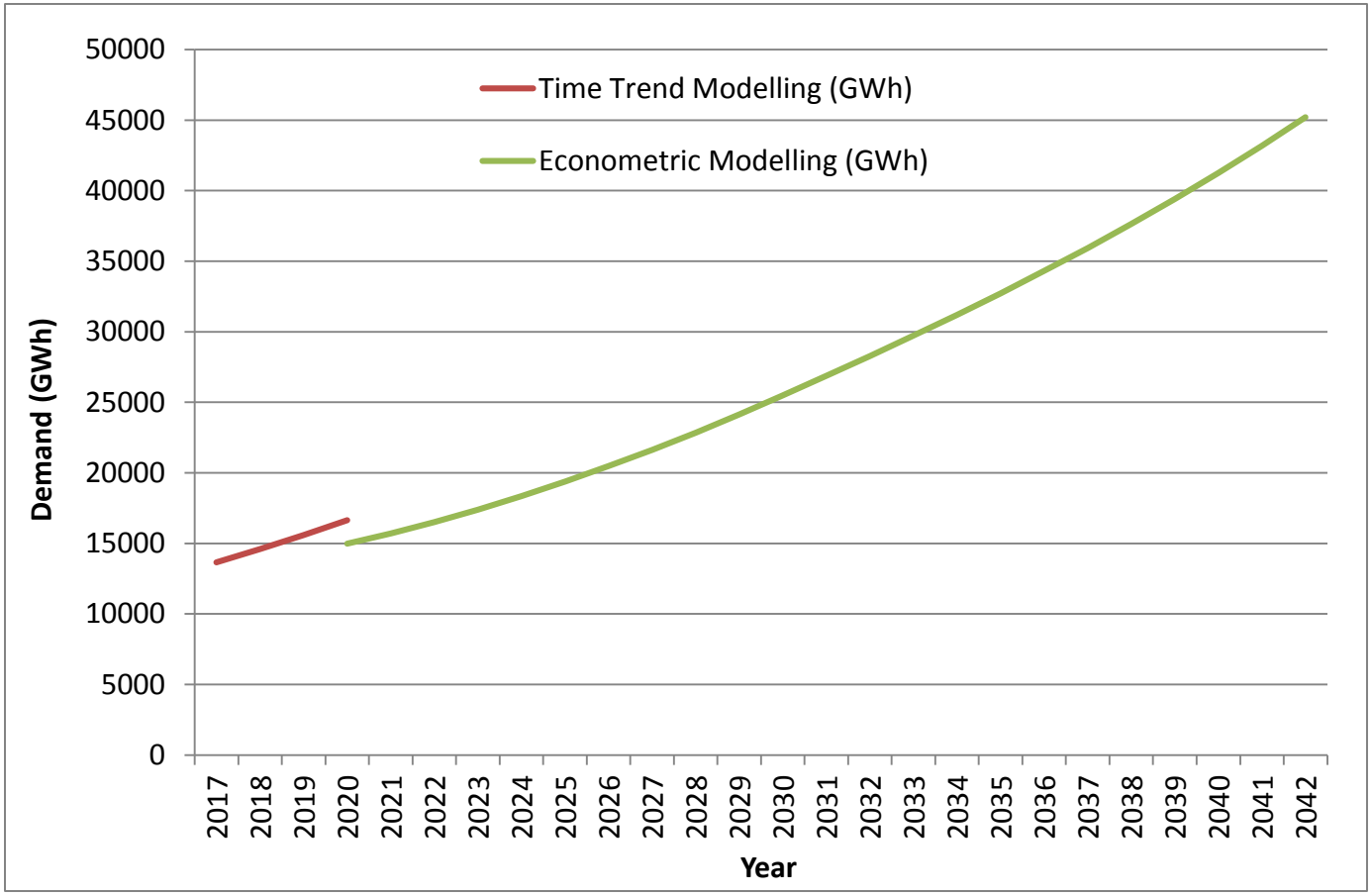
Year	Industries	Services	Agriculture, Forestry & Fishing
2016	26.3%	56.6%	7.8%
2020	26.8%	56.5%	7.5%
2025	27.1%	56.3%	7.3%
2030	27.5%	56.2%	7.0%
2035	28.0%	56.1%	6.6%

LONG TERM ECONOMETRIC FORECAST

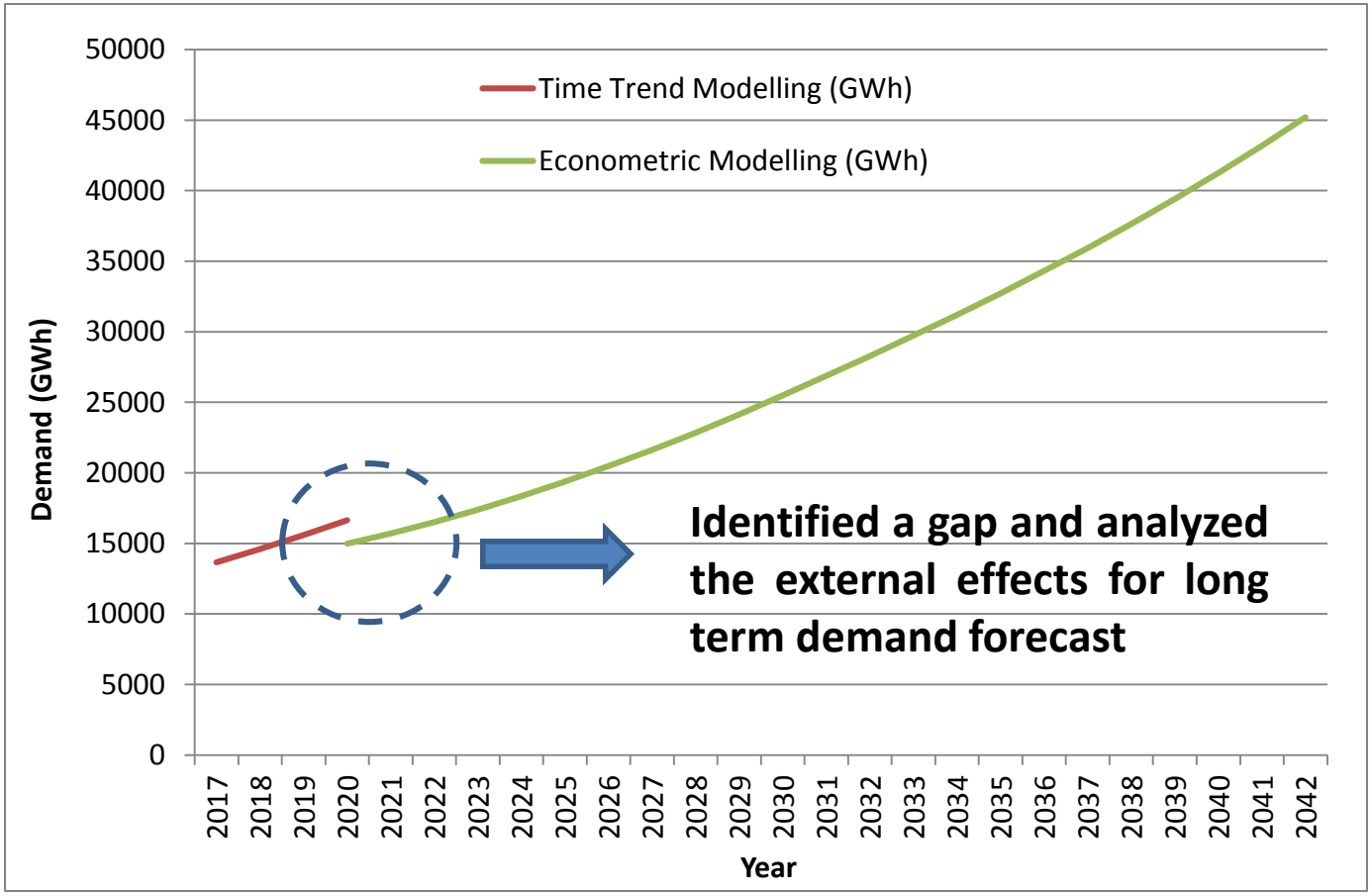
Electricity Demand Forecast 2021-2042 from Econometric Approach



COMBINATION OF MEDIUM TERM TIME TREND AND LONG TERM ECONOMETRIC RESULTS



COMBINATION OF MEDIUM TERM TIME TREND AND LONG TERM ECONOMETRIC RESULTS

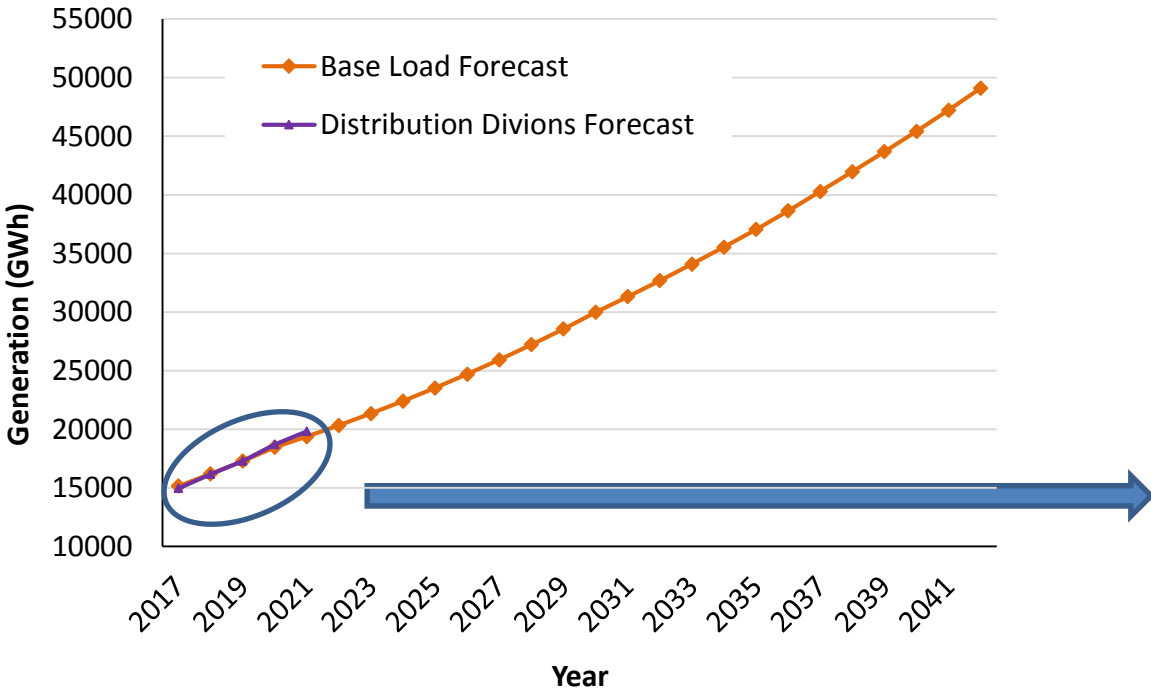


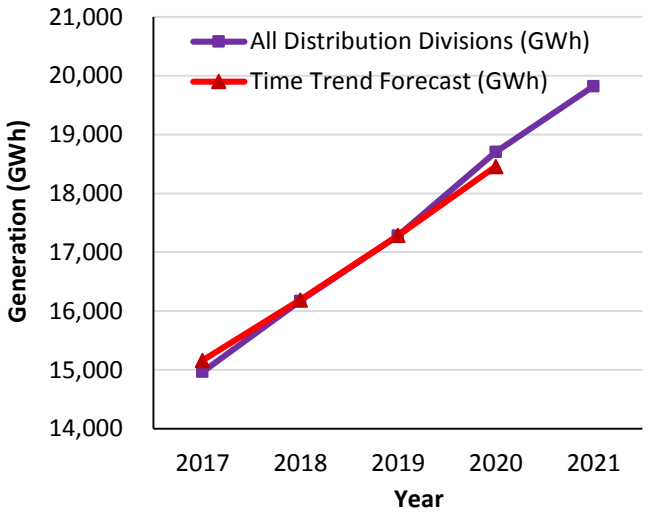
BASE LOAD FORECAST

Base Load Forecast = Time Trend Forecast +

(Econometric Forecast + External Effects)

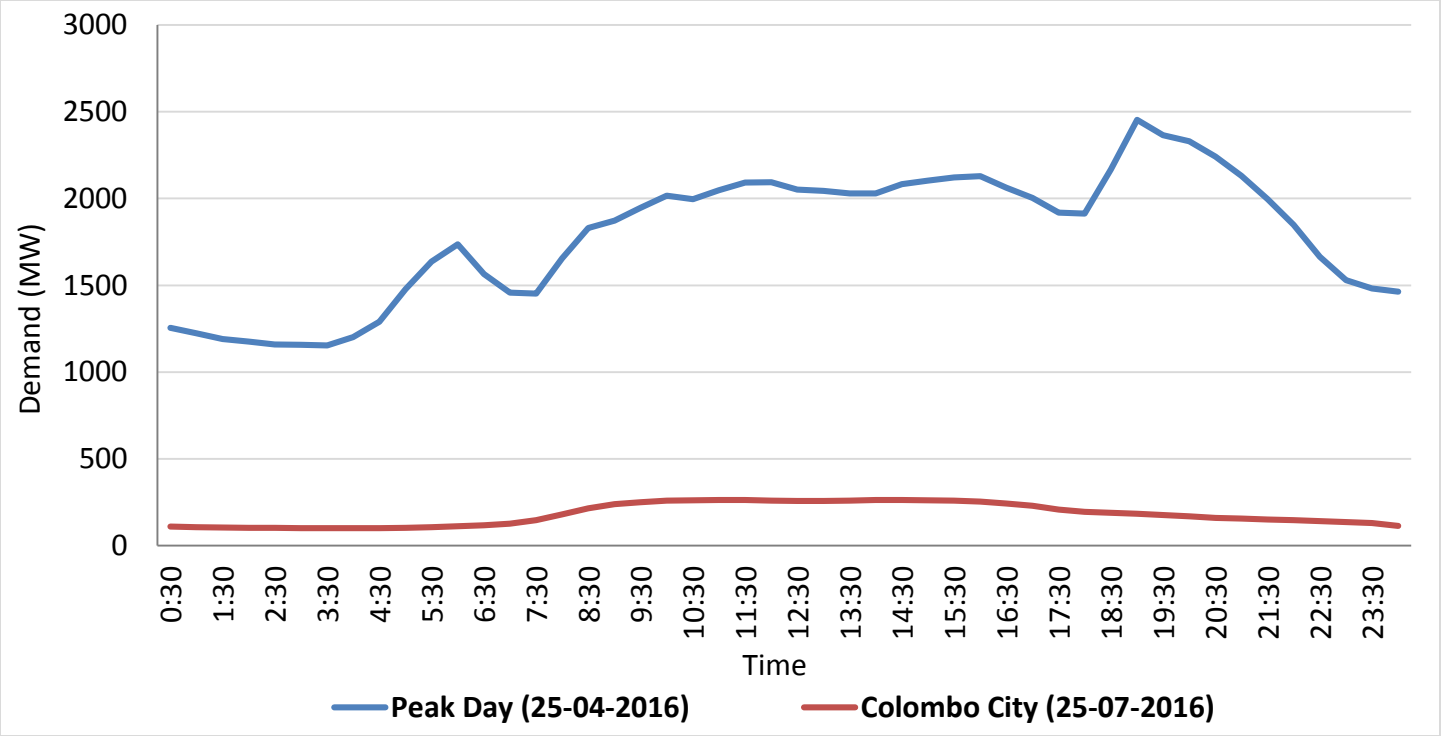
External effects on long term demand forecast were analyzed and considered.





ANALYSIS OF CHANGES IN DEMAND PROFILE

Present Daily Demand Profile Shape

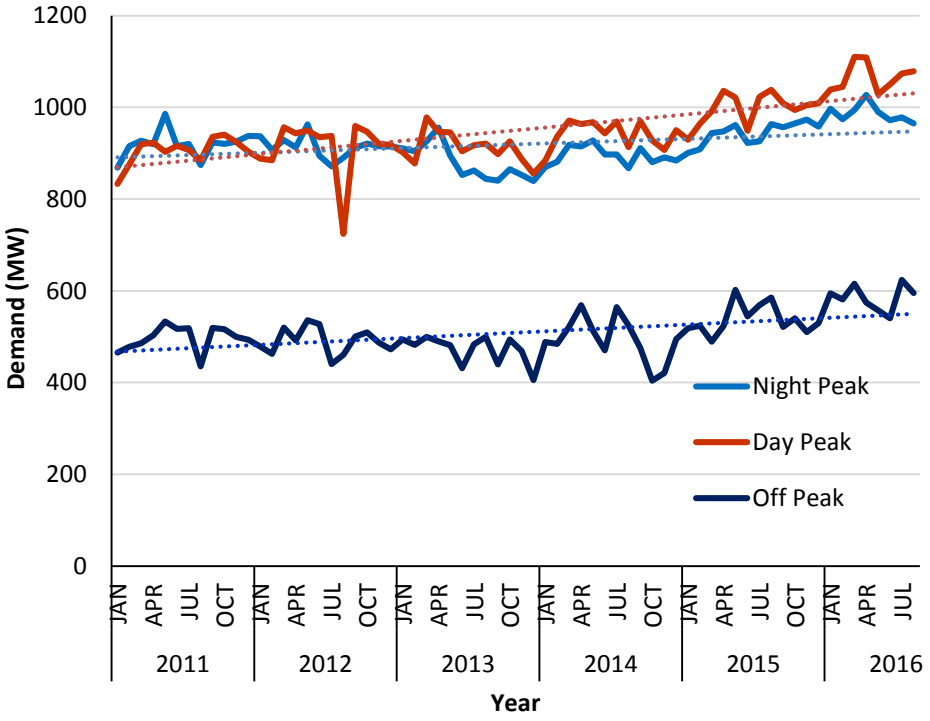


- Overall country demand profile with night peak dominant
- Colombo city (Capital of Sri Lanka) demand profile with day peak dominant

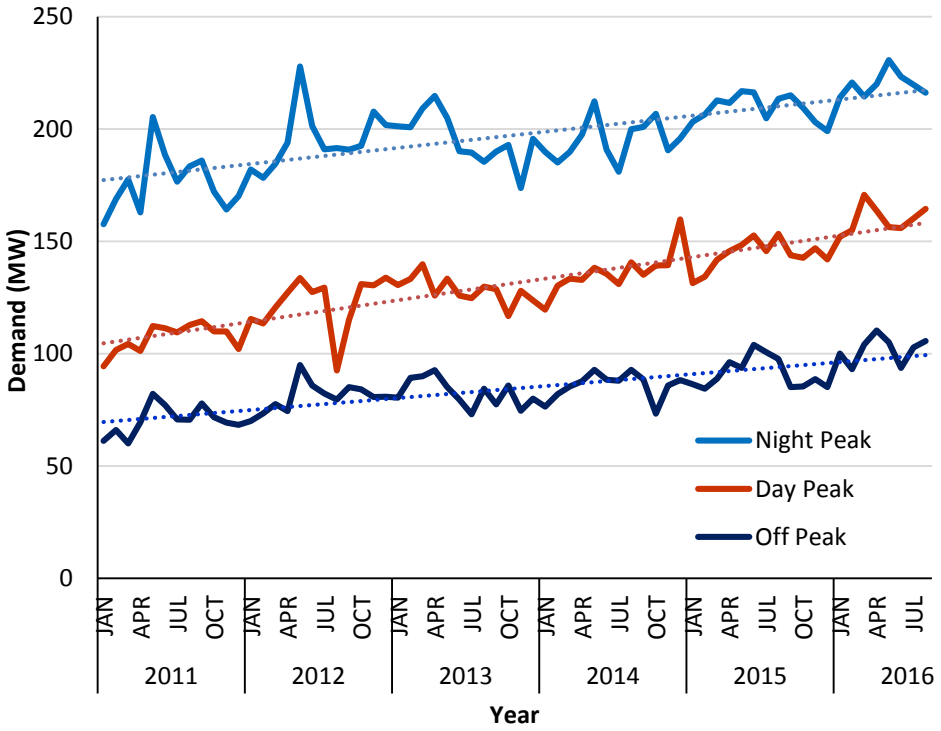
ANALYSIS OF CHANGES IN DEMAND PROFILE

Provincial Analysis – Night Peak, Day Peak & Off Peak

Western Province



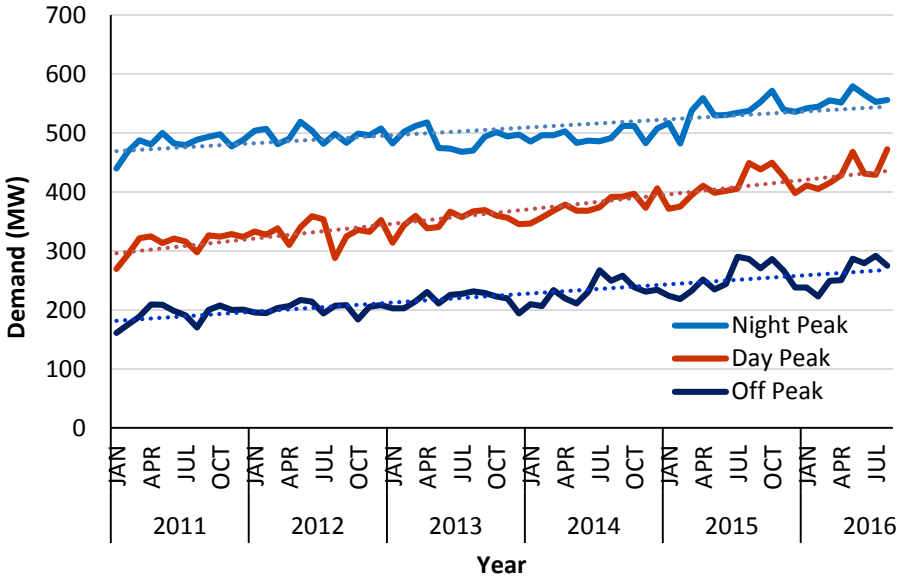
Southern Province



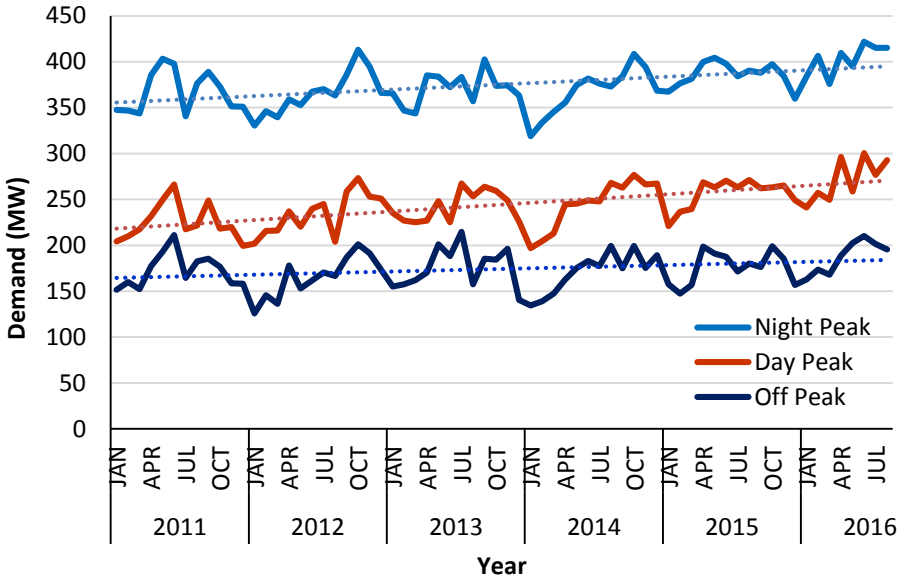
ANALYSIS OF CHANGES IN DEMAND PROFILE

CEYLON ELECTRICITY BOARD Enrich Life through Power

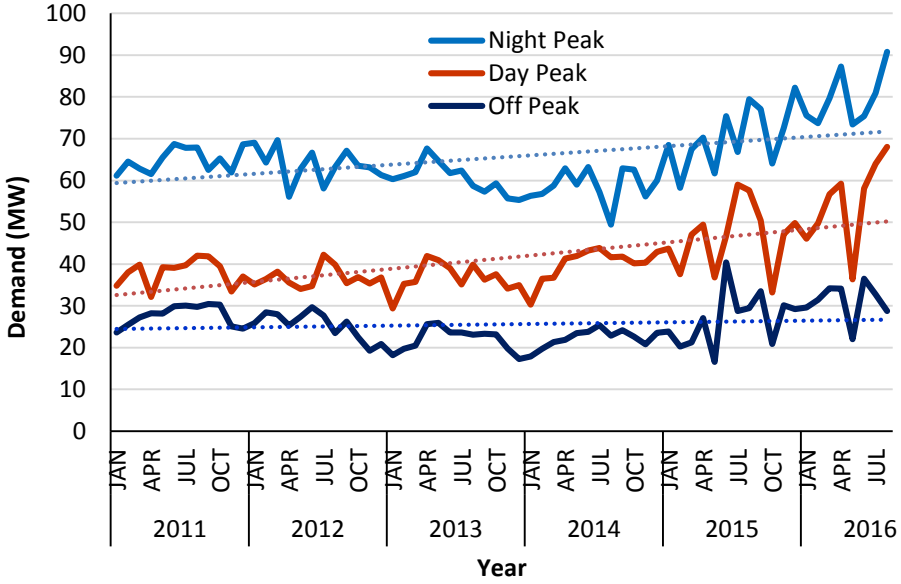
North-Central/North-Western/Central Provinces



Sabaragamuwa/Uva/Eastern Provinces



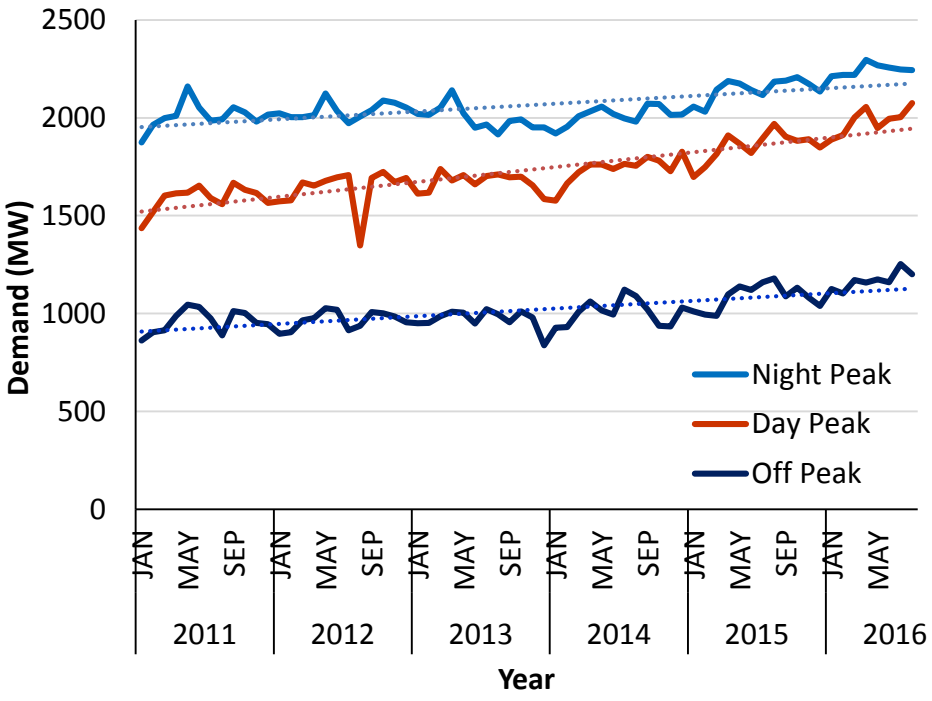
Northern Province



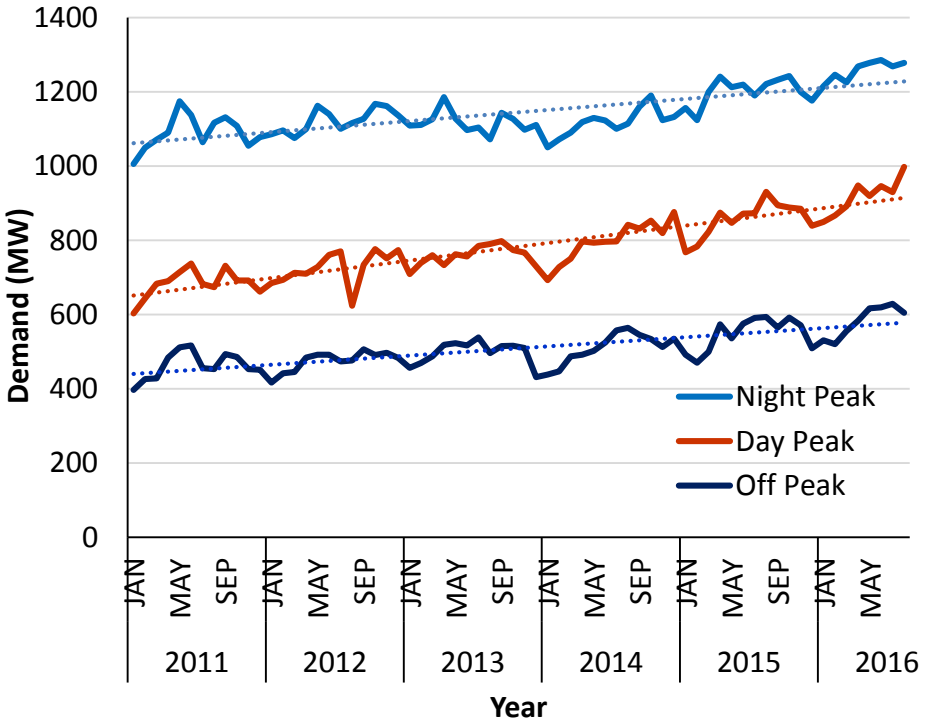
ANALYSIS OF CHANGES IN DEMAND PROFILE

Overall Country Representation – Night Peak, Day Peak & Off Peak

With Western Province

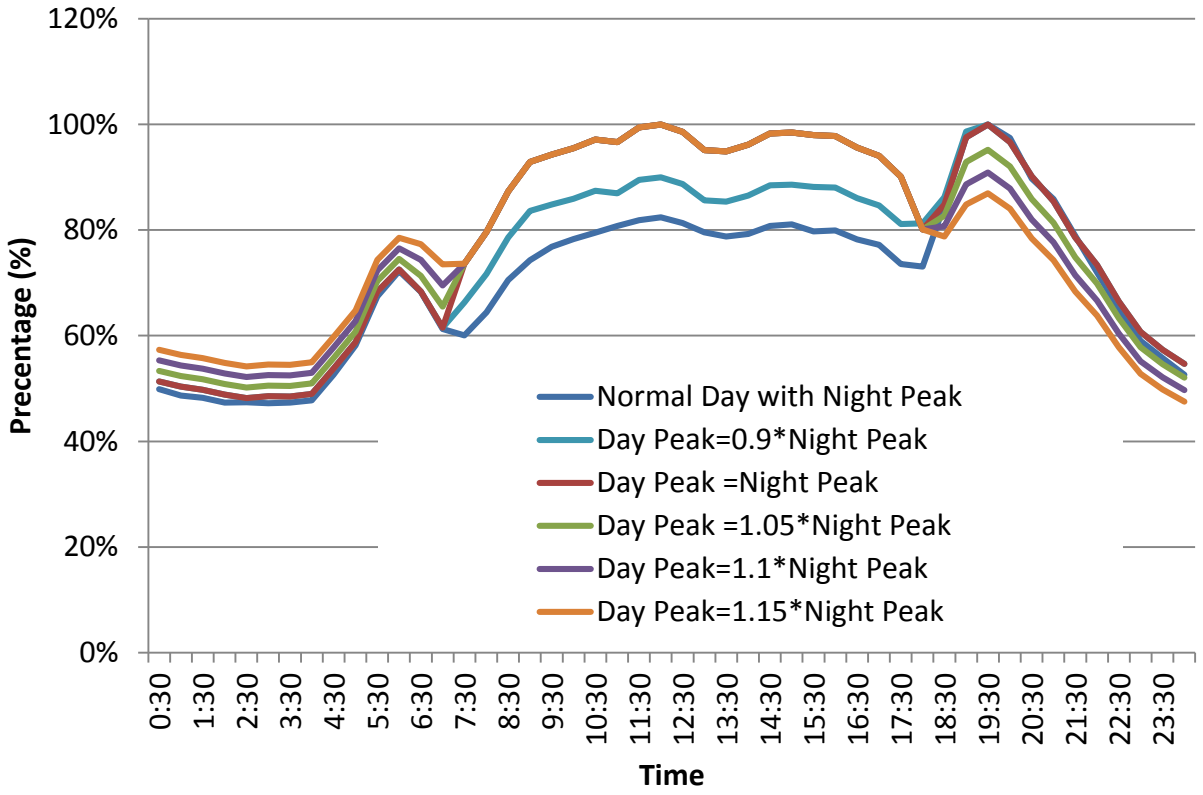


Without Western Province



ANALYSIS OF CHANGES IN DEMAND PROFILE

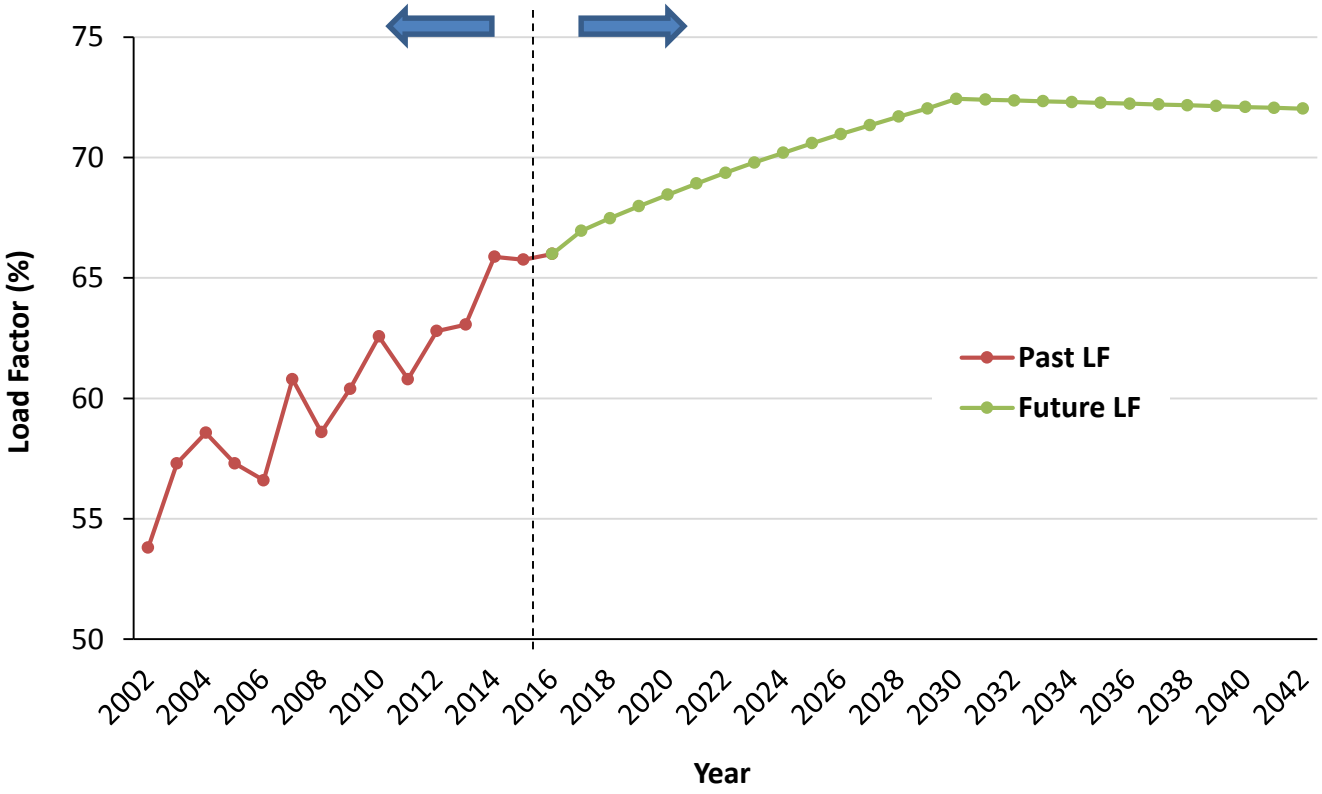
Future Projected Daily Load Profile



- Change in the load profile shape (Night peak → Day Peak) assumed in year 2030.
  - Higher energy demand in day time

ANALYSIS OF CHANGES IN DEMAND PROFILE

System Load Factor Forecast for Peak Determination



- Increasing trend of system load factor and 72.5% maximum by 2030
- Further improvements can be achieved with DSM measures

BASE DEMAND FORECAST 2018-2042

CEYLON ELECTRICITY BOARD Enrich Life through Power

Year	Demand (GWh)	Net Loss* (%)	Net Generation (GWh)	Peak Demand (MW)
2017	13656	9.92	15160	2585
2018	14588	9.88	16188	2738
2019	15583	9.84	17285	2903
2020	16646	9.81	18456	3077
2021	17478	9.77	19370	3208
2022	18353	9.73	20331	3346
2023	19273	9.69	21342	3491
2024	20242	9.65	22404	3643
2025	21260	9.61	23522	3804
2026	22332	9.58	24697	3972
2027	23459	9.54	25933	4149
2028	24639	9.50	27225	4335
2029	25867	9.46	28570	4527
2030**	27164	9.42	29990	4726
2031	28388	9.38	31328	4939
2032	29637	9.35	32692	5157
2033	30926	9.31	34099	5381
2034	32251	9.27	35546	5612
2035	33642	9.23	37063	5854
2036	35090	9.19	38642	6107
2037	36613	9.15	40302	6372
2038	38165	9.12	41992	6642
2039	39733	9.08	43699	6915
2040	41324	9.04	45431	7193
2041	42967	9.02	47227	7481
2042	44700	9.00	49121	7784
5 Year Average Growth (2018-2022)	**5.9%**		**5.9%**	**5.1%**
10 Year Average Growth (2018-2027)	**5.4%**		**5.4%**	**4.7%**
20 Year Average Growth (2018-2037)	**5.0%**		**4.9%**	**4.5%**
25 Year Average Growth (2018-2042)	**4.8%**		**4.7%**	**4.4%**

***** Net losses include losses at the Transmission & Distribution levels and any non-technical losses, Generation (Including auxiliary consumption) losses are excluded. This forecast will vary depend on the hydro thermal generation mix of the future.

** It is expected that day peak would surpass the night peak from this year onwards

THANK YOU

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