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**DEVELOPMENT OF AN ASSESSMENT CRITERIA FOR  
MAXIMUM ELECTRICAL DEMAND FOR BUILDINGS  
IN SRI LANKA**

"Development of an assessment criteria for maximum electrical  
demand in Sri Lanka" MSc report

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## **ABSTRACT**

This thesis describes an investigation into the maximum electrical demands of commercial and Residential buildings to compare and optimize the design stage electrical demand estimations. Consequently, optimize the main system and equipment capacities and thereby reduce the financial and space inefficiencies related to commercial and residential buildings.

This will bring direct benefits to the clients as well as to the country as a whole, to reduce the total project expenditure without sacrificing the performance and / or functionality of the building. Identifying the main reasons behind the oversizing of electrical equipment will be investigated in detail so that while in the design phase these factors can be accommodated to accurately forecast the real-life building power requirements.

Number of International documents have been developed with these considerations. However, it has been noted in the industry that in local context (i.e. local projects), there are deviations between the forecasted and actual results. Hence, as part of this review, a comprehensive review of these international documentation has been done.

The results of this review would serve as a useful reference, as an assessment criteria for MEP consultants to provide a much more optimized overall electrical design.

**Keywords:** Assessment Criteria, Electrical Maximum Demand, Commercial Buildings, Peak Demand, Residential Buildings

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## LIST OF NOMENCLATURE

<b>Abbreviation</b>	<b>Description</b>
AC	Air Conditioning
ASHRAE	American Society of Heating, Refrigerating & Air-Conditioning Engineers
AS/NZS	Australia and New Zealand Standards
BMS	Building Management System
BS	British Standard
BSRIA	Building Services Research and Information Association
CEB	Ceylon Electricity Board
CIBSE	Chartered Institution of Building Services Engineers
EMS	Energy Management System
HVAC	Heating, Ventilating and Air Conditioning
IEC	International Electro-technical Commission
LV	Low Voltage
MEP	Mechanical Electrical Plumbing
MRB	Multi-apartment Residential Buildings
MV	Medium Voltage
NEPRA	National Electric Power Regulatory Authority
PUCSL	Public Utilities Commission of Sri Lanka
SLS	Sri Lanka Standards

### 1. INTRODUCTION

#### 1.1 Introduction/ Background

In Sri Lanka, the demand for electricity in buildings has been increasing rapidly due to population growth and urbanization, which can lead to a shortage of electricity supply and interruptions in power supply. Therefore, it is necessary to have a comprehensive assessment of the maximum electrical demand for buildings to ensure that the electrical infrastructure can support the growing demand. However, while working as an Electrical / MEP engineer at a MEP Design consultancy firm, the engineers sometimes receive criticism for oversizing MEP equipment and systems. Most of the criticism is received prior to project completion, and there is no direct way of addressing the criticism and no good basis for the criticism.

The design criteria used to design MEP systems in Sri Lanka is more or less the same for all companies/consultants. However, for the local context, there are no guidelines set indicating acceptable values for maximum electrical demand. Therefore, it is essential to develop an assessment criteria for maximum electrical demand for buildings in Sri Lanka. The assessment criteria will take into account the different building types, sizes, and functions, as well as the climate conditions of different regions in Sri Lanka. The research will also consider the existing codes, standards, and regulations related to electrical demand in buildings and the availability of energy-efficient technologies.

The findings of this research will provide a useful tool for building designers, engineers, and policy makers to accurately estimate the maximum electrical demand for buildings and design electrical systems that can meet the demand. The research will also contribute to the development of sustainable and energy-efficient buildings that can reduce the overall energy consumption and carbon emissions in Sri Lanka. This research will be beneficial to the sustainable development of Sri Lanka and can have a significant impact on the energy security of the country.

## **1.2 Introduction to chapters**

In the design stage of MEP systems for buildings, various standards, guides, handbooks, calculations, simulations, and models are used to predict values for maximum electrical demand. However, these resources are often not developed for the local context in Sri Lanka. As a result, there is a growing disparity between predicted and actual building performance in terms of maximum electrical demand, with many buildings performing considerably less than predicted. Several factors can contribute to this disparity, including the unique climate conditions in Sri Lanka, building usage patterns, and equipment efficiency.

This research aims to compare the design and real-life performance of major MEP equipment in commercial and residential buildings in Sri Lanka. By analyzing data from existing projects, the research will develop guidelines to determine acceptable ranges of maximum electrical demand for different building categories, including hotels, residential buildings, offices, and retail spaces. The research will primarily focus on energy consumption and efficiency of MEP equipment, including lighting, air conditioning, ventilation, and electrical equipment.

The research methodology will involve collecting data from completed MEP projects in Sri Lanka and analyzing the data to determine the actual energy consumption of the major MEP equipment in the buildings. The data will be compared to the predicted values obtained during the design stage, and any differences will be analyzed to determine the factors contributing to the disparities. The analysis will also consider the impact of climate conditions, building usage patterns, and equipment efficiency on energy consumption and demand.

The findings of this research will provide valuable insights into the performance of systems in Sri Lankan buildings and will help identify the factors that contribute to demand. The research will also lead to the development of guidelines for determining acceptable ranges of maximum electrical demand for different building categories. These guidelines will be useful for building designers, engineers, and policy makers in Sri Lanka to design more energy-efficient buildings and to ensure that the electrical infrastructure can support the growing demand.

The research will also contribute to the development of sustainable and energy-efficient buildings in Sri Lanka, reducing the overall energy consumption and carbon emissions of the country. Additionally, the research will help to address the criticism

of oversizing MEP equipment and systems and ensure that buildings are designed based on the actual energy consumption and demand. By improving the accuracy of predictions for maximum electrical demand, the research will help to reduce the risk of power shortages and interruptions in power supply, contributing to the energy security of Sri Lanka.

Overall, this research will be crucial in the sustainable development of Sri Lanka, and its impact will be significant for the energy security and the reduction of energy consumption and carbon emissions in the country.

### **1.3 Aim**

The primary aim of this research is to minimize the disparities between predicted and actual performance of buildings in terms of maximum electrical demand. By achieving a more accurate MEP system and equipment sizing during the design stage, the research will bring financial benefits to the project, better space utilization, and minimize future problems. Accurate sizing of MEP systems and equipment will lead to reduced energy consumption, and therefore lower operating costs for building owners and tenants. This, in turn, will make buildings more attractive to potential tenants, leading to increased rental income and improved financial returns for building owners. Accurate sizing of MEP systems and equipment will also help in optimizing space utilization, as equipment can be designed to take up less space, freeing up more space for other uses. Additionally, accurate sizing will help in minimizing future problems, such as equipment failures or breakdowns, which can be costly and disruptive to building operations.

### **1.4 Objective**

The main objective of this research is to evaluate the differences between the real maximum demand and the calculated maximum electrical demand of different building user categories, which include hotels, residential buildings, offices, and retail spaces. To achieve this objective, the research will be conducted in three stages:

- 1) Firstly, a critical evaluation of commonly used standards and guides in the Sri Lankan context will be conducted. This will involve an in-depth review of international standards and guides, such as IEC standards, Schneider Guide,

BSRIA Thumb rules, and local guidelines and regulations to determine the suitability of these standards and guides for use in Sri Lanka.

- 2) Secondly, a comparison will be made between the calculated and actual maximum electrical demands of selected buildings in Sri Lanka. This will involve measuring the actual maximum electrical demand of the selected buildings and comparing it with the calculated maximum electrical demand, as per the standards and guides evaluated in the first stage. The selected buildings will include those from the different user categories of hotels, residential buildings, offices, and retail spaces.
- 3) Finally, based on the findings of the first and second stages, a list of average values for maximum electrical demand for commercial and residential buildings in Sri Lanka will be developed. This list of average values, or criteria, will be based on the actual maximum electrical demand of the selected buildings, and will serve as a guideline for engineers and designers to use during the MEP system and equipment sizing stage.

The ultimate goal of this research is to provide engineers and designers with a more accurate guideline for MEP system and equipment sizing, which will lead to more sustainable, energy-efficient, and cost-effective buildings in Sri Lanka. By achieving this goal, the research will contribute to the overall development of the construction industry in Sri Lanka, and lead to more efficient use of resources in the building sector.

## **1.5 Research Gap**

The literature review has identified several research gaps related to the topic of developing assessment criteria for maximum electrical demand for buildings in Sri Lanka. One major gap is the disparity in maximum electrical demand values suggested by different sources of literature. The lack of consistency in these values can lead to confusion and difficulty in determining the correct sizing of MEP systems and equipment.

Another significant gap is the difference between real loads in projects and calculated values. This can lead to MEP systems being oversized, resulting in financial losses due to higher costs or inadequate performance.

Additionally, it was found that the existing standards, guides, and handbooks are not developed for the specific context of Sri Lanka. This presents a challenge for MEP

engineers and consultants who are tasked with designing and sizing MEP systems and equipment for buildings in Sri Lanka.

Finally, the research gap of different consultants designing using different methods and references, without a consistent approach, further worsens the challenge of accurately assessing maximum electrical demand for buildings. Overall, these gaps highlight the need for a comprehensive and localized set of assessment criteria to guide MEP engineers and consultants in the accurate sizing of MEP systems and equipment for buildings in Sri Lanka.

## **1.6 Methodology**

The methodology of this research is centered on collecting data and analyzing it to develop a Guideline for determining acceptable ranges of Maximum Electrical Demand for Sri Lankan buildings. The following steps will be taken to achieve this goal:

1. **Selection of Projects:** The first step is to select suitable projects for the benchmarking exercise. This study will cover the following building types: Hotel, Residential, Office, and Retail. Three (3) projects from each building type will be selected for the study. The projects should be in different locations across the country, to ensure that the data collected is representative of Sri Lanka as a whole.
2. **Obtaining Real Maximum Electrical Demand:** The real maximum electrical demand of the selected projects will be obtained from the project reports or directly from the clients. These will be collected for the past three (3) years each month. In some cases, it may not be readily available. In such cases, an estimated predicted maximum demand will be calculated based on the capacities of the main equipment such as transformers, generators, and main panels. For more detailed analysis, a high-level design calculation will be conducted to estimate the predicted maximum demand.
3. **Calculating Peak Electrical Demand:** The peak electrical demand for the selected projects will be calculated using Regression analysis. A critical evaluation of the main factors affecting the Peak electrical demand will be done. Two (2) main factors identified will be used to perform Regression analysis based on the collected data.

4. Comparison of Calculated and Real Maximum Electrical Demands: The calculated maximum electrical demand will be compared with the real maximum electrical demand for the selected projects. The aim is to identify any patterns or trends in the data and determine the degree of deviation between the predicted and actual values. This difference will be indicated as a safety factor that can be reduced to optimize the design.
5. Developing Assessment Criteria for Maximum Electrical Demand: The final step is to develop a Guideline to determine acceptable ranges of Maximum Electrical Demand for Sri Lankan buildings. This will be based on the data collected and the interpretation of that data. The Guideline will serve as a benchmark for future projects, and it will enable MEP engineers and consultants to design more accurately, minimize future problems, and achieve financial benefits for the project.

The methodology of this research is based on the premise that there is a disparity between the predicted and actual performance of buildings in terms of Maximum Electrical Demand. By benchmarking real projects, this study will enable us to identify the reasons behind this disparity and develop a Guideline to minimize it. This research will be beneficial for all stakeholders in the construction industry in Sri Lanka, including MEP consultants, architects, building owners, and developers.

To ensure the accuracy and reliability of the data collected, the following measures will be taken:

1. The projects will be selected based on their availability and suitability for the study. Projects that have incomplete data or are not suitable for the benchmarking exercise will be excluded.
2. The real maximum electrical demand will be obtained from reliable sources, such as project reports and clients. In cases where the data is not readily available, estimates will be made based on the capacities of the main equipment and high-level design calculations.
3. The calculated maximum electrical demand will be determined using commonly used Standards and Guides. The suitability and accuracy of these Standards and Guides for Sri Lankan buildings will be critically evaluated.
4. The comparison of the calculated and real maximum electrical demands will be conducted with care to ensure the accuracy of the data collected. Correction

factors will be developed to ensure that the analysis is more accurate and relevant.

In conclusion, the methodology of this research is centered on collecting data and analyzing it to develop a Guideline for determining acceptable ranges of Maximum Electrical Demand for Sri Lankan buildings. By benchmarking real projects, this study will enable us to identify the reasons behind the disparity between the predicted and actual performance.

### 2. LITERATURE REVIEW

While doing the Literature review, it was concluded that most of the relevant documentation are in the form of International or local; Standards, Guides, Handbooks etc. Additionally, it was concluded that the extent of directly relevant Research papers was limited even in international as well as local context. Hence, more focus was given to critically analyze the mentioned Standards, Guides, Handbooks etc.

#### 2.1 Schneider Installation Guide

##### 2.1.1 Findings

Schneider Installation Guide developed by Schneider Electric is a commonly used guide by Electrical designers when calculating the Maximum demand and Equipment sizing. Following were extracted from the Schneider Installation Guide.

*“In order to design an installation, the actual maximum load demand likely to be imposed on the power-supply system must be assessed. To base the design simply on the arithmetic sum of all the loads existing in the installation would be extravagantly uneconomical, and bad engineering practice. The aim of this chapter is to show how some factors taking into account the diversity (non-simultaneous operation of all appliances of a given group) and utilization (e.g. an electric motor is not generally operated at its full-load capability, etc.) of all existing and projected loads can be assessed. The values given are based on experience and on records taken from actual installations. In addition to providing basic installation-design data on individual circuits, the results will provide a global value for the installation, from which the requirements of a supply system (distribution network, MV/LV transformer, or generating set) can be specified.” [1]*

*“It may be noted that, strictly speaking, the total kVA of apparent power is not the arithmetical sum of the calculated kVA ratings of individual loads (unless all loads are at the same power factor). It is common practice however, to make a simple arithmetical summation, the result of which will give a kVA value that exceeds the true value by an acceptable “design margin”. When some or all of the load characteristics are not known, the values shown in **Figure 1** may be used to give a very approximate estimate of VA demands (Individual loads are generally too small to be expressed in kVA or kW).” [1]*

<b>Fluorescent lighting (corrected to <math>\cos \varphi = 0.86</math>)</b>		
<b>Type of application</b>	<b>Estimated (VA/m<sup>2</sup>) fluorescent tube with industrial reflector<sup>(1)</sup></b>	<b>Average lighting level (lux = lm/m<sup>2</sup>)</b>
Roads and highways storage areas, intermittent work	7	150
Heavy-duty works: fabrication and assembly of very large work pieces	14	300
Day-to-day work: office work	24	500
Fine work: drawing offices high-precision assembly workshops	41	800
<b>Power circuits</b>		
<b>Type of application</b>	<b>Estimated (VA/m<sup>2</sup>)</b>	
Pumping station compressed air	3 to 6	
Ventilation of premises	23	
Electrical convection heaters:		
private houses	115 to 146	
flats and apartments	90	
Offices	25	
Dispatching workshop	50	
Assembly workshop	70	
Machine shop	300	
Painting workshop	350	
Heat-treatment plant	700	

(1) example: 65 W tube (ballast not included), flux 5,100 lumens (lm), luminous efficiency of the tube = 78.5 lm / W.

**Fig. A9:** Estimation of installed apparent power

**Figure 1** - Electrical Loads for Different Building Types as per Schneider Electrical Guide [1]

*“All individual loads are not necessarily operating at full rated nominal power nor necessarily at the same time. Factors Factor of maximum utilization ( $k_u$ ) and Diversity factor - Coincidence factor ( $k_s$ ) allows the determination of the maximum power and apparent-power demands actually required to dimension the installation.” [1]*

*“Diversity factor for an apartment block.” Refer **Figure 2.** [1]*

Number of downstream consumers	Diversity factor (ks)
2 to 4	1
5 to 9	0.78
10 to 14	0.63
15 to 19	0.53
20 to 24	0.49
25 to 29	0.46
30 to 34	0.44
35 to 39	0.42
40 to 49	0.41
50 and more	0.38

**Fig. A10:** Example of diversity factors for an apartment block as defined in French standard NFC14-100, and applicable for apartments without electrical heating

**Figure 2** - Diversity factor for an apartment block as per Schneider Installation Guide

### 2.1.2 Review

#### *General*

Schneider Installation guide provides somewhat of a comprehensive method to calculate the maximum demand of a project. At per the guide, in Chapter 4: Power Loading of an Installation, cover to do the estimation. As there first step, how to do the Estimation of the installed apparent power is explained. Four (4) scenarios of estimating lighting load with area-based calculations is explained. Following are the Four (4) instances

1. Roads and highways storage areas, intermittent work
2. Heavy-duty works: fabrication and assembly of very large work pieces
3. Day-to-day work: office work
4. Fine work: drawing offices high-precision assembly workshops

Additionally, VA/m<sup>2</sup> values for Power circuit installed apparent power estimation is given in ten (10) scenarios.

Type of application	Estimated (VA/m <sup>2</sup> )
Pumping station compressed air	3 to 6
Ventilation of premises	23
Electrical convection heaters:	
private houses	115 to 146
flats and apartments	90

Offices	25
---------	----

After estimating the installed loads, with the use of Factor of maximum utilization ( $k_u$ ) and Diversity factor - Coincidence factor ( $k_s$ ), Actual Maximum (kVA) demand shall be estimated. In this stage different diversity values are defined in following categories;

1. Diversity factor for an apartment block
2. Rated Diversity Factor for distribution switchboards
3. Diversity factor according to circuit function

With the application of the above diversities, the maximum demand shall be calculated.

Although the mentioned method is useful when estimating the maximum demand of a project, a lot will depend on the designer and there is a high change of mistakes / deviations when the calculations are done. Main reason is that the guide doesn't define any values as references to determine whether the Maximum Demand estimated for the project is at an acceptable level or not.

### ***Office***

Although guide mentions a VA/m<sup>2</sup> value for Installed Apparent load in Offices, this doesn't fully reflect the overall VA/m<sup>2</sup> of an entire office building.

### ***Hotel***

This document does not mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### ***Retail***

This document does not mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### ***Residential***

Although guide mentions some VA/m<sup>2</sup> value for Installed Apparent load in Residentials, this doesn't fully reflect the overall VA/m<sup>2</sup> of an entire office building. Guide goes into details of applying diversity when there are multiple apartments.

## 2.2 BSRIA Rules of Thumb (5th Edition)

### 2.2.1 Findings

BSRIA Rules of Thumb is published by Building Services Research and Information Association (BSRIA) based in United Kingdom (UK). It defines Electrical loads for different types of buildings as extracted in **Figure 3** and **Figure 4**.

**Table 19:** Electrical loads for different types of building (W/m<sup>2</sup> gross internal area, unless otherwise stated)

Building type	Rule of Thumb	Comments	Ref
	<b>Electrical load (W/m<sup>2</sup>)</b>	These electrical loads cover requirements for lighting, general power and mechanical power for building services systems. Please refer to the glossary for a definition of gross internal area and net internal area	4, 6, 12, 63, 64
Banks and building societies	50 (non-air conditioned) 150 (air conditioned)		
Car parks	10 (covered) 4 (surface)	An allowance should be added for any manned offices.	
Colleges (higher education)	55		
Data centres	1500	This figure is based on the net area of the data hall	
Department stores	150 – 250	Higher loads relate to stores with a high proportion of display lighting for fashion and cosmetic areas and/or catering provision	
Flats/ apartments	80	This figure is given for high specification flats with gas cooking and heating 3 kW per apartment can be employed for apartments with gas cooking and heating, 7.5 kW per apartment can be employed for apartments with all electric cooking and heating For apartment blocks a coincident diversity may be applied	
Hospitals	65	This figure is for a general hospital. It is expressed in W/m <sup>2</sup> NIA, based on a net to gross ratio of 80%. It includes medical power requirements Luxury air conditioned hospitals will have a higher electrical demand of 80 W/m <sup>2</sup> NIA	
Houses	5.5 kW per house	This figure is for a house with 3 or 4 bedrooms with gas central heating For housing estates, a coincident diversity may be applied	
Hotels	2.1 kW per bedroom	This figure is given for a hotel providing accommodation only. 1 kW per bedroom should be added for hotels with conference facilities	
Libraries	50		
Offices – air conditioned	87		
Offices – non air conditioned	62	Gas heating and mechanical ventilation has been assumed	
Prisons	1.5 kW per cell		
Restaurants	225	This figure is based on the use of gas cooking. A figure of 0.5 kW per cover can also be employed Fast food outlets typically have a higher electrical load of 500 W/m <sup>2</sup> GIA	

**Figure 3 - Electrical Loads for Different Building Types as per BSRIA Rules of Thumb [2]**

**Table 20:** Electrical loads for different types of building – continued (W/m<sup>2</sup> gross internal area, unless otherwise stated)

Building type	Rule of Thumb	Comments	Ref
	<b>Electrical load (W/m<sup>2</sup>)</b>	These electrical loads cover requirements for lighting, general power and mechanical power for building services systems. Please refer to the glossary for a definition of gross internal area and net internal area	4, 6, 12, 63
Schools – naturally ventilated	35	A figure of 0.35 kW per student can also be employed	
Schools – mechanically ventilated	50	A figure of 0.5 kW per student can also be employed	
Shops	160	This figure is provided for small high street or shopping mall establishments	
Sports centres with swimming pool	50	This type of facility includes exercise rooms, a fitness room, racket courts and a restaurant	
Student residences/halls of residence	28	A figure of 1.6 kW per student can also be employed	
Supermarkets and hypermarkets	185	This figure is based on 30-40% of floor area consumed by fridges	
Warehouses/stores	17	Cold stores and refrigerated stores are not included	

**Figure 4 -** Electrical Loads for Different Building Types as per BSRIA Rules of Thumb [2]

### 2.2.2 Review

#### *General*

In BSRIA Rules of Thumb, it defines the W/m<sup>2</sup> of each building category covering almost all the types of buildings. Most of the values can be considered as references in determining target values of Maximum electrical demands of buildings. See below table for the extract of all the categories studied in this Literature review.

Building Type	Electrical Load (W/m <sup>2</sup> )	Remarks
Residential (Flats / Apartments)	80	For apartment blocks coincident diversity may be applied
Hospital	65 ~ 80	
Hotels	2.1 ~ 3.1 kW / guestroom	
Office	62 ~ 87	
Retails / Shops	160	

#### *Office*

As shown in **Table 2** for office buildings, BSRIA Rules of Thumb recommends a power density of 62 to 87 W/m<sup>2</sup> where higher range is applicable of the office is fully air conditioned. As these values are developed in UK context, it is not clear whether these can be applied for Sri Lankan context directly.

### ***Hotel***

For hotel, BSRIA Rules of Thumb recommendations 2.1 kW per guestroom if it only provides accommodation, however if the hotel provides conference facilities, the value should be increased by 1 kW per guestroom. (i.e. of a hotel has 100 guestrooms and is only providing accommodation, the total maximum load of the project shall be 210 kW.) As these values are developed in the UK context, it is not clear whether these can be applied for Sri Lankan context directly.

### ***Retail***

For retail, BSRIA Rules of Thumb recommends a power density of 160 W/m<sup>2</sup>. As these values are developed in the UK context, it is not clear whether these can be applied for Sri Lankan context directly.

### ***Residential***

For Residential, BSRIA Rules of Thumb recommends 80 W/m<sup>2</sup>. However, this figure is given for high specification flats with gas cooking and heating. 3 kW per apartment can be employed for apartments with gas cooking and heating. 7.5 kW per apartment can be employed for apartments with all electric cooking and heating.

Additionally, for apartment blocks a coincident diversity may be applied. However, the document doesn't define or advise what sort of diversity to be used for different apartment sizes or types.

As these values are developed in the UK context, it is not clear whether these can be applied for Sri Lankan context directly.

## **2.3 BS 7671 On-site Guide**

### **2.3.1 Findings**

BS 7671 On-site Guide is a commonly used guide by Electrical designers when calculating the Maximum demand. Following were extracted from the mentioned Guide.

*“This appendix provides information on the determination of the maximum demand for an installation and includes the current demand to be assumed for commonly used equipment. It also includes some notes on the application of allowances for diversity. The information and values given in this appendix are intended only for guidance because it is impossible to specify the appropriate allowances for diversity for every type of installation and such allowances call for special knowledge and experience.*

The values given in Table A2, therefore, may be increased or decreased as decided by the installation designer concerned. No guidance is given for blocks of residential dwellings, large hotels, industrial and large commercial premises; such installations should be assessed on a case-by-case basis. The current demand of a final circuit is determined by adding the current demands of all points of utilisation and equipment in the circuit and, where appropriate, making an allowance for diversity. Typical current demands to be used for this addition are given in Table A1.” [3]

▼ **Table A1** Current demand to be assumed for points of utilisation and current-using equipment

Point of utilisation or current-using equipment	Current demand to be assumed
Socket-outlets other than 2 A socket-outlets and other than 13 A socket-outlets See note 1	Rated current
2 A socket-outlets	At least 0.5 A
Lighting outlet See note 2	Current equivalent to the connected load, with a minimum of 100 W per lampholder
Electric clock, shaver supply unit (complying with BS EN 61558-2-5), shaver socket-outlet (complying with BS 4573), bell transformer, and current-using equipment of a rating not greater than 5 VA	May be neglected for the purpose of this assessment
Household cooking appliance	The first 10 A of the rated current plus 30 % of the remainder of the rated current plus 5 A if a socket-outlet is incorporated in the control unit
All other stationary equipment	British Standard rated current, or normal current

**Figure 5** – Current Demand as per BS 7671 On-site Guide [3]

“The current demand of an installation consisting of a number of final circuits may be assessed by using the allowances for diversity given in Table A2 which are applied to the total current demand of all the equipment supplied by the installation. The current demand of the installation should not be assessed by adding the current demands of the individual final circuits obtained as outlined above. In Table A2 the allowances are expressed either as percentages of the current demand or, where followed by the letters f.l. (full load), as percentages of the rated full load current of the current-using equipment. The current demand for any final circuit which is a standard circuit arrangement complying with Appendix H is the rated current of the overcurrent protective device of that circuit.”

*“An alternative method of assessing the current demand of an installation supplying a number of final circuits is to add the diversified current demands of the individual circuits and then apply a further allowance for diversity. In this method the allowances given in Table A2 should not be used, the values to be chosen being the responsibility of the installation designer.”*

*“The use of other methods of determining maximum demand is not precluded where specified by the installation designer. After the design currents for all the circuits have been determined, enabling the conductor sizes to be chosen, it is necessary to check that the limitation on voltage drop is met.” [3]*

▼ **Table A2** Allowances for diversity (see opposite for notes \* and †)

Purpose of the final circuit fed from the conductors or switchgear to which the diversity applies	Type of premises		
	Individual household installations including individual dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1 Lighting	66 % of total current demand	90 % of total current demand	75 % of total current demand
2 Heating and power (but see 3 to 8 below)	100 % of total current demand up to 10 A +50 % of any current demand in excess of 10 A	100 % f.l. of largest appliance +75 % f.l. of remaining appliances	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances
3 Cooking appliances	10 A + 30 % f.l. of connected cooking appliances in excess of 10 A + 5 A if a socket-outlet is incorporated in the control unit	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances	100 % f.l. of largest appliance +80 % f.l. of second largest appliance +60 % f.l. of remaining appliances
4 Motors (other than lift motors, which are subject to special consideration)	Not applicable	100 % f.l. of largest motor +80 % f.l. of second largest motor +60 % f.l. of remaining motors	100 % f.l. of largest motor +50 % f.l. of remaining motors
5 Water-heaters (instantaneous type)*	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances	100 % f.l. of largest appliance +100 % f.l. of second largest appliance +25 % f.l. of remaining appliances
6 Water-heaters (thermostatically controlled)	No diversity allowable†		
7 Floor warming installations	No diversity allowable†		
8 Thermal storage space heating installations	No diversity allowable†		
9 Standard arrangement of final circuits in accordance with Appendix H	100 % of current demand of largest circuit +40 % of current demand of every other circuit	100 % of current demand of largest circuit +50 % of current demand of every other circuit	
10 Socket-outlets (other than those included in 9 above and stationary equipment other than those listed above)	100 % of current demand of largest point of utilisation +40 % of current demand of every other point of utilisation	100 % of current demand of largest point of utilisation +70 % of current demand of every other point of utilisation	100 % of current demand of largest point of utilisation +75 % of current demand of every other point in main rooms (dining rooms, etc.) +40 % of current demand of every other point of utilisation

**Figure 6** - Allowance for Diversity as per BS 7671 On-site Guide [3]

### 2.3.2 Review

#### *General*

BS 7671 On-site guide is a reputed standard which is followed in most of the countries including Sri Lanka. As per this standard, the values are to be considered as suggestions and the values may be increased or decreased as decided by the installation designer concerned. The method of estimation of the Maximum electrical demand for a project as per this standard is by using the final circuits and by applying the recommended diversity factor as the **Figure 5**. Although this a more accurate way of

estimating the Maximum Electrical Demand, the main drawback is that at the initial stages of design when the main equipment is sized and the maximum demand is estimated, full information of the final circuits is not available. Hence, although the mentioned method is useful when estimating the maximum demand of a project at later stages of design, this is not useful in the initial design stages of a project. Additionally, the standard doesn't define any values as references to determine whether the Maximum Demand estimated for the project is at an acceptable level or not.

### ***Office***

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### ***Hotel***

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### ***Retail***

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### ***Residential***

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

## **2.4 AS/NZS 3000:2018 - Electrical installations “Wiring Rules”**

### **2.4.1 Findings**

AS/NZS 3000 is a commonly used Standard in New Zealand and Australia. Following were extracted from the AS/NZS 3000 Standard.

“The alternative calculation method set out below may be used for commercial and light-industrial applications. This method is based on experience and energy consumption figures for different types of occupancy within installations. The values shown in Table C3 (**Figure 7**) depend on factors such as the climate, occupancy hours and levels, energy management systems, and the degree to which equipment is uniformly distributed in the affected area. An example is provided to demonstrate how the energy demand figures are converted to demand current.” [4]

**TABLE C3**  
**MAXIMUM DEMAND—ENERGY DEMAND METHOD**  
**FOR NON-DOMESTIC INSTALLATIONS**

Type of occupancy		Energy demand	
		Range, VA/m <sup>2</sup>	Average, VA/m <sup>2</sup>
Offices	Light and power	40–60	50
	Airconditioning:		
	— Cooling	30–40	35
	— Reverse cycle	20–30	25
	— Zonal reheat	40–60	50
	— Variable volume	20	20
* Carparks	Open air	0–10	5
	EV charging	5–15	10
	Basement	10–20	15
	EV charging	10–30	20
Retail shops	Light and power	40–100	70
	Airconditioning	20–40	30
Warehouses	Light and power	5–15	10
	Ventilation	5	5
	Special equipment	(use load details)	
Light industrial	Light and power	10–20	15
	Ventilation	10–20	15
	Airconditioning	30–50	40
	Special equipment	(use load details)	
Taverns, licensed clubs	Total	60–100	80
Theatres	Total	80–120	100

NOTE: EV charging relates to charging equipment associated with electric vehicles and should be considered in addition to all other energy demands.

**Figure 7 - AS/NZS 3000:2018 - Electrical installations “Wiring Rules” [4]**

## 2.4.2 Review

### *General*

In AS/NZS 3000, it defines the W/m<sup>2</sup> of each building category covering few types of buildings. Most of the values can be considered directly as references in determining

target values of Maximum electrical demands of buildings. See below **Table 3** for the extract of all the categories studied in this Literature review.

<b>Table 3 - Electrical Loads as per BSRIA Rules of Thumb</b>		
<b>Building Type</b>	<b>Electrical Load (VA/m<sup>2</sup>)</b>	<b>Remarks</b>
Office	40 ~ 100	Average 85 VA/m <sup>2</sup> with Air Conditioning.
Retails / Shops	40 ~ 140	Average 100 VA/m <sup>2</sup> with Air Conditioning.

### ***Office***

For office Maximum demand calculation, AS/NZS 3000 recommends values in few scenarios. If the office is not air conditioned AS/NZS 3000, recommends a power density of 40 to 60 VA/m<sup>2</sup> to be used when calculating the Maximum electrical demand. Whereas of conventional type air conditioning is available additional 30 to 40 VA/m<sup>2</sup> to be used when calculating the Maximum electrical demand.

As these values are developed in New Zealand and Australian context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Hotel***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Retail***

For retail Maximum demand calculation, AS/NZS 3000 recommends values in one (1) scenario. If the retail is not air-conditioned AS/NZS 3000, recommends a power density of 40 to 100 VA/m<sup>2</sup> to be used when calculating the Maximum electrical demand. Whereas air conditioning is available an additional 20 to 40 VA/m<sup>2</sup> to be used when calculating the Maximum electrical demand.

As these values are developed in New Zealand and Australian context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Residential***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

## **2.5 Bangladesh Building Code 2020**

### 2.5.1 Findings

Bangladesh Building Code is a well-knowns Standard / code in Bangladesh. Following was extracted from the Bangladesh Building Code. [5]

**Table 8.1.17: Minimum Load Densities**

Type of Occupancy	Unit Load (Watts/m <sup>2</sup> )	
	Non A/C	A/C
Residence/ Dwelling : Single family	20	75
Residence/ Dwelling : Multi-family (other than hotels)	20	75
Hospitals	32	80
Hotels, including apartment house (excluding any provisions for electric cooking)	24	75
Office and commercial multi-storeyed buildings	28	75
Industrial building (excluding the loads for machines)	16	-

Type of Occupancy	Unit Load (Watts/m <sup>2</sup> )	
	Non A/C	A/C
Departmental stores	28	75
Banks	20	75
Restaurants (excluding any provisions for electric cooking)	16	75
Barber shops and beauty parlours	32	75
Schools and colleges	12	70
Parking area in commercial buildings	4	-
Warehouses, large storage areas	2	-

**Figure 8** - Bangladesh Building Code 2020 [5]

### 2.5.2 Review

In Bangladesh Building Code, it defines the W/m<sup>2</sup> of each building category covering almost all the types of buildings. Most of the values can be considered as references in determining target values of Maximum electrical demands of buildings. See below **Table 4** for the extract of all the categories studied in this Literature review.

<b>Table 4 - Electrical Loads as per Bangladesh Building Code</b>		
<b>Building Type</b>	<b>Electrical Load (W/m<sup>2</sup>)</b>	<b>Remarks</b>
Residential	20 ~ 75	
Hospital	32 ~ 80	
Hotels	24 ~ 75	Excluding any provisions for electric cooking
Office	28 ~ 75	
Retails / Department Stores	28 ~ 75	

### ***Office***

As shown in **Table 4** for office buildings, Bangladesh Building Code recommends a power density of 28 to 75 W/m<sup>2</sup> where higher range is applicable of the office is fully air conditioned. As these values are developed in the Bangladesh context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Hotel***

As shown in **Table 4** for hotel buildings, Bangladesh Building Code recommends a power density of 24 to 75 W/m<sup>2</sup> where higher range is applicable of the Hotel is fully air conditioned. However, this is excluding any provisions for electric cooking. Provision for electric cooking has not been defined. As these values are developed in the Bangladesh context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Retail***

As shown in **Table 4** for Retail buildings, Bangladesh Building Code recommends a power density of 28 to 75 W/m<sup>2</sup> where higher range is applicable of the Retail is fully air conditioned. As these values are developed in the Bangladesh context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Residential***

As shown in **Table 4** for Residential buildings, Bangladesh Building Code recommends a power density of 20 to 75 W/m<sup>2</sup> where higher range is applicable of the Residential is fully air conditioned. As these values are developed in the Bangladesh context, it is not clear whether these can be applied for the Sri Lankan context directly.

## **2.6 National Electrical Code - India**

## 2.6.1 Findings

National Electrical Code is a well-known Standard / code in India. Following were extracted from the National Electrical Code.

*“In determining the maximum demand of an installation or parts thereof, diversity may be taken into account. Table 2 gives guidance on diversity, but it is emphasized that the calculation of diversity would have to take into account several factors which would need special knowledge and experience. By consulting Table 2, a reasonable estimate can be obtained as to what the maximum load is likely to be, but it must be stressed that each installation must be dealt with on its own merits.” [6]*

**Table 2 Typical Allowances for Diversity**  
(Clause 5.5 )

SI No.	Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies	Type of Premises		
		Individual house- hold installations, including individual dwelling of a block	Small shops, stores offices and business premises	Small hotels, boarding houses etc
(1)	(2)	(3)	(4)	(5)
i)	Lighting	66 percent of total current demand	90 percent of total current demand	75 percent of total current demand
ii)	Heating and power [also see Sl. No. (iii) to (iv) below]	100 percent of total current demand upto 10 A +50 percent of any current demand in excess of 10A	100 percent of full load of largest appliance +75 percent of remaining appliances	100 percent of full load of largest appliance +80 percent of second largest appliances +60 percent of remaining appliances
iii)	Cooking appliances	10A +30 percent of full load of connected cooking appliances in excess of 10 A + 6 A if socket-outlet incorporated in unit	100 percent of full load of largest appliance +80 percent of full load of second largest appliance +60 percent of full load of remaining appliances	100 percent of largest appliance +80 percent of full load of second largest appliance +60 percent of full load of remaining appliances
iv)	Motors (other than lift motors which are subject to special consideration)		100 percent of full load of largest motor +80 percent of full load of second largest motor +60 percent of full load of remaining motors	100 percent of full load of largest motor +50 percent of full load of remaining motors.
v)	Water heater (instantaneous type <sup>1)</sup> )	100 percent of full load of largest appliance +100 percent of full load of second largest appliance +25 percent of full load of remaining appliances	100 percent of full load of largest appliance +100 percent of full load of second largest appliance +25 percent of full load of remaining appliances	100 percent of full load of largest appliance +100 percent of full load of second largest appliance +25 percent of full load of remaining appliances
vi)	Water heaters (thermostatically controlled)	No diversity allowable <sup>2)</sup>	+25 percent of full load of remaining appliances	
vii)	floor warming installations	No diversity allowable <sup>2)</sup>		
viii)	Water heaters thermal storage space heating installations	No diversity allowable <sup>2)</sup>		
ix)	Standard arrangements of final circuits in accordance with IS 732	100 percent of current demand of largest circuit +40 percent of current demand of every other circuit	100 percent of current demand of largest circuit +50 percent of current demand of every other circuit	
x)	Socket outlets other than those included in Sl No. (ix) above and stationary equipment other than those listed above	100 percent of current demand of largest point +40 percent of current demand of every other point	100 percent of current demand of largest point +75 percent of current demand of every other point	100 percent of current demand of largest point +75 percent of current demand of every point in main rooms (dinning rooms, etc) +40 percent of current demand of every other point

**Figure 9 - Typical Allowances for Diversity from National Electrical Code - India [6]**

## 2.6.2 Review

### *General*

National Electrical Code of India is a commonly used standard in India; however, this is not commonly used in Sri Lanka. The method of estimation of the Maximum electrical demand for a project as per this standard is by using the final circuits and by applying the recommended diversity factor as the **Figure 9**. This is similar to the method explained in BS 7671 On-site Guide. Although, this a more accurate way of estimating the Maximum Electrical Demand, the main drawback is that at the initial stages of design when the main equipment is sizes and the maximum demand is estimated, full information of the final circuits is not available. Hence, although the mentioned method is useful when estimating the maximum demand of a project at later stages of design, this is not useful in the initial design stages of a project. Additionally, the standard doesn't define any values as references to determine whether the Maximum Demand estimated for the project is at an acceptable level or not.

### *Office*

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### *Hotel*

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for the category of building.

### *Retail*

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the document will have to be followed in estimating the Maximum Power Demand for this category of building.

### *Residential*

This document doesn't mention any Maximum Power Demand information specific for this category of building. As per the document, standard method noted in the

document will have to be followed in estimating the Maximum Power Demand for this category of building.

## **2.7 CIBSE Guide K - Electricity in Buildings**

### **2.7.1 Findings**

CIBSE Guide K is a well-recognized Standard, which is developed by Chartered Institution of Building Services Engineers based in United Kingdom (UK). Following were extracted from the CIBSE Guide K.

*“The electrical load within most commercial buildings can be arranged into the following broad categories:*

- lighting*
- small power and special user equipment*
- heating, ventilating and air conditioning (HVAC) equipment*
- lifts and escalators.*

*The electrical demand is directly connected to the heat output and this is discussed in section 6 of CIBSE Guide A: Environmental design.*

*An evaluation of the main electrical services requirements in a building should begin with an estimate of the likely load requirements. This is usually based upon a unit loading on a square metre basis. The unit loading used should be based upon a reasonable figure, statistically determined from an analysis of similar buildings.*

*When applying unit loads on a  $W \cdot m^{-2}$  basis for initial design calculations, it is suggested that the gross area of the building be utilised, subtracting the known areas of lifts, shaft ways, etc. Reducing areas to take account of the thicknesses of exterior walls or columns is an unnecessary level of precision for estimating loads. The difference between lettable areas and building gross areas has little impact on equipment selection, unless unreasonably large unit loads are used for the calculations. Table 3.1 summarises unit load estimates for lighting and small power for various types of building. An estimate for mechanical apparatus such as lifts, air conditioning equipment, pumps etc., should be added to each of these figures. These loadings are recommended minimum requirements.*

*Table 3.2 presents a summary of measured maximum operating demand loads for modern ‘high-tech’ commercial office buildings. Each building is fully air conditioned and contains dealing facilities of various sizes, some accommodating as many as 250*

traders. It is significant to note that the highest recorded demand is considerably below some recent user expectations of 150–200 W·m<sup>-2</sup>.” [7]

**Table 3.1** Minimum design load capacities for lighting and small power equipment for various types of building

Building type	Minimum load capacity / (W/m <sup>2</sup> )
Office	60
School	30
Residential building	30
Hospital	25
Hotel	25
Church	15

**Figure 10** - CIBSE Guide K - Electricity in Buildings [7]

### 2.7.2 Review

#### *General*

As per CIBSE Guide K, followings four (4) types of loads need to be considered when estimating the maximum demand.

1. Lighting
2. Small power and special user equipment
3. Heating, ventilation and air conditioning (HVAC) equipment
4. Lifts and escalators

As shown in **Figure 10**, CIBSE Guide K recommends the minimum Load capacities in W/m<sup>2</sup> for few building categories. See below **Table 5** for the extract of all the categories studied in this Literature review.

Building Type	Min. Electrical Load (W/m <sup>2</sup> )	Remarks
Residential	30	Only includes lighting and small power
Hospital	25	Only includes lighting and small power
Hotels	25	Only includes lighting and small power
Office	60	Only includes lighting and small power

Heating, ventilating, and air conditioning (HVAC) loads, and lift / escalator loads must be added to the above values. However, CIBSE Guide K doesn't mention full details on what values to be used for the above loads.

### ***Office***

For office, CIBSE Guide K recommends a power density of 60 W/m<sup>2</sup> for lighting and small power. As these values are developed in the UK context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Hotel***

For Hotel, CIBSE Guide K recommends a power density of 25 W/m<sup>2</sup> for lighting and small power. As these values are developed in the UK context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Retail***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Residential***

For Residential, CIBSE Guide K recommends a power density of 30 W/m<sup>2</sup> for lighting and small power. As these values are developed in the UK context, it is not clear whether these can be applied for the Sri Lankan context directly.

## **2.8 NEPRA Consumer Service Manual - Pakistan**

### **2.8.1 Findings**

NEPRA Consumer Service Manual well-recognized Standard in Pakistan developed by National Electric Power Regulatory Authority of Pakistan. Following were extracted from the NEPRA Consumer Service Manual. Refer **Figure 11** and **Figure 12**.

**Annexure - VI**  
**Load Assessment Criteria for Housing Societies, High-rise Buildings,**  
**Commercial Plazas, Multi-storey Buildings, etc.**

Description		Size of Plot	Load Assessment
Individual Houses		03 Marla	3.15 kW
		05 Marla	5.0 kW
		07 Marla	5.70 kW
		10 Marla	6.60 kW
		12 Marla	7.45 kW
		14 Marla	8.75kW
		01 Kanal	10.61 kW
		02 Kanal	17.74 kW
<b>Farm Houses/ plots (Area: above 2 kanals)</b>			
<ul style="list-style-type: none"> <li>• Load of first 2 Kanals will be assessed @ 17.74 kW.</li> <li>• 1/4<sup>th</sup> area of rest of the plot will be assessed @ 0.4 kW per Marla.</li> </ul>			
Apartments	Area	<b>Maximum Load Assessment</b>	
		<b>Urban Areas</b>	<b>Rural Areas</b>
	Upto 700 Sq.ft	125 w/100 sq.ft + 10 % flats with 1 AC of 1.5 kW	100 w/100 sq.ft with no AC
	701-900 Sq. ft	150 w/100 sq.ft + 25 % flats with 1 AC of 1.5 kW	125 w/100 sq.ft with no AC
	901-1200 Sq. ft	175w/100 sq.ft + 50 % flats with 1 AC of 1.5 kW	150 w/100 sq.ft + 10 % flats with 1 AC of 1.5 kW
	1201-1600 Sq. ft	175 w/100 sq.ft + 100 % flats with 2 ACs of 1.5 kW each	150w/100 sq.ft + 25 % flats with 1 AC of 1.5 kW
	Above 1600 Sq. ft	200 w/100 sq.ft + 100 % flats with 3 ACs of 1.5 kW	175w/100 sq.ft + 50 % flats with 2 AC of 1.5 kW
Shops / Clinics	Any Area	1000 w/100 sq.ft (AC load inclusive)	500 w/100 sq.ft (AC load inclusive )
Super Market	Any Area	1000w/100 sq.ft (AC load inclusive)	800 w/100 sq.ft (AC load inclusive)
Offices	Any Area	700 w/100 sq.ft (AC load inclusive)	500 w/100 sq.ft (AC load inclusive)
Covered Godown	Any area	50 w/100 sq.ft	40 w/100 sq.ft
Open Godown	Any Area	25 w/100 sq.ft	20 w/100 sq.ft
Corridors	Any area residential	40 w/100 sq.ft	30 w/100 sq.ft
	Any area offices	60 w/100 sq.ft	50 w/100 sq.ft

**Figure 11 - Load Assessment Criteria from NEPRA Consumer Service Manual - January 2021**

	Any area commercial activity	75 w/100 sq.ft	60 w/100 sq.ft
Parking/ Air Raid Shelter	Any Area	60 w /100 sq.ft	60 w /100 sq.ft
Marriage halls	Any Area	250 W/ 100 sq.ft + 1 AC of 1.5 kW for office	250 W/ 100 sq.ft + 1 AC of 1.5 kW for office
Banquets	Any Area	1000 W/ 100 sq.ft (AC load inclusive)	700 W/ 100 sq.ft (AC load inclusive)
Community Hall / Centre	Any Area	250 W/ 100 sq.ft + 1 A Cof 1.5 kW	200 W/ 100 sq.ft + 1 AC of 1.5 kW
Restaurants	Any Area	1000 w/100 sq.ft (AC load inclusive)	800 w/100 sq.ft (AC load inclusive)
Open Air Restaurants	Any Area	250w / 100sq.ft	200w / 100sq.ft
Children Play Area (Covered/Within Boundary)	Any Area	150w / 100sq.ft	100w / 100sq.ft
Health Club / Recreation Club	Any Area	500 w/100 sq.ft (AC load inclusive )	200w/100 sq.ft (AC load inclusive)
Swimming Pool	Any Area	5 kW	4 kW
Plant Nursery	Any Area	4 kW	3 kW
Schools / Colleges/ University/Coaching/ Centre/IT Institutes	Any Area	150 w/100 sq.ft for constructed area with 1 AC of 1.5 kw for office	100 w/100 sq.ft For constructed area
Parks	Any Area	3 kW	2 kW
Madrassa	Any Area	150 w/100 sq.ft.	100 w/100 sq.ft.
Places Of Worship	Any Area	150 w/100 sq.ft.	100 w/100 sq.ft.
Hostel	Any Area	100 w/100 sq.ft. AC load as per actual	100 w/100 sq.ft and AC load as per actual
Library	Any Area	400 w/100 sq.ft (inclusive AC load)	300 w/100 sq.ft and AC load as per actual.
Snooker Club	Any Area	500 w/ 100 sq.ft (AC load inclusive)	250 w/100 sq.ft and AC load as per actual
Lift	-	7 kW OR as per technical specifications	7 kW OR as per technical specifications
Street Lighting	-	60W (LED) per pole 100 W (others) per pole	60W (LED) per pole 100 W (others) per pole
Water Pump	-	5 kW OR as per technical specifications	5 kW OR as per technical specifications

**Figure 12** – Load Assessment Criteria from NEPRA Consumer Service Manual - January 2021

### 2.8.2 Review

In NEPRA Consumer Service Manual, it defines the W/m<sup>2</sup> of each building category covering almost all the types of buildings. Most of the values can be considered as

references in determining target values of Maximum electrical demands of buildings. See below table for the extract of all the categories studied in this Literature review.

<b>Table 6 - Electrical Loads as per NEPRA Consumer Service Manual - Urban Areas</b>		
<b>Building Type</b>	<b>Electrical Load (W/m<sup>2</sup>)</b>	<b>Remarks</b>
Residential (Flats / Apartments)	Refer <b>Figure 11</b>	Varies with apartment size
Hospital / Clinics	107	Including Air Conditioning
Office	75	Including Air Conditioning
Retails / Shops	107	Including Air Conditioning

### ***Office***

As shown in **Table 6** for office buildings, NEPRA Consumer Service Manual recommends a power density of 75 W/m<sup>2</sup> with the office fully air conditioned. As these values are developed in the Pakistan context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Hotel***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Retail***

As shown in **Table 6** for retail buildings, NEPRA Consumer Service Manual recommends a power density of 107 W/m<sup>2</sup> with the retail fully air conditioned. As these values are developed in the Pakistan context, it is not clear whether these can be applied for the Sri Lankan context directly.

### ***Residential***

For Residential, NEPRA Consumer Service Manual defines criteria to estimate load for each apartment based on the size of the apartment. It is not clear to how diversity shall be added when taking the total building load. Refer **Figure 11** for recommendation from NEPRA Consumer Service Manual. As these values are developed in the Pakistan context, it is not clear whether these can be applied for the Sri Lankan context directly.

## **2.9 Research Paper - Calculation of Electrical Loads of Residential & Public Buildings Based on Actual Data - Yu I Soluyanov / A I Fedotov / A R Ahmetshin**

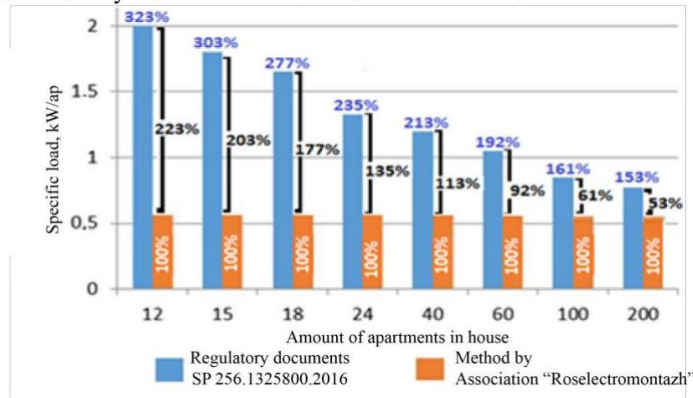
### 2.9.1 Findings

Following was extracted from the research paper published in International Scientific Electric Power Conference – 2019 written by a team of Russians. Refer **Figure 13**.

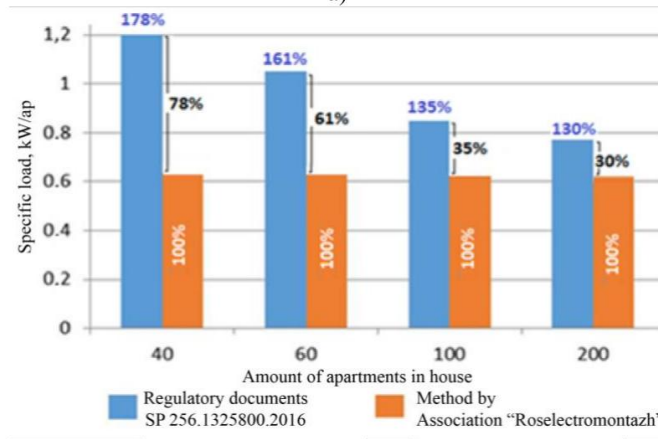
*“Design organizations use normative specific load to calculate the power consumed by residential and public building. The practice of construction and operation of urban power supply systems has shown that in most cases real loads are less than calculated ones by 1.5–2 times. A revision of the standard load values is needed based on experimental measurements of power profiles. The newly built cable networks and transformer substations of 10/0.4 kV in fact turn out to be underloaded. Moreover, this underloading is such that transformers rarely operate at 50% of their capacity during hours of maximum power consumption. The death of investments for power grid companies is obvious, since after the nearest site development, it becomes almost impossible to connect a new consumer.” [8]*

Further calculations showed that the actual values of power consumption during periods of maximum load are lower than the values given in SP 256.1325800.2016 by 30 - 223%.

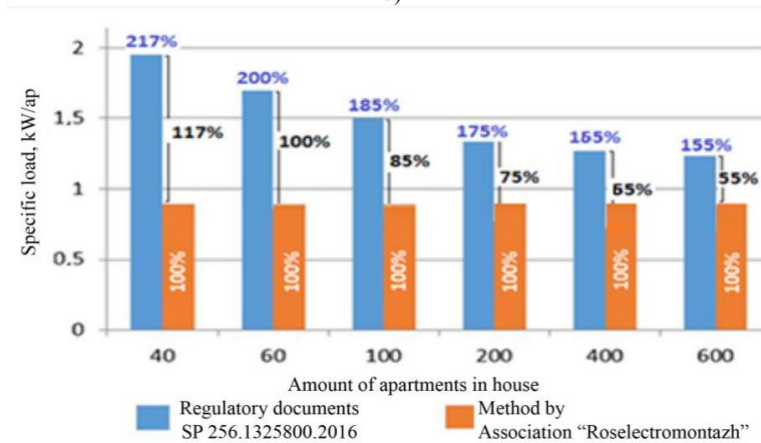
Figure 5 presents a comparison between specific load set according to SP 256.1325800.2016 and that calculated by the Association “Roselectromontazh”.



a)



b)



c)

**Figure 5.** Comparison between specific load set according to SP 256.1325800.2016 and that calculated by the Association “Roselectromontazh” (a – MRB up to 5 floors; b – MRB of 7 – 10 floors; c – MRB of 12 floors and more).

**Figure 13 - Calculation of Electrical Loads of Residential & Public Buildings Based on Actual Data - Yu I Soluyanov / A I Fedotov / A R Ahmetshin [8]**

## **2.9.2 Review**

### ***General***

The Russian team has evaluated multiple Apartment buildings in Russia and found out that in most cases real loads are less than calculated ones by 1.5 ~ 2 times.

### ***Office***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Hotel***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Retail***

This document doesn't mention any Maximum Power Demand information specific for this category of building.

### ***Residential***

The research paper doesn't mention anything about the gross floor area of the evaluated buildings. Hence a power density couldn't be calculated using the mentioned kW values.

## **2.10 SUMMARY OF FINDINGS**

In conducting the literature review, it was found that there was a limited number of directly relevant research papers available, both internationally and locally. As a result, the review focused more on the analysis of standards, guides, and handbooks that are commonly used in the MEP industry. The identified sources cover various aspects of MEP system design, including electrical load calculations, equipment sizing, and system design requirements, among others. However, the team also observed that the majority of the documents were developed for international contexts and may not fully address the unique needs and local conditions in Sri Lanka.

To overcome this challenge, a critical evaluation of the available standards and guides to identify the most relevant ones to the Sri Lankan context was done. The study looked for factors such as the year of publication, the applicability of the content to the local context, and the comprehensiveness of the material in addressing the specific challenges of MEP system design in Sri Lanka. The review also examined any

significant differences between the guidelines, where different standards were compared for the same types of building and MEP systems. Additionally, the review looked at how well the guidelines reflected the real performance of buildings in terms of maximum electrical demand.

Overall, the literature review showed that there is a significant disparity between the predicted and actual performance of buildings in Sri Lanka. The review identified various reasons for this discrepancy, including the lack of consistency in design methods and references used by different consultants, the lack of availability of Sri Lanka-specific guidelines, and the significant differences in the maximum electrical demand values suggested by various literature sources. The literature review highlights the need for further research to bridge the gap between the predicted and actual performance of buildings in Sri Lanka, which can provide financial benefits, better space utilization, and minimize future problems.

#### **Standards and Guidelines:**

Several international standards and guidelines have been developed to address the issue of maximum electrical demand in buildings. These include the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook, the Chartered Institution of Building Services Engineers (CIBSE) Guide, and the International Electrotechnical Commission (IEC) Standard. However, the applicability of these standards in Sri Lanka needs to be evaluated as they are not specific to Sri Lanka.

#### **Research Papers:**

A limited number of research papers were found on the development of an assessment criteria for maximum electrical demand in buildings in Sri Lanka. However, one study conducted by Gunawardena and Dias (2018) identified the need for a comprehensive database of maximum electrical demand in buildings in Sri Lanka. The study also recommended the development of guidelines for the sizing of electrical equipment in buildings.

#### **Local Standards and Guidelines:**

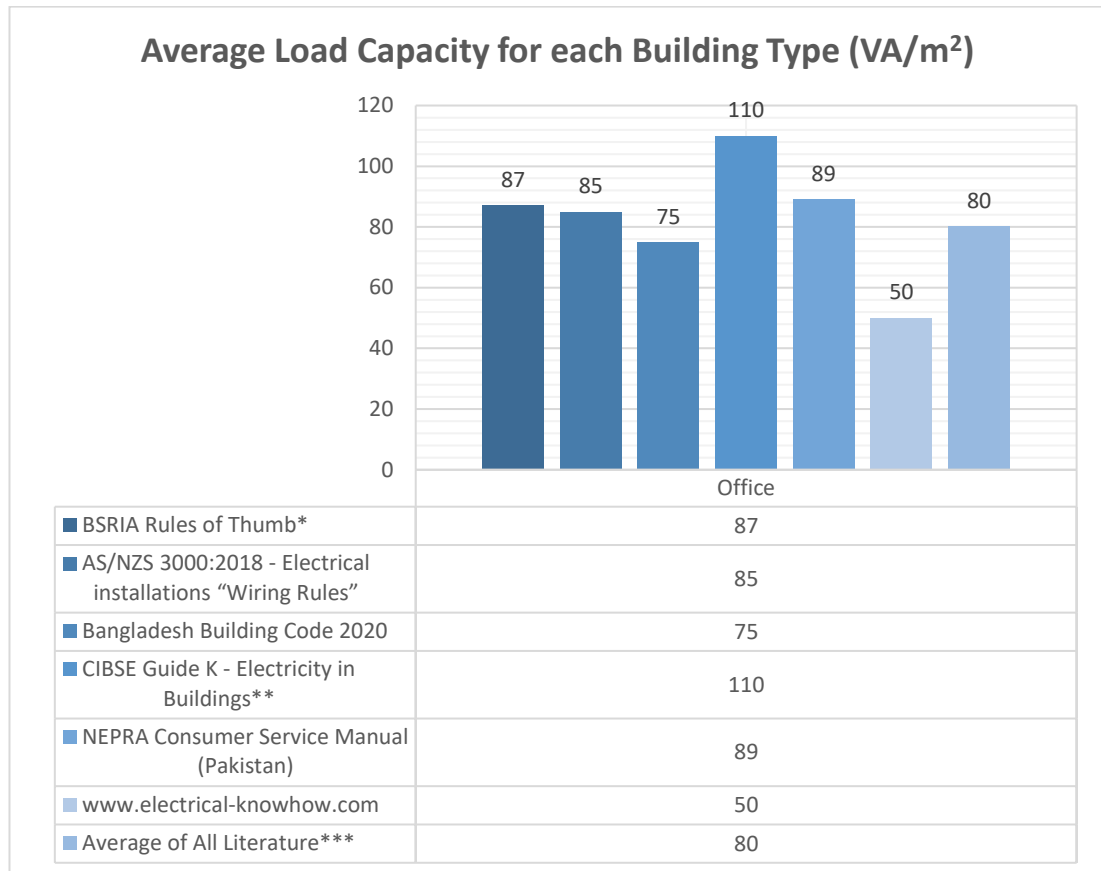
In Sri Lanka, the Ceylon Electricity Board (CEB) has established a set of standards and guidelines for electrical installations in buildings. These include the Sri Lanka Standard Code of Practice for Electrical Wiring Installations (SLS 1016), the CEB Electrical Engineering Handbook, and the Electrical Installations in Buildings

Regulations. However, these guidelines mainly focus on safety aspects rather than addressing the issue of maximum electrical demand in buildings.

**Conclusion:**

The literature review highlights the importance of developing an assessment criteria for maximum electrical demand in buildings in Sri Lanka. Although several international standards and guidelines have been developed, their applicability in Sri Lanka needs to be evaluated. Research papers on the topic are limited, and there is a need for comprehensive data on maximum electrical demand in buildings in Sri Lanka. Local standards and guidelines mainly focus on safety aspects and need to be updated to address the issue of maximum electrical demand in buildings.

### 2.10.1 Office



**Figure 14 - Office Average Load as per Literature Review**

Notes;

*\*Residential load without diversity*

*\*\*with assumed AC loads added*

*\*\*\*calculated average*

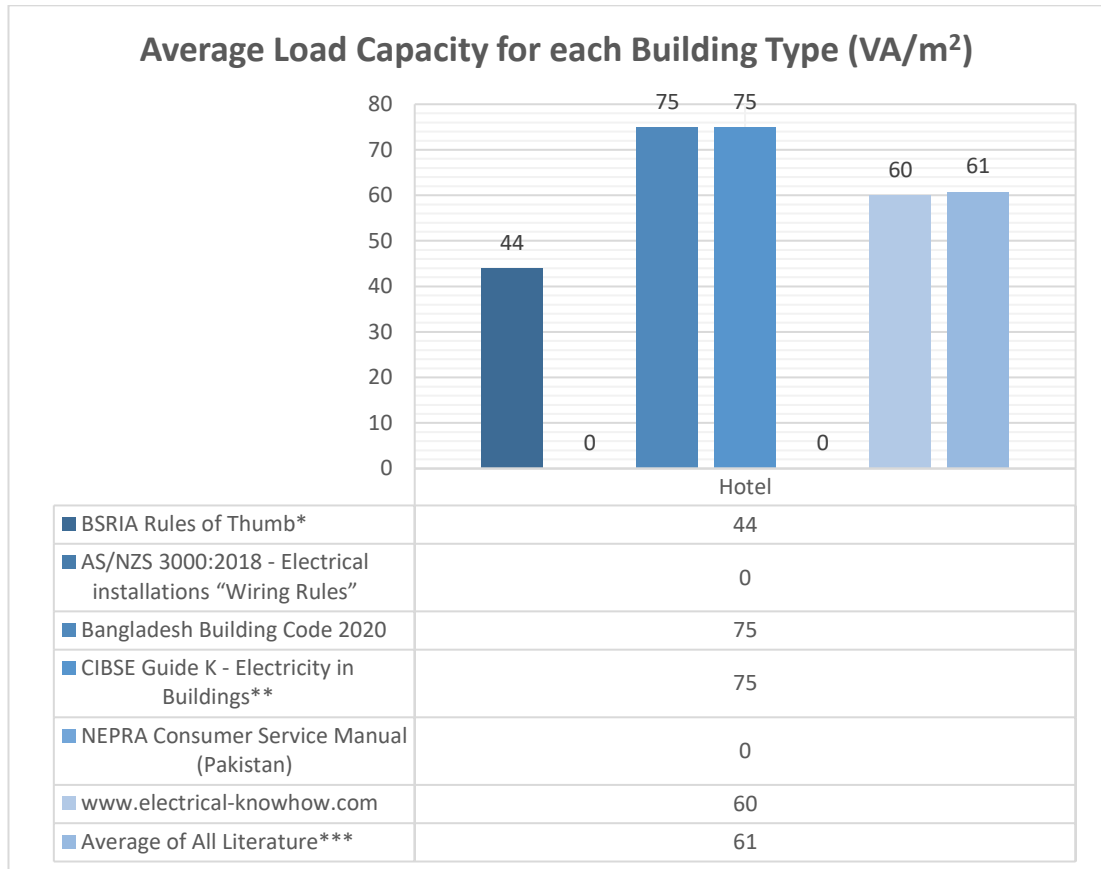
The recommended maximum electrical demand values for office buildings suggested by the reviewed documents show significant differences. The average value of 80 VA/m<sup>2</sup> suggested by all the reviewed documents can only provide a rough idea as each value cannot be compared directly. Therefore, it is important to critically evaluate each document and determine the most appropriate value for Sri Lanka's context.

One reason for the disparity in the recommended values could be due to the variation in the electrical equipment used in different countries. Additionally, different countries may have different building regulations, climate conditions, and energy efficiency standards that may affect the electrical demand of office buildings. Therefore, it is

essential to consider these factors when determining the most appropriate maximum electrical demand value for office buildings in Sri Lanka.

To ensure that the electrical systems of office buildings in Sri Lanka are designed accurately and efficiently, it is important to conduct a detailed analysis of real building data. This analysis should consider the actual building occupancy, equipment, and environmental conditions to accurately estimate the electrical demand of office buildings in Sri Lanka. This will help to determine the most appropriate maximum electrical demand value for office buildings in Sri Lanka, which can result in a more efficient and cost-effective design of electrical systems.

### 2.10.2 Hotel



**Figure 15 - Hotel Average Load as per Literature Review**

Notes;

*\*Residential load without diversity*

*\*\*with assumed AC loads added*

*\*\*\*calculated average*

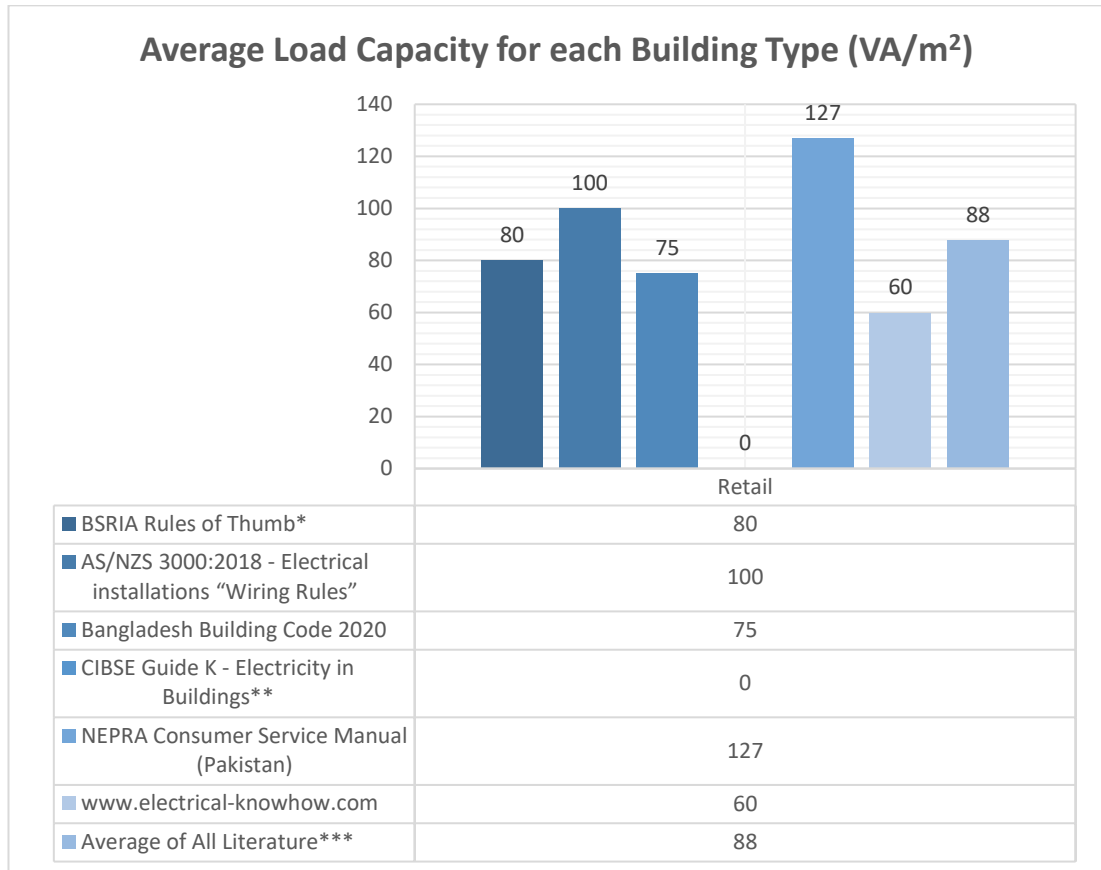
After reviewing the available literature on maximum electrical demand for hotel buildings, it was found that there are significant differences between the values recommended by different sources. The average value suggested by the reviewed documents was 61 VA/m<sup>2</sup>, which is notably lower than the average value suggested for office buildings.

One possible reason for this discrepancy could be that hotel buildings typically have a higher proportion of non-fixed loads such as lighting and air conditioning, which can vary greatly depending on occupancy levels and time of day. Therefore, it may be more challenging to accurately predict the maximum electrical demand for hotels compared to office buildings.

Another factor that may impact the maximum electrical demand in hotels is the type and level of services offered. For example, a luxury hotel with multiple restaurants, spas, and entertainment facilities would likely have higher demand compared to a budget hotel with limited amenities. However, the reviewed literature did not provide detailed information on how different hotel types and services may affect maximum electrical demand.

Overall, more research is needed to develop a comprehensive understanding of the factors that influence maximum electrical demand in hotel buildings, and to establish appropriate assessment criteria that can be applied in the Sri Lankan context.

### 2.10.3 Retail



**Figure 16** – Retail Average Load as per Literature Review

Notes;

*\*Residential load without diversity*

*\*\*with assumed AC loads added*

*\*\*\*calculated average*

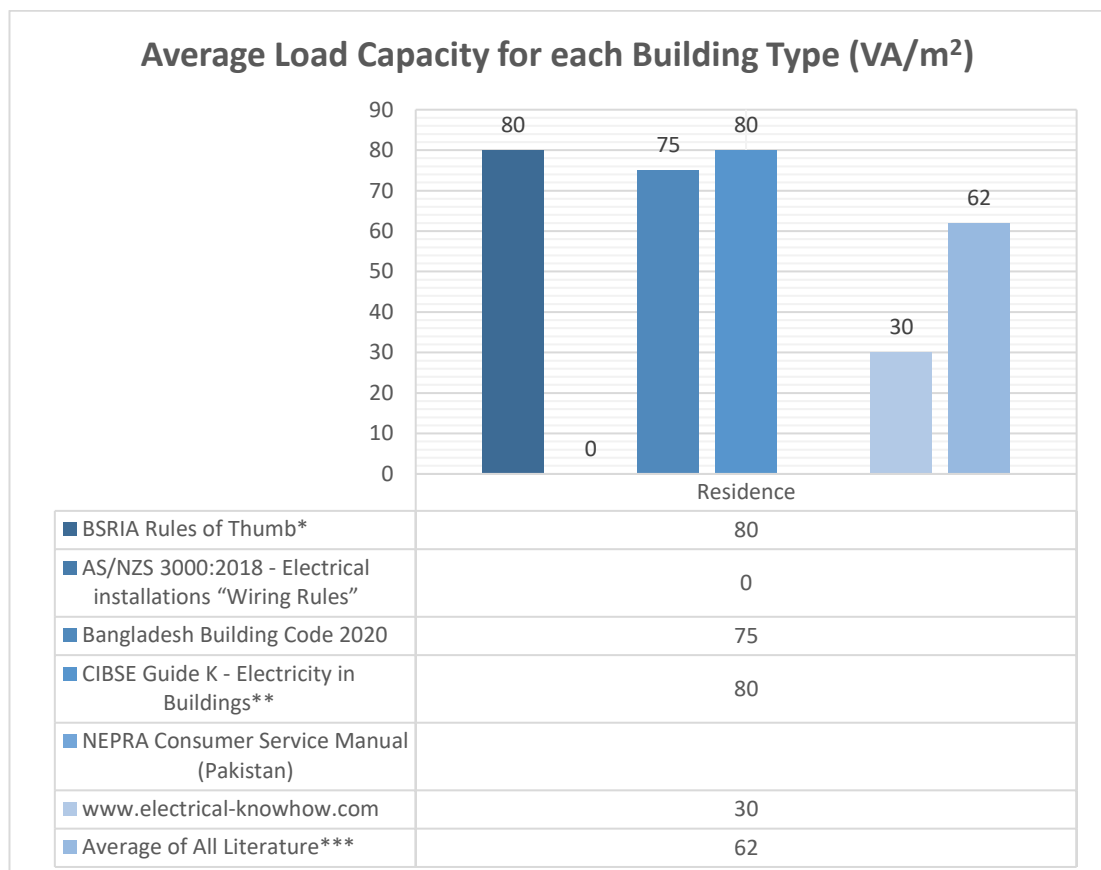
In the reviewed literature on retail buildings, it was found that the recommended maximum electrical demand values vary significantly. Most of the reviewed documents suggest values in the range of 50 to 120 VA/m<sup>2</sup>. The average value suggested by all the reviewed documents is 88 VA/m<sup>2</sup>, which indicates a higher demand compared to office and hotel buildings.

One reason for this higher demand could be the type of appliances and equipment used in retail buildings. Retail spaces typically require high levels of lighting, air conditioning, and ventilation to create a comfortable shopping environment. Additionally, retail spaces often have multiple floors, escalators, elevators, and other systems that consume significant amounts of energy.

The recommended values for maximum electrical demand in retail buildings also depend on the size and function of the building. For example, larger retail spaces may require higher electrical demand to accommodate more customers and products. Additionally, certain retail types, such as supermarkets and department stores, may require higher electrical demand compared to smaller shops.

Overall, the reviewed literature highlights the need for a more accurate assessment of maximum electrical demand in retail buildings. A comprehensive benchmarking study of retail buildings in Sri Lanka can help identify the average values for maximum electrical demand for different types and sizes of retail spaces. This can then be used to develop more accurate assessment criteria for maximum electrical demand in retail buildings in Sri Lanka.

#### 2.10.4 Residential



**Figure 17** – Residential Average Load as per Literature Review

Notes;

*\*Residential load without diversity*

*\*\*with assumed AC loads added*

*\*\*\*calculated average*

In the literature review on residential buildings, it was found that there are significant differences in the recommended values for maximum electrical demand. The average value suggested by all reviewed documents is around 62 VA/m<sup>2</sup>. However, it is important to note that each document uses different calculation methods, and therefore the values cannot be directly compared.

One of the main factors influencing the maximum electrical demand in residential buildings is the type of appliances and equipment used. The number of occupants in the building, their lifestyles, and the duration of their stay also have a significant impact on the maximum demand. It was observed that the maximum demand in residential buildings is significantly affected by the use of air conditioning systems, water heating systems, and cooking appliances.

It is important to consider the geographical location of the building as well. For instance, buildings located in warmer regions may have a higher maximum demand due to the increased use of air conditioning systems. Additionally, the construction quality of the building and the type of insulation used also affect the maximum demand.

Overall, it is clear that there is a need for a more standardized approach to determining the maximum electrical demand for residential buildings. The development of an assessment criteria for maximum demand in Sri Lanka would be beneficial in ensuring that buildings are designed and constructed to meet the energy needs of their occupants while also ensuring efficiency and sustainability.

### 3. DATA COLLECTION

In order to develop a reliable assessment criteria for maximum electrical demand in Sri Lankan buildings, it is crucial to gather accurate and comprehensive data related to various building types. The initial stage of data collection focused on four building categories, namely Hotel, Residential, Office, and Retail. Several parameters were gathered to provide a complete overview of the electrical demand characteristics of these buildings.

The first parameter collected was the Gross Floor Area ( $m^2$ ) of the building, which is a critical factor that influences electrical demand. The requested demand from Ceylon Electricity Board (CEB) (kVA) was also recorded as it provides insight into the building's power requirements. Transformer size (kVA) was also recorded to determine the building's backup power requirements.

The actual electrical demand of each building was determined by recording the real maximum demand (kVA) for the past three (3) years each month along with the % occupancy.

As of now, data on three (3) buildings from each of the four (4) categories, Retail, Apartment, Hotel, and Office, have been collected. The data collected will provide the foundation for developing an assessment criteria that is relevant to Sri Lankan buildings. By analyzing the data collected, patterns and trends can be identified, which will aid in the development of appropriate correction factors to improve the accuracy of the assessment criteria. The aim is to develop an assessment criteria that is reliable, relevant, and useful in optimizing electrical demand in Sri Lankan buildings.

For building categories; Hotel, Residential, Office & Retail following parameters were gathered as the initial stage of data collection.

1. Gross Floor area ( $m^2$ )
2. Requested Demand from CEB (kVA)
3. Transformer Size (kVA)
4. Real Maximum Demand (kVA)
5. Occupancy rate (%)

### 3.1 Retail

#### 3.1.1 Majestic city

##### *Building Introduction*

Majestic City is a shopping mall and commercial complex located in the heart of Colombo, located in Bambalapitiya. The building is situated on Galle Road, which is one of the busiest streets in the city and a major commercial hub.

Majestic City was built in the 1990s and has since undergone several renovations and upgrades. It has a total of six floors, including a basement level and a rooftop terrace.

The shopping mall at Majestic City is spread over three floors and features a wide range of stores (240), including fashion retailers, electronics shops, and bookstores. The mall also has a cinema complex, which screens the latest movies in multiple languages. The building has a large parking lot and is easily accessible by public transportation.

##### *Collected Data*

Collected data are as follows;

<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	20,500	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,000 x 2	kVA
<b>Real Maximum Demand (kVA)</b>	885	kVA
<b>Real Maximum Occupancy (%)</b>	60	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	25	525
<b>Feb-21</b>	27.6	30	575
<b>Mar-21</b>	28	30	585
<b>Apr-21</b>	28.7	35	645
<b>May-21</b>	28.8	35	650
<b>Jun-21</b>	28.7	35	645
<b>Jul-21</b>	28.5	25	545
<b>Aug-21</b>	28.1	10	395
<b>Sep-21</b>	28	15	440
<b>Oct-21</b>	27.8	30	580

<b>Nov-21</b>	27.5	40	665
<b>Dec-21</b>	27.3	45	710
<b>Jan-22</b>	27.5	40	665
<b>Feb-22</b>	27.6	40	670
<b>Mar-22</b>	28	30	585
<b>Apr-22</b>	28.7	25	550
<b>May-22</b>	28.8	20	505
<b>Jun-22</b>	28.7	10	410
<b>Jul-22</b>	28.5	25	545
<b>Aug-22</b>	28.1	30	585
<b>Sep-22</b>	28	40	680
<b>Oct-22</b>	27.8	45	720
<b>Nov-22</b>	27.5	50	760
<b>Dec-22</b>	27.3	55	805
<b>Jan-23</b>	27.5	45	715
<b>Feb-23</b>	27.6	50	765
<b>Mar-23</b>	28	55	820
<b>Apr-23</b>	28.7	60	885
<b>May-23</b>	28.8	45	745
<b>Jun-23</b>	28.7	50	790
<b>Jul-23</b>	28.5	50	785
<b>Aug-23</b>	28.1	50	775
<b>Sep-23</b>	28	45	725
<b>Oct-23</b>	27.8	50	770
<b>Nov-23</b>	27.5	55	810
<b>Dec-23</b>	27.3	60	850

### 3.1.2 One Galle Face

#### *Building Introduction*

One Galle Face is a mixed-use complex of buildings built near the Galle Face Green in Colombo, Sri Lanka. It is also Sri Lanka's first internationally developed and managed mixed-use project and was officially opened in November 2019. The mall consists of 46,000 square metres (490,000 sq ft) of lettable commercial space distributed among seven (7) floors. The facility consists of four skyscrapers, one which will be open for businesses to set up offices, two for the residential component, and the fourth as part of a hotel.

#### *Collected Data*

Collected data are as follows;

<b>Table 9 - Summary of Collected Data – Retail – One Galle Face</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>

<b>Gross Floor area (m2)</b>	93,000	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	2,500 + 2,000 x 4	kVA
<b>Real Maximum Demand (kVA)</b>	4,325	kVA
<b>Real Maximum Occupancy (%)</b>	80	%

<b>Table 10 – Total Collected Data – Retail – One Galle Face</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	30	2,455
<b>Feb-21</b>	27.6	40	2,790
<b>Mar-21</b>	28	40	2,895
<b>Apr-21</b>	28.7	45	3,240
<b>May-21</b>	28.8	45	3,265
<b>Jun-21</b>	28.7	45	3,240
<b>Jul-21</b>	28.5	30	2,720
<b>Aug-21</b>	28.1	10	1,995
<b>Sep-21</b>	28	20	2,275
<b>Oct-21</b>	27.8	40	2,845
<b>Nov-21</b>	27.5	50	3,075
<b>Dec-21</b>	27.3	60	3,330
<b>Jan-22</b>	27.5	50	3,075
<b>Feb-22</b>	27.6	50	3,100
<b>Mar-22</b>	28	40	2,895
<b>Apr-22</b>	28.7	30	2,775
<b>May-22</b>	28.8	25	2,645
<b>Jun-22</b>	28.7	10	2,155
<b>Jul-22</b>	28.5	30	2,720
<b>Aug-22</b>	28.1	40	2,925
<b>Sep-22</b>	28	50	3,205
<b>Oct-22</b>	27.8	60	3,465
<b>Nov-22</b>	27.5	65	3,540
<b>Dec-22</b>	27.3	70	3,640
<b>Jan-23</b>	27.5	60	3,385
<b>Feb-23</b>	27.6	65	3,565
<b>Mar-23</b>	28	70	3,825
<b>Apr-23</b>	28.7	80	4,325
<b>May-23</b>	28.8	60	3,730
<b>Jun-23</b>	28.7	65	3,860
<b>Jul-23</b>	28.5	65	3,805
<b>Aug-23</b>	28.1	65	3,700
<b>Sep-23</b>	28	60	3,515
<b>Oct-23</b>	27.8	65	3,620
<b>Nov-23</b>	27.5	70	3,695
<b>Dec-23</b>	27.3	80	3,950

### 3.1.3 Liberty Plaza

#### *Building Introduction*

Liberty Plaza is a shopping mall and office complex located in the heart of Colombo, the capital city of Sri Lanka.

The Liberty Plaza building was built in 1982 and has since undergone several renovations and expansions. It has a total of eight (8) floors, including a basement level and a rooftop terrace.

The shopping mall at Liberty Plaza is spread over four (4) floors and features a variety of stores, including fashion retailers, electronics shops, and restaurants. The building has a large parking lot and is easily accessible by public transportation.

#### *Collected Data*

<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	19,500	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,000 x 2	kVA
<b>Real Maximum Demand (kVA)</b>	860	kVA
<b>Real Maximum Occupancy (%)</b>	70	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	30	620
<b>Feb-21</b>	27.6	35	650
<b>Mar-21</b>	28	35	660
<b>Apr-21</b>	28.7	40	705
<b>May-21</b>	28.8	40	705
<b>Jun-21</b>	28.7	40	705
<b>Jul-21</b>	28.5	30	645
<b>Aug-21</b>	28.1	10	530
<b>Sep-21</b>	28	15	555
<b>Oct-21</b>	27.8	35	655
<b>Nov-21</b>	27.5	40	670
<b>Dec-21</b>	27.3	45	690
<b>Jan-22</b>	27.5	45	695
<b>Feb-22</b>	27.6	45	700
<b>Mar-22</b>	28	35	660
<b>Apr-22</b>	28.7	30	650
<b>May-22</b>	28.8	20	600

<b>Jun-22</b>	28.7	10	550
<b>Jul-22</b>	28.5	30	645
<b>Aug-22</b>	28.1	35	660
<b>Sep-22</b>	28	45	710
<b>Oct-22</b>	27.8	50	730
<b>Nov-22</b>	27.5	55	750
<b>Dec-22</b>	27.3	60	770
<b>Jan-23</b>	27.5	65	800
<b>Feb-23</b>	27.6	65	805
<b>Mar-23</b>	28	65	815
<b>Apr-23</b>	28.7	70	860
<b>May-23</b>	28.8	65	835
<b>Jun-23</b>	28.7	60	805
<b>Jul-23</b>	28.5	60	800
<b>Aug-23</b>	28.1	65	815
<b>Sep-23</b>	28	60	790
<b>Oct-23</b>	27.8	60	785
<b>Nov-23</b>	27.5	65	800
<b>Dec-23</b>	27.3	70	820

### 3.2 Apartments

#### 3.2.1 One Galle Face

##### *Building Introduction*

One Galle Face is a mixed-use complex of buildings built near the Galle Face Green in Colombo, Sri Lanka. It is also Sri Lanka's first internationally developed and managed mixed-use project and was officially opened in November 2019. The twin towers of the residential component are 51 storeys each. [1]

##### *Collected Data*

Collected data are as follows;

<b>Table 13 - Collected Data – Apartment – One Galle Face</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	155,000	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,500 x 5	kVA
<b>Real Maximum Demand (kVA)</b>	1,200	kVA
<b>Real Maximum Occupancy (%)</b>	60	%

<b>Table 14 – Total Collected Data – Apartment – One Galle Face</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	50	711

<b>Feb-21</b>	27.6	50	700
<b>Mar-21</b>	28	50	716
<b>Apr-21</b>	28.7	45	735
<b>May-21</b>	28.8	45	735
<b>Jun-21</b>	28.7	45	735
<b>Jul-21</b>	28.5	45	700
<b>Aug-21</b>	28.1	45	720
<b>Sep-21</b>	28	50	850
<b>Oct-21</b>	27.8	50	850
<b>Nov-21</b>	27.5	55	987
<b>Dec-21</b>	27.3	55	987
<b>Jan-22</b>	27.5	45	685
<b>Feb-22</b>	27.6	45	685
<b>Mar-22</b>	28	45	685
<b>Apr-22</b>	28.7	45	735
<b>May-22</b>	28.8	45	735
<b>Jun-22</b>	28.7	45	735
<b>Jul-22</b>	28.5	45	700
<b>Aug-22</b>	28.1	45	700
<b>Sep-22</b>	28	45	700
<b>Oct-22</b>	27.8	50	850
<b>Nov-22</b>	27.5	50	950
<b>Dec-22</b>	27.3	55	950
<b>Jan-23</b>	27.5	55	950
<b>Feb-23</b>	27.6	55	950
<b>Mar-23</b>	28	55	950
<b>Apr-23</b>	28.7	55	1,000
<b>May-23</b>	28.8	50	1,000
<b>Jun-23</b>	28.7	50	1,000
<b>Jul-23</b>	28.5	50	1,000
<b>Aug-23</b>	28.1	50	1,000
<b>Sep-23</b>	28	55	1,120
<b>Oct-23</b>	27.8	55	1,090
<b>Nov-23</b>	27.5	60	1,200
<b>Dec-23</b>	27.3	60	1,180

### 3.2.2 AVIC Astoria

#### *Building Introduction*

Avic Astoria Apartments is a super luxury apartment centrally located at R A De Mel Mawatha, Colombo 03, Sri Lanka, is a luxury Apartment complex at the heart of Colombo comprising with 4 towers and 608 luxury apartments overlooking the Indian Ocean. [1]

#### *Collected Data*

Collected data are as follows;

<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	113,000	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,600 x 3	kVA
<b>Real Maximum Demand (kVA)</b>	990	kVA
<b>Real Maximum Occupancy (%)</b>	75	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	65	675
<b>Feb-21</b>	27.6	65	680
<b>Mar-21</b>	28	70	845
<b>Apr-21</b>	28.7	70	885
<b>May-21</b>	28.8	65	755
<b>Jun-21</b>	28.7	60	605
<b>Jul-21</b>	28.5	60	595
<b>Aug-21</b>	28.1	60	570
<b>Sep-21</b>	28	65	705
<b>Oct-21</b>	27.8	65	695
<b>Nov-21</b>	27.5	70	815
<b>Dec-21</b>	27.3	70	805
<b>Jan-22</b>	27.5	60	535
<b>Feb-22</b>	27.6	60	540
<b>Mar-22</b>	28	65	700
<b>Apr-22</b>	28.7	60	605
<b>May-22</b>	28.8	55	470
<b>Jun-22</b>	28.7	60	605
<b>Jul-22</b>	28.5	60	595
<b>Aug-22</b>	28.1	65	710
<b>Sep-22</b>	28	60	565
<b>Oct-22</b>	27.8	65	695

<b>Nov-22</b>	27.5	65	675
<b>Dec-22</b>	27.3	70	800
<b>Jan-23</b>	27.5	70	815
<b>Feb-23</b>	27.6	65	680
<b>Mar-23</b>	28	65	705
<b>Apr-23</b>	28.7	70	885
<b>May-23</b>	28.8	65	755
<b>Jun-23</b>	28.7	65	745
<b>Jul-23</b>	28.5	65	735
<b>Aug-23</b>	28.1	65	710
<b>Sep-23</b>	28	70	845
<b>Oct-23</b>	27.8	75	990
<b>Nov-23</b>	27.5	75	945
<b>Dec-23</b>	27.3	70	805

### 3.2.3 Capital Trust Residencies

#### *Building Introduction*

Located in Colombo, this project consists of eight (8) floors and 32 extravagantly appointed two, three and four-bedroom apartments, which command panoramic views of the city. This complex has a large swimming pool, a fully equipped gymnasium, and a rooftop terrace for private gatherings.

#### *Collected Data*

Collected data are as follows;

<b>Table 17 - Collected Data – Apartment – Capital Trust Residencies</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	6,500	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	250	kVA
<b>Real Maximum Demand (kVA)</b>	75	kVA
<b>Real Maximum Occupancy (%)</b>	75	%

<b>Table 18 – Total Collected Data – Apartment – Capital Trust Residencies</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	75	65
<b>Feb-21</b>	27.6	75	65
<b>Mar-21</b>	28	75	70
<b>Apr-21</b>	28.7	75	70
<b>May-21</b>	28.8	75	75
<b>Jun-21</b>	28.7	70	60
<b>Jul-21</b>	28.5	70	60

<b>Aug-21</b>	28.1	70	60
<b>Sep-21</b>	28	75	70
<b>Oct-21</b>	27.8	75	65
<b>Nov-21</b>	27.5	75	65
<b>Dec-21</b>	27.3	75	65
<b>Jan-22</b>	27.5	75	65
<b>Feb-22</b>	27.6	75	65
<b>Mar-22</b>	28	75	70
<b>Apr-22</b>	28.7	75	70
<b>May-22</b>	28.8	75	75
<b>Jun-22</b>	28.7	75	70
<b>Jul-22</b>	28.5	75	70
<b>Aug-22</b>	28.1	75	70
<b>Sep-22</b>	28	75	70
<b>Oct-22</b>	27.8	75	65
<b>Nov-22</b>	27.5	75	65
<b>Dec-22</b>	27.3	75	65
<b>Jan-23</b>	27.5	75	65
<b>Feb-23</b>	27.6	70	55
<b>Mar-23</b>	28	70	60
<b>Apr-23</b>	28.7	65	50
<b>May-23</b>	28.8	65	55
<b>Jun-23</b>	28.7	70	60
<b>Jul-23</b>	28.5	70	60
<b>Aug-23</b>	28.1	70	60
<b>Sep-23</b>	28	70	60
<b>Oct-23</b>	27.8	75	65
<b>Nov-23</b>	27.5	75	65
<b>Dec-23</b>	27.3	75	65

### 3.3 Hotel

#### 3.3.1 One Galle Face

##### *Building Introduction*

One Galle Face is a mixed-use complex of buildings built near the Galle Face Green in Colombo, Sri Lanka. It is also Sri Lanka's first internationally developed and managed mixed-use project and was officially opened in November 2019. The hotel has 500 rooms and 41 serviced apartments. [1]

##### *Collected Data*

Collected data are as follows;

<b>Table 19 - Collected Data – Hotel – One Galle Face</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	60,000	m <sup>2</sup>

<b>Transformer Size (kVA)</b>	1,500 x 4	kVA
<b>Real Maximum Demand (kVA)</b>	2,150	kVA
<b>Real Maximum Occupancy (%)</b>	60	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	10	1,930
<b>Feb-21</b>	27.6	15	1,950
<b>Mar-21</b>	28	20	1,850
<b>Apr-21</b>	28.7	20	1,990
<b>May-21</b>	28.8	25	2,010
<b>Jun-21</b>	28.7	20	2,050
<b>Jul-21</b>	28.5	10	1,955
<b>Aug-21</b>	28.1	10	1,945
<b>Sep-21</b>	28	10	1,945
<b>Oct-21</b>	27.8	10	1,940
<b>Nov-21</b>	27.5	25	2,050
<b>Dec-21</b>	27.3	40	2,020
<b>Jan-22</b>	27.5	40	2,025
<b>Feb-22</b>	27.6	45	2,045
<b>Mar-22</b>	28	50	2,070
<b>Apr-22</b>	28.7	40	2,000
<b>May-22</b>	28.8	25	2,010
<b>Jun-22</b>	28.7	10	1,960
<b>Jul-22</b>	28.5	20	1,985
<b>Aug-22</b>	28.1	25	1,995
<b>Sep-22</b>	28	25	1,990
<b>Oct-22</b>	27.8	25	1,985
<b>Nov-22</b>	27.5	40	2,120
<b>Dec-22</b>	27.3	55	2,070
<b>Jan-23</b>	27.5	55	2,075
<b>Feb-23</b>	27.6	60	2,090
<b>Mar-23</b>	28	60	2,150
<b>Apr-23</b>	28.7	60	2,120
<b>May-23</b>	28.8	55	2,105
<b>Jun-23</b>	28.7	50	2,050
<b>Jul-23</b>	28.5	60	2,115
<b>Aug-23</b>	28.1	60	2,105
<b>Sep-23</b>	28	55	2,085
<b>Oct-23</b>	27.8	55	2,080
<b>Nov-23</b>	27.5	55	2,075
<b>Dec-23</b>	27.3	60	2,085

### 3.3.2 Galadari Hotel

#### *Building Introduction*

Galadari Hotel is a luxury hotel located in Colombo, the capital city of Sri Lanka. The Galadari Hotel was built in 1984 and has undergone several renovations and upgrades since then. It has a total of twelve (12) floors, including a rooftop terrace, and offers 450 rooms and suites.

The hotel offers a range of amenities for guests, including multiple restaurants and bars, a swimming pool, a fitness center, a spa, and a casino. It also has several meeting and event spaces, including a grand ballroom that can accommodate up to 1,000 guests.

#### *Collected Data*

Collected data are as follows;

<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	40,500	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	2,000 x 2	kVA
<b>Real Maximum Demand (kVA)</b>	1,185	kVA
<b>Real Maximum Occupancy (%)</b>	45	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	10	895
<b>Feb-21</b>	27.6	10	900
<b>Mar-21</b>	28	15	925
<b>Apr-21</b>	28.7	15	1,065
<b>May-21</b>	28.8	20	960
<b>Jun-21</b>	28.7	15	940
<b>Jul-21</b>	28.5	10	1,020
<b>Aug-21</b>	28.1	10	910
<b>Sep-21</b>	28	10	905
<b>Oct-21</b>	27.8	10	905
<b>Nov-21</b>	27.5	20	930
<b>Dec-21</b>	27.3	35	1,145
<b>Jan-22</b>	27.5	30	1,120
<b>Feb-22</b>	27.6	35	985
<b>Mar-22</b>	28	40	1,010
<b>Apr-22</b>	28.7	30	990
<b>May-22</b>	28.8	20	960
<b>Jun-22</b>	28.7	10	920

<b>Jul-22</b>	28.5	15	1,075
<b>Aug-22</b>	28.1	20	945
<b>Sep-22</b>	28	20	1,100
<b>Oct-22</b>	27.8	20	940
<b>Nov-22</b>	27.5	30	965
<b>Dec-22</b>	27.3	40	995
<b>Jan-23</b>	27.5	40	1,000
<b>Feb-23</b>	27.6	45	1,100
<b>Mar-23</b>	28	45	1,030
<b>Apr-23</b>	28.7	45	1,040
<b>May-23</b>	28.8	40	1,025
<b>Jun-23</b>	28.7	35	1,010
<b>Jul-23</b>	28.5	45	1,185
<b>Aug-23</b>	28.1	45	1,030
<b>Sep-23</b>	28	40	1,010
<b>Oct-23</b>	27.8	40	1,065
<b>Nov-23</b>	27.5	40	1,000
<b>Dec-23</b>	27.3	45	1,015

### 3.3.3 Eden Hotel

#### *Building Introduction*

Eden Resort & Spa is a luxury hotel located in Beruwala, a coastal town in the southwestern part of Sri Lanka. The hotel is situated on a stretch of golden sand beach, overlooking the Indian Ocean.

The Eden Resort & Spa was built in 1995 and has undergone several renovations and upgrades since then. The building has a contemporary design with elegant interiors and offers 158 rooms and suites, all of which are tastefully decorated and equipped with modern amenities.

#### *Collected Data*

Collected data are as follows;

<b>Table 23 - Collected Data – Hotel – Eden Hotel</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m2)</b>	18,900	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,000	kVA
<b>Real Maximum Demand (kVA)</b>	480	kVA
<b>Real Maximum Occupancy (%)</b>	55	%

<b>Table 24 – Total Collected Data – Hotel – Eden Hotel</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	15	370
<b>Feb-21</b>	27.6	15	375
<b>Mar-21</b>	28	20	390
<b>Apr-21</b>	28.7	20	385
<b>May-21</b>	28.8	25	405
<b>Jun-21</b>	28.7	20	395
<b>Jul-21</b>	28.5	15	380
<b>Aug-21</b>	28.1	15	380
<b>Sep-21</b>	28	15	380
<b>Oct-21</b>	27.8	15	375
<b>Nov-21</b>	27.5	25	400
<b>Dec-21</b>	27.3	45	450
<b>Jan-22</b>	27.5	40	440
<b>Feb-22</b>	27.6	45	465
<b>Mar-22</b>	28	50	465
<b>Apr-22</b>	28.7	40	445
<b>May-22</b>	28.8	25	405
<b>Jun-22</b>	28.7	15	380
<b>Jul-22</b>	28.5	20	395
<b>Aug-22</b>	28.1	25	415
<b>Sep-22</b>	28	25	405
<b>Oct-22</b>	27.8	25	400
<b>Nov-22</b>	27.5	40	440
<b>Dec-22</b>	27.3	50	460
<b>Jan-23</b>	27.5	50	465
<b>Feb-23</b>	27.6	55	465
<b>Mar-23</b>	28	55	480
<b>Apr-23</b>	28.7	55	480
<b>May-23</b>	28.8	50	470
<b>Jun-23</b>	28.7	45	470
<b>Jul-23</b>	28.5	55	480
<b>Aug-23</b>	28.1	55	480
<b>Sep-23</b>	28	50	465
<b>Oct-23</b>	27.8	50	465
<b>Nov-23</b>	27.5	50	465
<b>Dec-23</b>	27.3	55	475

### 3.4 Office

#### 3.4.1 Sierra Office

##### *Building Introduction*

Sierra head office building situated at Havelock Road, Colombo 05, is a 14 storeys (with roof and basement) office building constructed in year 2016.

### Collected Data

Collected data are as follows;

<b>Table 25 - Collected Data – Office – Sierra Office</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m<sup>2</sup>)</b>	10,550	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,000	kVA
<b>Real Maximum Demand (kVA)</b>	310	kVA
<b>Real Maximum Occupancy (%)</b>	55	%

<b>Table 26 – Total Collected Data – Office – Sierra Office</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	30	170
<b>Feb-21</b>	27.6	30	170
<b>Mar-21</b>	28	30	175
<b>Apr-21</b>	28.7	30	185
<b>May-21</b>	28.8	30	190
<b>Jun-21</b>	28.7	30	185
<b>Jul-21</b>	28.5	30	185
<b>Aug-21</b>	28.1	10	80
<b>Sep-21</b>	28	15	95
<b>Oct-21</b>	27.8	20	120
<b>Nov-21</b>	27.5	25	140
<b>Dec-21</b>	27.3	30	165
<b>Jan-22</b>	27.5	35	195
<b>Feb-22</b>	27.6	35	210
<b>Mar-22</b>	28	30	175
<b>Apr-22</b>	28.7	20	125
<b>May-22</b>	28.8	15	105
<b>Jun-22</b>	28.7	10	80
<b>Jul-22</b>	28.5	15	100
<b>Aug-22</b>	28.1	30	180
<b>Sep-22</b>	28	30	175
<b>Oct-22</b>	27.8	35	200
<b>Nov-22</b>	27.5	40	225
<b>Dec-22</b>	27.3	45	245
<b>Jan-23</b>	27.5	45	260
<b>Feb-23</b>	27.6	45	250
<b>Mar-23</b>	28	45	260
<b>Apr-23</b>	28.7	45	270
<b>May-23</b>	28.8	50	300
<b>Jun-23</b>	28.7	50	295
<b>Jul-23</b>	28.5	50	295
<b>Aug-23</b>	28.1	50	285

<b>Sep-23</b>	28	50	285
<b>Oct-23</b>	27.8	55	310
<b>Nov-23</b>	27.5	55	305
<b>Dec-23</b>	27.3	50	275

### 3.4.2 Coworking Office

#### *Building Introduction*

Coworking Office building situated at Colombo 04, is a three (3) storey office building with offices in all three (3) floors. Office building constructed in year early 1990s.

#### *Collected Data*

Collected data are as follows;

<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m<sup>2</sup>)</b>	1,350	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	100	kVA
<b>Real Maximum Demand (kVA)</b>	50	kVA
<b>Real Maximum Occupancy (%)</b>	90	%

<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	45	35
<b>Feb-21</b>	27.6	45	35
<b>Mar-21</b>	28	45	35
<b>Apr-21</b>	28.7	50	40
<b>May-21</b>	28.8	50	50
<b>Jun-21</b>	28.7	50	40
<b>Jul-21</b>	28.5	50	40
<b>Aug-21</b>	28.1	10	30
<b>Sep-21</b>	28	10	30
<b>Oct-21</b>	27.8	35	35
<b>Nov-21</b>	27.5	40	35
<b>Dec-21</b>	27.3	45	35
<b>Jan-22</b>	27.5	60	35
<b>Feb-22</b>	27.6	60	35
<b>Mar-22</b>	28	45	35
<b>Apr-22</b>	28.7	30	40
<b>May-22</b>	28.8	15	35
<b>Jun-22</b>	28.7	15	35
<b>Jul-22</b>	28.5	25	35
<b>Aug-22</b>	28.1	45	40

<b>Sep-22</b>	28	50	45
<b>Oct-22</b>	27.8	60	40
<b>Nov-22</b>	27.5	65	45
<b>Dec-22</b>	27.3	70	40
<b>Jan-23</b>	27.5	70	40
<b>Feb-23</b>	27.6	75	40
<b>Mar-23</b>	28	75	40
<b>Apr-23</b>	28.7	75	45
<b>May-23</b>	28.8	85	50
<b>Jun-23</b>	28.7	85	45
<b>Jul-23</b>	28.5	80	45
<b>Aug-23</b>	28.1	85	45
<b>Sep-23</b>	28	85	50
<b>Oct-23</b>	27.8	90	45
<b>Nov-23</b>	27.5	90	40
<b>Dec-23</b>	27.3	85	40

### 3.4.3 AVIC Astoria Office

#### *Building Introduction*

Avic Astoria Office is a Class A office building centrally located at R A De Mel Mawatha, Colombo 03, Sri Lanka, It is comprising with four (4) towers, out of which one (1) is Office spaces. [1]

#### *Collected Data*

Collected data are as follows;

<b>Table 29 - Collected Data – Office – Avic Astoria Office</b>		
<b>Description</b>	<b>Value</b>	<b>Unit</b>
<b>Gross Floor area (m<sup>2</sup>)</b>	15,500	m <sup>2</sup>
<b>Transformer Size (kVA)</b>	1,600	kVA
<b>Real Maximum Demand (kVA)</b>	865	kVA
<b>Real Maximum Occupancy (%)</b>	70	%

<b>Table 30 – Total Collected Data – Office – Avic Astoria Office</b>			
<b>Date</b>	<b>Temperature (°C)</b>	<b>Occupancy (%)</b>	<b>Historical Demand (kVA)</b>
<b>Jan-21</b>	27.5	35	735
<b>Feb-21</b>	27.6	35	735
<b>Mar-21</b>	28	35	750
<b>Apr-21</b>	28.7	40	785
<b>May-21</b>	28.8	40	785
<b>Jun-21</b>	28.7	40	790

<b>Jul-21</b>	28.5	40	775
<b>Aug-21</b>	28.1	10	675
<b>Sep-21</b>	28	15	685
<b>Oct-21</b>	27.8	25	710
<b>Nov-21</b>	27.5	30	720
<b>Dec-21</b>	27.3	35	725
<b>Jan-22</b>	27.5	45	765
<b>Feb-22</b>	27.6	45	765
<b>Mar-22</b>	28	35	750
<b>Apr-22</b>	28.7	25	745
<b>May-22</b>	28.8	15	710
<b>Jun-22</b>	28.7	10	695
<b>Jul-22</b>	28.5	20	725
<b>Aug-22</b>	28.1	35	750
<b>Sep-22</b>	28	40	765
<b>Oct-22</b>	27.8	45	770
<b>Nov-22</b>	27.5	50	780
<b>Dec-22</b>	27.3	55	785
<b>Jan-23</b>	27.5	55	795
<b>Feb-23</b>	27.6	60	810
<b>Mar-23</b>	28	60	825
<b>Apr-23</b>	28.7	60	845
<b>May-23</b>	28.8	65	865
<b>Jun-23</b>	28.7	65	860
<b>Jul-23</b>	28.5	65	855
<b>Aug-23</b>	28.1	65	840
<b>Sep-23</b>	28	65	840
<b>Oct-23</b>	27.8	70	855
<b>Nov-23</b>	27.5	70	840
<b>Dec-23</b>	27.3	65	815

### 4. ANALYSIS

#### 4.1 Overview of Electrical Demand

Electrical demand refers to the amount of electrical power required by consumers at any given time. It is a critical component in the management and operation of electrical power systems. Understanding electrical demand involves various concepts such as

- **Peak demand:** Highest level of electricity consumption within a specific period.
- **Load forecasting:** Predicting future electrical demand based on historical data and other factors.

Effective management of electrical demand is essential for ensuring the stability and efficiency of power systems, preventing blackouts, and optimizing the operation of power plants.

#### 4.2 Factors Influencing Electrical Demand in Buildings

Several factors influence electrical demand in buildings. Following were identified as the most significant

- **Climate (Outdoor temperature):** Buildings in warmer climates tend to have higher demand for cooling, especially during peak summer months.
- **Building design** also plays a crucial role; factors such as insulation, window placement, and the use of energy-efficient materials can greatly affect the amount of electricity required to maintain comfortable indoor conditions.
- **Occupancy** patterns are another significant factor; the number of occupants, their behavior, and their schedules can lead to variations in electricity use. For instance, commercial buildings typically experience peak demand during business hours, while residential buildings may have higher demand in the evenings when occupants are at home.
- **Modern technologies and smart appliances** can influence demand patterns by either increasing overall consumption or optimizing it through energy-saving features.

After careful consideration, it was identified that in regions with extreme temperatures, such as Sri Lanka, the need for heating, ventilation, and air conditioning (HVAC) systems significantly impacts electricity consumption, which is directly related to Outside temperature and Occupancy.

Understanding these factors is essential for developing effective strategies to manage and reduce electrical demand in buildings. Hence data related to these two (2) factors were also collected from each building.

### 4.3 Estimating Potential Peak Demand

As identified Outside temperature and Occupancy are the main factors that affects Peak demand of a give project. It is crucial to estimate the maximum potential peak demand for a project. It is not correct to assume the maximum demand recorded in the past three (3) years or even the entire lifetime of the project, as there is always a chance of getting a higher maximum demand if several external factors change. Hence, Linear regression analysis is used to determine the Potential Peak Demand based of the collected past data.

#### 4.3.1 Using Linear Regression Analysis Overview

A common approach in doing this is to create a **predictive mathematical model** based on regression analysis, which can estimate future maximum demand based on historical data.

The **Multiple Linear Regression (MLR)** model is widely used to predict an outcome variable (in this case, **maximum electrical demand**) based on multiple predictor variables. For buildings, key predictors might include:

1. **Ambient Temperature (T)**: Since air conditioning loads are a major part of electrical demand, temperature plays a significant role.
2. **Occupancy Rate (O)**: Higher occupancy tends to increase demand.
3. **Historical Demand (D)**: Past electrical demand data for the building.

The general form of the **MLR** model could be expressed as:

$$\text{Peak Demand (kVA)} = \beta_0 + \beta_1 * T + \beta_2 * O + \beta_3 * D + \epsilon$$

Where:

- $\beta_0, \beta_1, \beta_2, \dots$  are coefficients to be determined by fitting the model to the data.
- T is the ambient temperature ( $^{\circ}\text{C}$ ).
- O is the occupancy rate (%).
- $\epsilon$  is the error term.

### ***Steps to Build the Model:***

- **Data Collection:** Using the monthly historical data collected such as Maximum Demand, Outside Temperature & Occupancy.
- **Data Preprocessing:** Normalize or standardize your data to bring variables like temperature, occupancy, and demand into similar scales.
- **Model Training:** Use the **ordinary least squares (OLS)** method to train the regression model using the available historical data. Split your data into a training set (to fit the model) and a test set (to validate the model).
- **Model Evaluation:** Evaluate the model's performance using metrics such as R-squared, Mean Squared Error (MSE), and Root Mean Squared Error (RMSE) to ensure it captures the variations in demand accurately.
- **Scenario Analysis:** Use the model to predict future demand based on changes in occupancy, temperature, or other variables. Run scenario analysis (e.g., impact of a rise in temperature, an increase in tourism) to assess how maximum demand might shift.

### ***Using the Model to Estimate the peak demand***

Following criteria is used to estimate the potential peak demand. When coming up with the peak demand it is paramount that the future demand doesn't go beyond the estimated peak and also that the estimated peak doesn't have a significant safety margin which we deem the result not accurate;

- **Maximum Outdoor temperature increased by 1 °C.** Considering global warming, this potential increase of the temperature is taken into account.
- **Occupancy reaching 100%.** It is highly unlikely that a building witnesses full occupancy which is 100%. However, always when a design is done, the building should have the ability to occupy 100% of the designed occupancy as there is always a change of this being true.

### **4.3.2 Linear Regression Analysis Results – Retail**

#### ***One Galle Face Retail***

Regression Analysis results are as follows;

Standard Error	1.56
Observations	36

ANOVA	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	10,146,950	5,073,475	2,087,351	0
<b>Residual</b>	33	80	2		
<b>Total</b>	35	10,147,031			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-5,808.88</b>	15.58	-372.84	0.00	-5,840.58	-5,777.18	-5,840.58	-5,777.18
<b>Temperature (°C)</b>	<b>266.73</b>	0.55	488.44	0.00	265.61	267.84	265.61	267.84
<b>Occupancy (%)</b>	<b>31.01</b>	0.02	2,033.99	0.00	30.97	31.04	30.97	31.04

Based on the results, the equation is as follows;

$\text{Peak Demand (kVA)} = -5,808.88 + 266.73 * \text{Temperature} + 31.01 * \text{Occupancy}$
---

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -5,808.88 + 266.73 * 29.8 \text{ }^\circ\text{C} + 31.01 * 100\% \\ &= \mathbf{5,240.1 \text{ kVA}} \end{aligned}$$

### *Majetic City Retail*

Regression Analysis results are as follows;

Standard Error	1.45
Observations	36

ANOVA	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	544,220	272,110	129,851	0
<b>Residual</b>	33	69	2		
<b>Total</b>	35	544,289			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-342.39</b>	14.50	-23.62	0.00	-371.88	-312.90	-371.88	-312.90
<b>Temperature (°C)</b>	<b>22.99</b>	0.51	45.30	0.00	21.96	24.03	21.96	24.03
<b>Occupancy (%)</b>	<b>9.47</b>	0.02	493.75	0.00	9.44	9.51	9.44	9.51

Based on the results, the equation is as follows;

$\text{Peak Demand (kVA)} = -342.39 + 22.99 * \text{Temperature} + 9.47 * \text{Occupancy}$
---

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -342.39 + 22.99 * 29.8 \text{ }^\circ\text{C} + 9.47 * 100\% \\ &= \mathbf{1,290.2 \text{ kVA}} \end{aligned}$$

### ***Liberty Plaza Retail***

Regression Analysis results are as follows;

Standard Error	1.39
Observations	36

<b>ANOVA</b>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	264,211	132,105	68,626	0
<b>Residual</b>	33	64	2		
<b>Total</b>	35	264,274			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-268.54</b>	13.52	-19.86	0.00	-296.05	-241.04	-296.05	-241.04
<b>Temperature (°C)</b>	<b>26.71</b>	0.48	56.17	0.00	25.75	27.68	25.75	27.68
<b>Occupancy (%)</b>	<b>5.20</b>	0.01	368.05	0.00	5.17	5.23	5.17	5.23

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = -268.54 + 26.71 * \text{Temperature} + 5.20 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -268.54 + 26.71 * 29.8 \text{ }^\circ\text{C} + 5.20 * 100\% \\ &= \mathbf{1,047.2 \text{ kVA}} \end{aligned}$$

### 4.3.3 Linear Regression Analysis Results – Apartment

#### *One Galle Face Apartment*

Regression Analysis results are as follows;

Standard Error	66.6
Observations	36

<b>ANOVA</b>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	739,513	369,757	83	0
<b>Residual</b>	33	146,342	4,435		
<b>Total</b>	35	885,856			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-3408.91</b>	831.31	-4.10	0.00	-5100.22	-1717.60	-5100.22	-1717.60
<b>Temperature (°C)</b>	<b>89.59</b>	26.49	3.38	0.00	35.70	143.48	35.70	143.48
<b>Occupancy (%)</b>	<b>35.24</b>	2.88	12.24	0.00	29.38	41.10	29.38	41.10

Based on the results, the equation is as follows;

$\text{Peak Demand (kVA)} = -3,408.91 + 89.59 * \text{Temperature} + 35.24 * \text{Occupancy}$
--

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -3,408.91 + 89.59 * 29.8 + 35.24 * 100 \\ &= \mathbf{2,784.8 \text{ kVA}} \end{aligned}$$

#### *AVIC Astoria Apartment*

Regression Analysis results are as follows;

Standard Error	4.32
Observations	36

<b>ANOVA</b>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	504,408	252,204	13,512	0
<b>Residual</b>	33	616	19		
<b>Total</b>	35	505,024			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-2694.17</b>	50.29	-53.57	0.00	-2796.50	-2591.85	-2796.50	-2591.85
<b>Temperature (°C)</b>	<b>56.40</b>	1.58	35.68	0.00	53.18	59.61	53.18	59.61
<b>Occupancy (%)</b>	<b>28.04</b>	0.17	160.29	0.00	27.68	28.39	27.68	28.39

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = -2,694.17 + 56.40 * \text{Temperature} + 28.04 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -2,694.17 + 56.40 * 29.8 + 28.04 * 100 \\ &= \mathbf{1,790.0 \text{ kVA}} \end{aligned}$$

### ***Capital Trust Apartment***

Regression Analysis results are as follows;

Standard Error	1.29
Observations	36

<b>ANOVA</b>	<b><i>df</i></b>	<b><i>SS</i></b>	<b><i>MS</i></b>	<b><i>F</i></b>	<b><i>Significance F</i></b>
<b>Regression</b>	2	1,020	510	307	0
<b>Residual</b>	33	55	2		
<b>Total</b>	35	1,074			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-238.03</b>	16.81	-14.16	0.00	-272.22	-203.84	-272.22	-203.84
<b>Temperature (°C)</b>	<b>5.44</b>	0.47	11.46	0.00	4.47	6.40	4.47	6.40
<b>Occupancy (%)</b>	<b>2.03</b>	0.08	24.78	0.00	1.86	2.19	1.86	2.19

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = -238.03 + 5.44 * \text{Temperature} + 2.03 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -238.03 + 5.44 * 29.8 + 2.03 * 100 \\ &= \mathbf{126.5 \text{ kVA}} \end{aligned}$$

#### 4.3.4 Linear Regression Analysis Results – Hotel

##### *One Galle Face Hotel*

Regression Analysis results are as follows;

Standard Error	35.42
Observations	36

<b>ANOVA</b>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	119,937	59,969	48	0
<b>Residual</b>	33	41,401	1,255		
<b>Total</b>	35	161,339			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>1213.03</b>	336.66	3.60	0.00	528.10	1897.96	528.10	1897.96
<b>Temperature (°C)</b>	<b>25.04</b>	11.92	2.10	0.04	0.79	49.29	0.79	49.29
<b>Occupancy (%)</b>	<b>3.16</b>	0.32	9.77	0.00	2.50	3.82	2.50	3.82

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = 1213.03 + 25.04 * \text{Temperature} + 3.16 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= 1213.03 + 25.04 * 29.8 + 3.16 * 100 \\ &= \mathbf{2,275.6 \text{ kVA}} \end{aligned}$$

### ***Galadari Hotel***

Regression Analysis results are as follows;

Standard Error	23.23
Observations	36

<b>ANOVA</b>	<b><i>df</i></b>	<b><i>SS</i></b>	<b><i>MS</i></b>	<b><i>F</i></b>	<b><i>Significance F</i></b>
<b>Regression</b>	2	103,924	51,962	96	0
<b>Residual</b>	33	17,800	539		
<b>Total</b>	35	121,724			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>320.25</b>	225.56	1.94	0.06	-21.66	896.16	-21.66	896.16
<b>Temperature (°C)</b>	<b>19.81</b>	7.97	2.49	0.02	3.60	36.02	3.60	36.02
<b>Occupancy (%)</b>	<b>3.46</b>	0.25	13.83	0.00	2.95	3.97	2.95	3.97

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = 320.25 + 19.81 * \text{Temperature} + 3.46 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= 320.25 + 19.81 * 29.8 + 3.46 * 100 \\ &= \mathbf{1,257.0 \text{ kVA}} \end{aligned}$$

### *Eden Hotel*

Regression Analysis results are as follows;

Standard Error	4.83
Observations	36

<b>ANOVA</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>Significance F</b>
<b>Regression</b>	2	53,730	26,865	1,152	0
<b>Residual</b>	33	770	23		
<b>Total</b>	35	54,500			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>197.84</b>	46.31	4.27	0.00	103.61	292.06	103.61	292.06
<b>Temperature (°C)</b>	<b>5.16</b>	1.64	3.16	0.00	1.84	8.49	1.84	8.49
<b>Occupancy (%)</b>	<b>2.52</b>	0.05	47.44	0.00	2.42	2.63	2.42	2.63

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = 197.84 + 5.16 * \text{Temperature} + 2.52 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= 197.84 + 5.16 * 29.8 + 2.52 * 100 \\ &= \mathbf{604.1 \text{ kVA}} \end{aligned}$$

#### 4.3.5 Linear Regression Analysis Results – Office

##### *Sierra Office*

Regression Analysis results are as follows;

Standard Error	3.85
Observations	36

<b>ANOVA</b>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
<b>Regression</b>	2	170,042	85,021	5,739	0
<b>Residual</b>	33	489	15		
<b>Total</b>	35	170,531			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-433.78</b>	37.34	-11.62	0.00	-509.75	-357.80	-509.75	-357.80
<b>Temperature (°C)</b>	<b>16.01</b>	1.31	12.18	0.00	13.33	18.68	13.33	18.68
<b>Occupancy (%)</b>	<b>5.47</b>	0.05	106.11	0.00	5.37	5.58	5.37	5.58

Based on the results, the equation is as follows;

$\text{Peak Demand (kVA)} = -433.78 + 16.01 * \text{Temperature} + 5.47 * \text{Occupancy}$
---

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -433.78 + 16.01 * 29.8 + 5.47 * 100 \\ &= \mathbf{590.5 \text{ kVA}} \end{aligned}$$

### *AVIC Astoria Office*

Regression Analysis results are as follows;

Standard Error	2.28
Observations	36

<b>ANOVA</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>Significance F</b>
<b>Regression</b>	2	97,836	48,918	9,417	0
<b>Residual</b>	33	171	5		
<b>Total</b>	35	98,008			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-182.28</b>	21.77	-8.37	0.00	-226.57	-138.00	-226.57	-138.00
<b>Temperature (°C)</b>	<b>29.52</b>	0.77	38.41	0.00	27.96	31.09	27.96	31.09
<b>Occupancy (%)</b>	<b>3.02</b>	0.02	136.73	0.00	2.97	3.06	2.97	3.06

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = -182.28 + 29.52 * \text{Temperature} + 3.02 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -182.28 + 29.52 * 29.8 + 3.02 * 100 \\ &= \mathbf{999.3 \text{ kVA}} \end{aligned}$$

### *Coworking Office*

Regression Analysis results are as follows;

Standard Error	2.26
Observations	36

<b>ANOVA</b>	<b>df</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>Significance F</b>
<b>Regression</b>	2	623	311	61	0
<b>Residual</b>	33	168	5		
<b>Total</b>	35	791			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
<b>Intercept</b>	<b>-113.11</b>	21.69	-5.22	0.00	-157.23	-68.99	-157.23	-68.99
<b>Temperature (°C)</b>	<b>5.19</b>	0.77	6.78	0.00	3.63	6.74	3.63	6.74
<b>Occupancy (%)</b>	<b>0.17</b>	0.02	9.99	0.00	0.13	0.20	0.13	0.20

Based on the results, the equation is as follows;

$$\text{Peak Demand (kVA)} = -113.11 + 5.19 * \text{Temperature} + 0.17 * \text{Occupancy}$$

Therefore, the estimated peak demand;

$$\begin{aligned} \text{Peak Demand (kVA)} &= -113.11 + 5.19 * 29.8 + 0.17 * 100 \\ &= \mathbf{58.0 \text{ kVA}} \end{aligned}$$

#### 4.4 Results Summary

##### 4.4.1 Retails

###### *One Galle Face Mall*

Calculated values are as follows;

Estimated Potential Peak Demand	5,240	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	56.3	VA/m <sup>2</sup>
Designed 100% demand	8,750	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	94.1	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	50	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%

Current Safety Factor	67	%
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### ***Majetic City***

Calculated values are as follows;

Estimated Potential Peak Demand	1,290	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	62.9	VA/m <sup>2</sup>
Designed 100% demand	1,667	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	81.3	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	65	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	29	%

### ***Liberty Plaza***

Calculated values are as follows;

Estimated Potential Peak Demand	1,047	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	53.7	VA/m <sup>2</sup>
Designed 100% demand	1,667	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	85.5	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	52	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	59	%

## **4.4.2 Apartments**

### ***One Galle Face Apartment***

Calculated values are as follows;

Estimated Potential Peak Demand	2,785	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	18.0	VA/m <sup>2</sup>
Designed 100% demand	6,250	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	40.3	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	37	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%

Current Safety Factor	124	%
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***AVIC Astoria Apartment***

Calculated values are as follows;

Estimated Potential Peak Demand	1,790	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	15.8	VA/m <sup>2</sup>
Designed 100% demand	4,000	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	35.4	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	37	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	123	%

***Capital Trust Apartment***

Calculated values are as follows;

Estimated Potential Peak Demand	126	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	19.5	VA/m <sup>2</sup>
Designed 100% demand	208	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	32.1	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	51	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	65	%

**4.4.3 Offices**

***Sierra Office***

Calculated values are as follows;

Estimated Potential Peak Demand	591	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	56.0	VA/m <sup>2</sup>
Designed 100% demand	833	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	79.0	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	59	%

Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	41	%

### ***AVIC Astoria Office***

Calculated values are as follows;

Estimated Potential Peak Demand	999	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	64.5	VA/m <sup>2</sup>
Designed 100% demand	1,333	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	86.0	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	62	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	33	%

### ***Coworking Office***

Calculated values are as follows;

Estimated Potential Peak Demand	58	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	43.0	VA/m <sup>2</sup>
Designed 100% demand	83	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	61.7	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	58	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	44	%

## **4.4.4 Hotels**

### ***One Galle Face Hotel***

Calculated values are as follows;

Estimated Potential Peak Demand	2,276	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	37.9	VA/m <sup>2</sup>
Designed 100% demand	5,000	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	83.3	VA/m <sup>2</sup>

Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	38	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	120	%

### ***Galadari Hotel***

Calculated values are as follows;

Estimated Potential Peak Demand	1,257	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	31.0	VA/m <sup>2</sup>
Designed 100% demand	3,333	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	82.3	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	31	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	165	%

### ***Eden Hotel***

Calculated values are as follows;

Estimated Potential Peak Demand	604	kVA
Estimated Potential Peak Demand @ 100% Occupancy (VA/m <sup>2</sup> )	32.0	VA/m <sup>2</sup>
Designed 100% demand	833	kVA
Designed 100% demand @ 100% Occupancy (VA/m <sup>2</sup> )	44.1	VA/m <sup>2</sup>
Transformer Maximum Loading (%) as per Estimated Potential Peak Demand	60	%
Transformer Maximum Loading (%) as per Designed 100% demand (Assumption)	80	%
Current Safety Factor	38	%

## **4.5 Reasons Behind the Deviation**

There are several factors that can lead to a deviation between the design and real demand of buildings. Deviations may be as a result of the following:

- 1) A lack of proper understanding of building design and the interaction between components.

- Buildings are complex systems that involve multiple components, such as heating, ventilation, and air conditioning (HVAC), lighting, and electrical systems. If these components are not properly designed and integrated, it can lead to energy inefficiencies and higher energy demand than anticipated.
- 2) Poor prediction tools.
    - Inaccurate modeling and simulation tools can lead to incorrect assumptions about the energy consumption of a building, resulting in overestimation or underestimation of the energy demand. This can also lead to inefficient building operation and higher energy bills.
  - 3) Inadequate detailing.
    - If the design and construction teams do not pay close attention to the details of the building components, such as insulation, windows, and doors, it can result in energy leaks and higher energy demand.
  - 4) Discrepancies between specifications and actual construction.
    - Discrepancies between specifications and actual construction can also contribute to the deviation, as the building may not be constructed according to the design specifications.
  - 5) Poor build quality.
    - If the building is not constructed to high quality standards, it can result in air leaks, poor insulation, and other energy inefficiencies that increase energy demand.
  - 6) The use of idealized performance data for products.
    - Manufacturers often provide performance data based on ideal conditions, which may not reflect the actual operating conditions of the building. As a result, the actual energy demand may be higher than anticipated.
  - 7) Improper user behavior or operation.
    - If building occupants do not use the building systems properly, such as leaving lights on or opening windows when the HVAC system is running, it can result in higher energy demand than anticipated.
  - 8) Unexpected power loads (such as additional ICT equipment, external lighting, and so on).

- As technology advances, new equipment may be added to the building that was not accounted for in the initial design, resulting in higher energy demand.

Overall, there are several factors that can lead to a deviation between the design and real demand of buildings. It is important for designers, builders, and building occupants to be aware of these factors and take steps to mitigate them in order to improve building energy efficiency and reduce energy costs.

#### **4.6 Hotel Load vs. Office Load – Anomaly Explanation**

One notable finding was the lower average electrical load per square meter in hotels compared to office buildings. This can be attributed to several factors:

- **Stringent Hotel Brand Standards:** Usually, hotels are design based on brand standards which are stringent on building energy usage. Hence that can bring down the maximum hotel loads.
- **Load Diversity:** Hotel room usage is staggered and intermittent, leading to higher diversity factors than the continuous usage seen in office spaces.
- **Equipment Utilization:** Hotels have centralized HVAC and hot water systems that benefit from diversity, whereas offices often feature multiple distributed systems operating simultaneously.
- **Occupancy Profiles:** Office buildings typically have near-full occupancy during working hours, whereas hotel occupancy varies daily and seasonally, leading to reduced average demand.
- **Lighting & Plug Loads:** Offices contain higher densities of IT and task lighting equipment, significantly increasing plug and lighting loads compared to hotels.

Further analysis needs to be undertaken as explained in Next Stages section.

### 5. RESULTS

In conclusion, the study aimed to develop an assessment criteria for maximum electrical demand for buildings in Sri Lanka, based on the analysis of real data collected from different building types. The data analysis showed a significant deviation between the designed and actual maximum demand for electricity in all building categories. The study identified several reasons for this deviation, including poor prediction tools, inadequate detailing, poor build quality, and unexpected power loads.

To address this deviation, the study proposes an assessment criteria for maximum electrical demand for buildings in Sri Lanka. The assessment criteria should be based on the following parameters: gross floor area, requested demand from the CEB, transformer size, generator size, real maximum demand, real average demand, per month average energy usage, and tariff category. By using these parameters, building owners and designers can have a better understanding of the electrical demand of their buildings and ensure that the design meets the actual demand.

The assessment criteria should also take into account the specific requirements of each building type, as there are significant differences in the recommended values for each building category. Therefore, the assessment criteria should be tailored to each building type, taking into account the specific needs and usage patterns of each category.

Overall, the study highlights the importance of accurate design and assessment of the maximum electrical demand for buildings in Sri Lanka. The proposed assessment criteria can help building owners and designers to ensure that the electrical demand is accurately estimated, and the design meets the actual demand. This can lead to significant savings / cost reductions in the long run.

#### 5.1 Limitations of the Study

While this study provides valuable insight into the actual versus predicted maximum electrical demand in various building categories in Sri Lanka, there are several limitations to be acknowledged:

- **Basement Loads Not Included:** Electrical loads associated with basement areas (e.g., ventilation, parking lighting, sump pumps) were not separately considered, potentially underrepresenting the total demand. Majority of the buildings don't have Energy Management Systems (EMS) or Building Management System (BMS) which can separate the basement maximum loads. Hence, basements loads could not be taken into account separately.
- **Exclusion of Fire Pumps in Small Buildings:** In smaller buildings where fire pumps are required, their electrical demand might be significant part of the maximum demand, possibly affecting the accuracy of the assessment criteria for smaller structures.
- **Climate Uniformity Assumption:** Regional temperature differences within Sri Lanka were not distinctly factored in, which can impact cooling loads. These limitations highlight the need for careful interpretation when applying the findings to buildings outside the study's scope.

Due to these limitations further analysis shall be carried out as explained in Next Stages section.

## 5.2 Assessment Criteria

Using the collected data and analysis performed, following assessment criteria is developed;

<b>Table 31 – Load Assessment Criteria</b>			
	Current Average Designed Power Density*	<b>Proposed Average Design Power Density*</b>	Proposed % Reduction
<b>Hotel</b>	45 ~ 85 VA/m <sup>2</sup>	<b>30 ~ 40 VA/m<sup>2</sup></b>	45%
<b>Retail</b>	80 ~ 95 VA/m <sup>2</sup>	<b>55 ~ 65 VA/m<sup>2</sup></b>	30%
<b>Residential</b>	30 ~ 40 VA/m <sup>2</sup>	<b>15 ~ 20 VA/m<sup>2</sup></b>	50%
<b>Office</b>	60 ~ 85 VA/m <sup>2</sup>	<b>45 ~ 65 VA/m<sup>2</sup></b>	25%

\*This is the Design density without engineer safety factor. Usually, a safety factor of 15 ~ 20% is used based on the nature of the project in addition to the above values mentioned.

### 5.3 Disclaimer on the Use of Assessment Criteria

The assessment criteria for maximum electrical demand developed in this study are based on a limited sample of buildings and specific contextual conditions in Sri Lanka. These values are intended to serve as a preliminary guideline and benchmarking tool for design-stage estimations.

**Users are strongly advised not to adopt these criteria blindly or without professional judgment.** Project-specific factors such as building usage patterns, operational schedules, occupancy rates, equipment specifications, and local climatic variations can significantly affect actual electrical demand.

Engineers and designers should always validate assumptions with project-specific data, engage in detailed load analysis, and comply with relevant regulatory standards and client requirements. The author assumes no responsibility for any decisions made solely based on the generalized values presented in this study.

### 5.4 Next stages

After concluding the research on the development of an assessment criteria for maximum electrical demand for buildings in Sri Lanka, there are several potential next stages that can be pursued to further improve the accuracy of electrical demand estimation and reduce the deviation between design and actual demand.

- **Conduct a more extensive data collection process with more detailed parameters.** This can help to refine the assessment criteria and tailor it to the specific needs of different building categories and usage patterns.
- **Building Height and Size Consideration:** Future studies should evaluate how vertical distribution (number of floors) and building footprint influence demand profiles.
- **Expanded Sample Size:** Incorporating more projects across additional geographic regions and building types would increase robustness.
- **Fire System Integration:** Investigate methods to incorporate fire protection systems, especially pumps, into the demand calculation framework for more complete estimations.
- **Incorporate the assessment criteria into building design software and tools,** making it easier for designers and engineers to estimate the maximum

electrical demand accurately. This can lead to more accurate and efficient building designs, reducing energy waste and cost overruns.

- **It is essential to conduct awareness and training programs** for building owners and operators, emphasizing the importance of accurate electrical demand estimation and the benefits of energy efficiency. This can help to ensure that the buildings are operated efficiently, and energy waste is minimized.
- **Monitoring and evaluation of building energy performance**, to identify any discrepancies between the estimated and actual electrical demand and make necessary adjustments. This can help to maintain the efficiency and sustainability of the buildings over time.

In conclusion, several potential next stages can be pursued to further improve the accuracy of electrical demand estimation and reduce the deviation between design and actual demand. By pursuing these next stages, building owners, designers, and operators can ensure that buildings are operated efficiently and sustainably, leading to energy savings and cost reductions in the long run.

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