SINGAPORE INTITUTE OF TECHNOLOGY

MASTER OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 6110 Professional Practices in Electrical Engineering

ASSIGNMENT 2

Design of electricity distribution in a mixed commercial development –
to meet the diverse needs of the stakeholders and in compliance with Singapore Standard SS 638: 2018 Code of Practice for Electrical Installations

This Assignment 2 constitutes 30% of the total marks for the course module EEE6110.

Objective:

- To develop capability in design/development of solutions for complex engineering problems through an authentic design exercise on a major building electrical installation, that meets the diverse needs of stakeholders and in compliance with relevant local codes and standards, including sustainability requirements.

Learning Outcomes:

a) (Engineering Knowledge) Apply knowledge of engineering fundamentals and electrical engineering principles to assess the diverse needs of the stakeholders in developing the design philosophy of the electrical installations, taking into account the particular requirements and site conditions of the project.
b) (Design/Development of Solutions) Design electrical installations in buildings which are fit for purpose, and meet requirements of standards and code of practices, including sustainability requirements in energy efficiency.
c) (Engineer and Society) Apply reasoning informed by power engineering knowledge to assess health and safety issues and the consequent responsibilities relevant to professional engineering practice, including electric shock, fires, lightning hazards, and human health arising from exposure to excessive electromagnetic field.

ASSIGNMENT DETAILS

A commercial mixed development project comprises a shopping mall and an office block as shown in Figure 1. The developer aims to attain BCA Green Mark certification at the Platinum category. The major components of the development are:

1) The **podium block** of 7-floor shopping mall from B1 to level 6, with per floor GFA of 3,500 m^2.
    - Assuming 20% GFA as non-Net Lettable Area [(1)]
    - 30% of level 6 mall space is used as F&B space for restaurants [(2)]
    - 25% of level B1 mall space is used as F&B space for restaurants and food court [(2)]
    - The remaining mall space is used as retail space.
2) The **car park** is on basement floors of B2 and B3, with a per floor GFA of approximately 3,500m^2.
3) The **office tower block** extends from level 7 to level 26, with per floor GFA of 1,000 m^2.
    - Assuming 20% GFA as non-Net Lettable Area

Note:

[(1)] Net Lettable Area means the floor area in a building that is to be leased and in respect of which a rent is payable, which generally excludes common areas (such as corridors, public atrium and toilets etc.) and areas used to accommodate building and property management facilities and services (such as Fire Command Center, services risers and M&E plant rooms etc.).

[(2)] For the purpose of this assignment, assume that the power requirement of F&B space is 6 times that of the general power requirement of a retail shopping mall.

The Mechanical & Electrical (M&E) plant rooms and facility installations [(3)] are placed at the rooftop above level 6 shopping mall, and house the following key installations:

- The consumer intake switch-room, transformer rooms
- Electrical boards and sub-systems of the PV installations
- The chillers and cooling towers

Note:

[(3)] Due to mechanical loading and accessibility requirements, the heavy chiller plant room is usually located at basement or ground level. SPPA (22kV/LT) electrical substation is required to be at ground level as per SPPA's guideline unless waiver is granted.

RENEWABLE ENERGY SYSTEM:

In line with Singapore's push for more renewable energy, PV panels are installed at two locations:

a) on rooftop of shopping mall, and
b) on rooftop of office tower

ELECTRIC VEHICLE CHARGING STATIONS

Each level of the B2 and B3 car parks will be equipped with 10 Level 1 charging stations and two Level 3 fast charging stations for electric vehicles.

AIR-CONDITIONING & MECHANICAL VENTILATION SYSTEM:

All shopping mall units and the office tower are provided with centralized air conditioning system.

VERTICAL TRANSPORTATION SYSTEM:

There are two sets of escalators serving B1 to Level 6 of the shopping mall.

There are 2 lift lobbies, each consisting of 1 fireman lift and 3 passenger lifts. Lift lobby A has 4 lifts serving B3 to Level 6 of the shopping mall. Lift lobby B has 4 lifts serving B3, B2 to all levels of the office tower.

ASSIGNMENT REPORT REQUIREMENTS

You have been appointed to take charge of the electrical design work. You are required to conduct research and literature survey to determine the power requirements of similar buildings, andthen carry out the following exercises:

(A) Design philosophy and considerations [20%]

Discuss your design philosophy and particular considerations for the project, including the assessment of general characteristics, building and site conditions. Considerations **to include**:

- Energy efficiency strategy in meeting BCA Green Mark certification
- Requirements and impacts of the vehicle charging stations.
- Requirements and impacts of the PV installations.
- Justification for 22 kV connection to power grid
- Selection of the type of transformer and their optimal sizing (considering data from maximum demand estimation)
- Selection of cables and busducts for building power distribution
- Electrical safety and fire hazards
- Electromagnetic compatibility (EMC) considerations, including power quality arising from PV installations, electric vehicle charging stations and variable speed drives for energy efficiency applications.
- Location of major power equipment and cable routing to prevent possible health hazards arising from exposure to electromagnetic field (EMF)
- Sizing and considerations taken for standby generator(s)
- any other additional considerations

(B) Maximum demand estimation [20%]

You are required to determine the maximum demand in order to apply for a supply connection from network operator – SP PowerGrid.

Your report should include details of spreadsheet calculations to show how you conduct your design estimations and sizing.

You are **to include** the following process in determining the maximum demand:

- List the major electricity consuming equipment and their power ratings (reasonably estimated or extracted from manufacturer's catalogues/datasheets).
- Estimate the power requirement based on per m^2 best practice or guidelines that can be found in Singapore Standards and Green Mark requirements on
  i. lighting requirement at shopping mall
  ii. general power requirement at shopping mall
  iii. lighting power requirement at office tower
  iv. general power requirement at office tower
  v. power requirements for common facilities

- Estimate or extracted from manufacturer's catalogues/datasheets the power requirement of electric vehicle charging stations.
- Estimate the power requirement of restaurants and food court which use primarily electric cookers, ovens, and kitchen extraction fans.
- Estimate and discuss the power demand provided by the PV installation.
- Other loads and provisions assumptions.
- Apply diversity factor where applicable to estimate the maximum demand.
- Plot the estimated demand profile for a typical weekday.
- What is your estimated maximum demand charge per month based on prevailingelectricity tariffs?

(C) Photovoltaic Installations [10%]

You are required to conduct a literature and procurement survey of commercially available PV modules to enable you to understand the power capacity and other performance parameters. You should also make a reasonable estimate of the available space for PV installations at the two designated areas indicated in Figure 1.

- Estimate the available area/space for PV installation.
- Estimate the available kWp or MWp of the PV installations.
- Estimate the likely yearly MWh energy generated by the PV installations based on Singapore weather and particular site conditions.
- Discuss the practical challenges and particular requirements for executing the PV projects.
- Use figures and diagrams to illustrate the connection of the PV installations to the facility LV ac supply system, indicating the major components of the PV electrical system and protective devices.

(D) Conceptual design of power distribution circuits [20%]

- Generate **a conceptual main schematic diagram** of power distribution circuit taking into consideration:
  - Number of transformers and their ratings
  - Backup power requirements & standby generator(s) selection and sizing
  - Power distribution to the shopping mall
  - Riser and power distribution to the office tower
  - Requirements of common services, including MVAC systems
  - PV installation
  - Electric vehicle charging stations
  - Essential/safety service requirements
  - Reliability/availability/redundancy of supply to the mall and to the offices
  - Other significant circuits, if any, in accordance with your design
- The conceptual main schematic diagram should contain important information such as main intake cable size, busduct trunking rating, switchboard & equipment ratings, location of installation etc.
- ***Check that the transformers selected are sufficiently sized with the use ETAP to generate load-flow analysis of the entire network, based on simplification/ assumptions of load modelling. Attach ETAP load-flow results in report.***
- ***Use ETAP to construct the one-line diagram for the overview of the electrical network.***

(E) Detailed design [30%]

1) Low Voltage Main Switchboards:

The low-voltage (LV) side of each transformer is connected to a LV Main Switch Board (MSB) which provides multiple feeds to downstream distribution boards.

(a) Determine the short circuit fault current at each Main Switch Board (MSB) corresponding to a particular transformer.

(b) Determine the required continuous current rating and the short circuit rating of the incoming air circuit breaker at the MSB.

(c) Select the appropriate type of cable for connecting the transformer to the MSB and size the required cable cross-sectional area taking into consideration the maximum continuous current rating and the short-circuit current.

(d) Draw **a Single Line Diagram** to show all the necessary components of a MSB.

(e) Determine the settings of overcurrent relay and earth fault relay according to the authority's requirements. (Refer to Reference [7]).

2) Power distribution circuit to the office tower
   (a) Determine the power requirement for each floor of the office tower.
   (b) Discuss and compare the relative merits of bus-duct distribution system with cable distribution system for the office tower.
   (c) Select the appropriate main bus-duct distribution system for the office tower from the respective main switch board (MSB) to Level 7 and up to the 26th level; You may refer to manufacturer's catalogue or the relevant information in SS 638: 2018 Code of Practice for Electrical Installations.
   (d) Determine the voltage drop at the highest floor (level 26) of the office tower, with reference to the parameters of the bus-duct you selected.

You are required to make reasonable assumptions and design decisions for missing information necessary to complete this assignment.

References

(1) Singapore Standard SS 638: 2018 Code of Practice for Electrical Installations

(2) Course references provided via LMS@SIT

(3) BS HD 60364-8-1:2019 Low Voltage Electrical Installations, Part 9-1: Functional aspects – energy efficiency (IEC 60364-8-1:2019)

(4) Singapore Standard SS 530:2014– Code of Practice for Energy Efficiency Standard for Building Services and Equipment and

(5) Handbook for Solar Photovoltaic (PV) Systems, published jointly by EMA and BCA

(6) Photovoltaic Systems by James P. Dunlop. Published by Amer Technical Pub 3rd (third) edition (2012) ISBN-10 1935941054

(7) How to Apply For Electricity Connection by SP Group (published in April 2021)

(8) Green Mark Non Residential Building 2015 Criteria by Building and Construction Authority (Revision R3)

(9) BCA Green Mark 2021, Energy Efficiency by Building and Construction Authority.

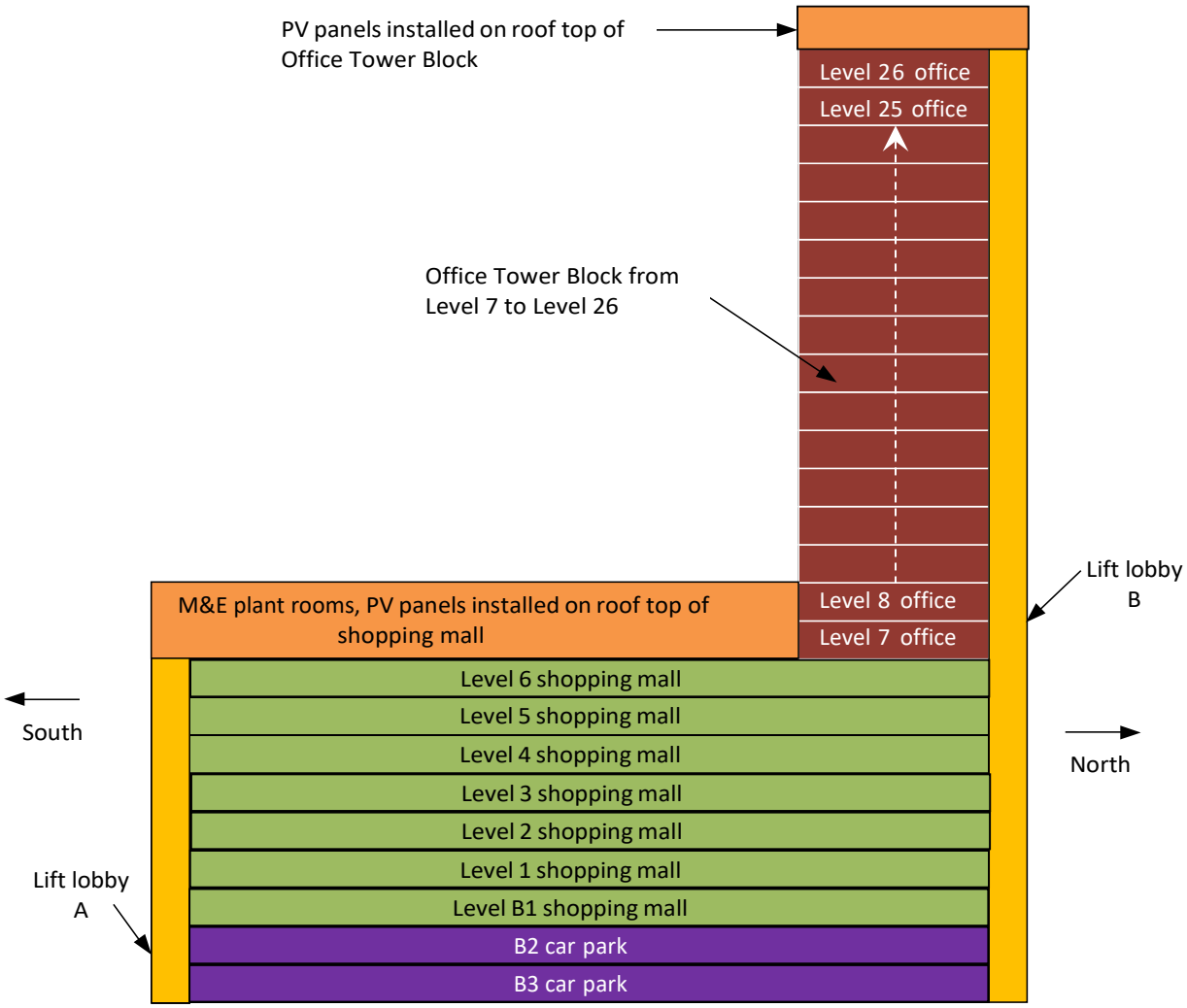

Figure 1 – A mixed development of shopping mall cum office tower

ASSIGNMENT REPORT SUBMISSION

Students are required to submit a PDF report of not more than 30 pages (excluding cover page, content page & attachments, if any). The one-line diagrams, calculations, etc. stated in the Assignment requirements should be included in the report. The report is to be submitted via LMS dropbox for grading at the end of Week 10, Friday 08-Nov-2024 23:59.

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****END OF ASSIGNMENT****