Project Team: Group

ENEL 674: Industrial and Commercial Power System

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Milestone 2

Based on the initial calculations of equipment sizes, this report includes the design of the overall equipment layout. This is a preliminary stage. At this point, this report would be able to give a "client" recommendations or limitations regarding their needs, as well as the approximate amount needed, equipment space requirements, and any additional space, rooms, or buildings needed. These layouts take into consideration aspects such as load distribution, cable routing, and accessibility for maintenance in order to maximize the electrical system's efficiency and safety. This report will be divided into few sections to ease the documentation process. This is the improvised version of milestone.

Normal Power Single Line Diagram

An electrical distribution system for a building or facility is shown in a simplified image called a Normal Power Single Line Diagram (SLD). It offers a concise and understandable summary of the parts of electricity distribution and how they are connected. Standardized symbols are usually used in single line diagrams to depict different electrical equipment and devices. Some components that would be seen in this report is power source, circuit breakers and transformers.

Emergency Power Single Line Diagram

A schematic representation of the electrical distribution system that focuses on parts associated with emergency power sources and distribution is called an Emergency Power Single Line Diagram (SLD). Understanding how power is delivered in emergency situations, like power outages, requires this kind of illustration. Some key elements that can be seen in this diagram include emergency power source, transfer switches and emergency lighting.

Lighting Layout Drawing

To make sure the lighting system in the building is appropriately built, implemented, and maintained, it is imperative to have a lighting layout drawing. The drawing includes comprehensive information about the location, kind, voltage and wattage requirements, number of lights, and other important features of the light fixtures. The correct operation of the lighting system and the security of the building's residents depend on this information. Thus, it is essential to have a lighting arrangement drawing in this structure to guarantee the effective and safe installation and maintenance of the lighting system. Proper drawing is required, and it must be very specific and clean to be view by the engineering team.

For this projects, three types of LED lights have been selected. These three lights are distributed accordingly based on the room’s requirements. Below are the three types of LED lights:

I. 38W LED light (2x4 troffer module)
II. 21W LED light (2x2 troffer module)
III. 9W Spotlight

The 38W LED is an ambient lighting and it is used in the bigger rooms such as mechanical, telecom and electrical rooms. These rooms are important as it has mechanical and electrical equipment, and it should be luminated properly for safety purposes as regular maintenance or scheduled checking will be done in these areas. Even the kitchen will be installed with this light as there are sharp objects that will be used here. The 21W LED light is similar to the 38 LED light but instead of having a 2x4 panel, it has a 2x2 panel. Therefore, it has less lumens. This type of light is used in areas such as classrooms, offices, and storage as it is sufficient to light these areas up. The 9W spotlight will be installed in the exhibit gallery as there will be art displays such as painting which would need concentrated illuminance on them. These three lights have an efficacy of 110 and above, therefore they are highly efficient LED's.

In order to calculate the number of illuminates needed, few assumptions have been made. Below is the list of assumptions made:

I. Room cavity in the range of 5-8 ft.
II. Light Loss Factor (LLF) is 0.9.
III. If the Room Cavity Ratio (RCR) is more than 10, RCR = 10 is used for the luminaire cut sheets.
IV. Coefficients of Utilization of 80/30/20 is used.
V. Desired illuminance is assumed based on the table below:

Environment	Typical Lux
Hospital Theatre	1,000
Supermarket, Sports Hall	750
Factory, Workshop	750
Office, Show Rooms, Laboratories, Kitchens	500
Warehouse Loading Bays	300 to 400
School Classroom, University Lecture Hall	250
Lobbies, Public Corridors, Stairwells	200
Warehouse Aisles	100 to 200
Homes, Theatres	150
Family Living Room	50

Figure 1: Lux requirements.

The dimensions of each room are retrieved from AUTCAD base plan layout, and it has been scaled accordingly. The formula's used to calculate the number of lights needed is shown below:

$$RCR = \frac{5\ x\ room\ cavity\ height\ x\ (L+W)}{area\ of\ room}$$

$$Coefficient\ of\ utilization\ (CU) = Based\ on\ datasheet\ of\ light$$

$$Number\ of\ Lights = \frac{Desired\ fc\ x\ area\ of\ room}{Lumen\ of\ light\ x\ CU\ x\ LLF}$$

By using the formulas above, the calculated results for each room are tabulated below:

Table 1: Values for each room

Room	RCR	CU	LLF	Number of Lights
Mechanical 203	3.9	0.62	0.9	7
Telecom	6.9	0.43	0.9	3
Classroom 121	3.24	0.63	0.9	9
Exhibit Gallery	4.5	0.57	0.9	9

Exhibit Gallery Spotlight	4.5	0.51	0.9	3
Tea Ceremony	8.33	0.37	0.9	2
Foyer	11.67	0.31	0.9	2
Classroom 101	3.24	0.63	0.9	2
Closet	12.5	0.31	0.9	1
Women's WR	4.69	0.59	0.9	3
Men's WR	6.89	0.43	0.9	3
Water Meter	12.5	0.31	0.9	1
Stair	22.6	0.31	0.9	3
Corr	15.86	0.31	0.9	1
Jan	14.58	0.31	0.9	1
Snack Preparation	12.56	0.51	0.9	1
Kitchenette	3.03	0.7	0.9	4
Kitchenette Spotlight	3.03	0.42	0.9	2
Commons	2.93	0.7	0.9	4
Vestibule	10.1	0.31	0.9	3
Staff	6.0	0.47	0.9	3
Mechanical 117	10	0.31	0.9	2
Admin Office	6.25	0.43	0.9	3
ED Office	5.0	0.54	0.9	3
Information and Gift Shop	3.38	0.65	0.9	7
Storage 114	12.5	0.31	0.9	1
Yukata	7.14	0.39	0.9	3
Storage 111	8.75	0.37	0.9	1
Cultural Activity Room	1.9	0.93	0.9	8
Electrical Room	6.89	0.43	0.9	3

In order to calculate the number of lights required by the rooms, the dimension of the room is also needed. Below is the dimension of each room that were scaled accordingly from the base layout using AUTOCAD.

Table 2: Calculation for number of lights

Room	Light Type	Proposed No. Lights	Width (ft)	Length (ft)	Required lux	Required fc	Lumens of light
Mechanical 203	38	7.00	20.00	21.00	450.00	41.81	4656
Telecom	38	3.00	8.00	21.00	400.00	37.16	4656
Classroom 121	21	9.00	16.00	22.00	400.00	37.16	2571
Exhibit Gallery	21	9.00	12.00	22.00	475.00	44.13	2571
Exhibit Gallery Spotlight	9	3.00	12.00	22.00	476.00	44.22	1057
Tea Ceremony	21	2.00	6.00	14.00	150.00	13.94	2571
Foyer	21	2	6.00	8.00	300.00	27.87	2571
Classroom 101	21	9	16.00	22.00	400.00	37.16	2571

Closet	21	1	4.00	6.00	150.00	13.94	2571
Women's WR	21	3	16.00	14.00	200.00	18.58	2571
Men's WR	21	3	10.50	13.00	200.00	18.58	2571
Water Meter	21	1	4.00	6.00	150.00	13.94	2571
Stair	21	3	3.20	30.00	200.00	18.58	2571
Corr	21	1	5.20	8.00	200.00	18.58	2571
Jan	21	1	4.00	6.00	150.00	13.94	2571
Snack Preparation	21	1	4.00	12.00	200.00	18.58	2571
Kitchenette	38	4	18.00	22.00	300.00	27.87	4656
Kitchenette	9	2	18.00	22.00	300.00	27.87	1057
Commons	38	4	22.00	36.00	300.00	27.87	4656
Vestibule	21	3	5.00	11.00	250.00	23.23	2571
Staff	21	3	10.00	10.00	375.00	34.84	2571
Mechanical 117	38	2	10.00	8.00	400.00	37.16	4656
Admin Office	21	3	8.00	12.00	320.00	29.73	2571
ED Office	21	3	12.00	12.00	320.00	29.73	2571
Information and Gift Shop	21	7	20.00	16.00	350.00	32.52	2571
Storage 114	21	1	6.00	4.00	150.00	13.94	2571
Yukata	21	3	14.00	6.00	300.00	27.87	2571
Storage 111	21	1	6.00	8.00	150.00	13.94	2571
Cultural Activity Room	38	8	48.00	24.00	275.00	25.55	4656
Electrical Room	38	3	6.00	15.00	450.00	41.81	4565

After calculating the number of lights needed for each room, it is important to develop a luminaire schedule. A luminaire schedule is a document that gives specific details on the luminaires (light fixtures) that will be utilized in this project. It is used in lighting design and engineering. It serves as a reference for designers and contractors ensuring all the lighting requirements are met and most importantly, it is installed correctly.

Cost Analysis

In this section, few options of light models are suggested. This analysis takes into account various aspects, including the cost of the initial purchase, energy efficiency, maintenance costs, and possible long-term savings. The most affordable option that satisfies the building's functional and aesthetic needs by contrasting several lighting types is presented. In order to create an environment that is both well-lit and economically sustainable, this strategy balances initial investment with ongoing operational and energy costs to guarantee the best possible resource utilization. The table below shows option 1 of the lighting models.

Option 1

This option was demonstrated in milestone 1. It has a good balance between pricing affordability and the spacing required for the installation of the lighting. But to give more choices for the lights, another two options have been developed for milestone 2.

Type	Model	Price (CAD)	Quantity	Total (CAD)
1	24EN-LD2-45-UNV-L835-CD1-U	$297.43	33	$9815.19
2	22EN-LD2-25-UNV-L835-CD1-U	$193.05	61	$11776.05
3	T271L 9W Arc LED	$116.66	5	$583.3
Gross Total (CAD)		**$21773.59**		

Option 2

Type 1 light has the same specifications as the light in option 1 with very similar efficacy and control system but is less in terms of lumens per watt produced. Therefore, more lights are required to be installed if we would like to use this light as an option. Instead of using 33 modules, we would have to use 42 modules, but it will still be cheaper than option 1. But this might not be very convenient as some rooms such as kitchenette uses this type of light and adding more lights to the room might be challenge.

Type 2 light is another version with a better efficacy, but more lumens produced. Therefore, the number of lights may be reduced in some rooms. The room where the number of lights can be decreased is classrooms, exhibit gallery, offices and information and gift shop. With the number of lumens of 3200, it is a good option as its price is lower than option 1.

Type 3 light is a track or also known as spotlight. This type of light is needed for the exhibit gallery where it is used to illuminate artwork. It is also used on the countertop of the kitchenette. It has a slightly higher number of lumens produced which is about 1460 lumens. It has similar dimensions as well as the light in option 1. The number of lights installed would remain the same.

Type	Model	Price (CAD)	Quantity	Total (CAD)
1	Lithonia CPX-2X4 LED Flat Panel Troffer Light	$144.99	42	$6299.58
2	Lithonia CPX-2X2 LED Flat Panel	$132.35	55	$7279.25
3	Eglo 95633A Salto LED Track Light	$129.00	5	$645.00
Gross Total (CAD)		**$14223.83**		

Option 3

In this option, the first light type which is the 2x4 LED troffer has cheaper price compared to other two options but due to the number of lumens produced is at 3300 lumens, slightly more panels would have to be installed. The same goes for the type 2 panel where its lumens output is about 2400. The type 3 light has the same specifications as the other two options, therefore the number of lights needed would be the same as the other options.

Type	Model	Price (CAD)	Quantity	Total (CAD)
1	Commercial Electric 2x4 Integrated LED Flat Panel Troffer	$124.00	48	$5952.00
2	Commercial Electric 2x2 Integrated LED Flat Panel Troffer	$89.88	75	$6749.25

3	Tech Lighting 700FJBRK8272006S Track Light	$100.00	5	$500.00
Gross Total (CAD)		**$13201.25**		

Luminaire Schedule

Table 3: Luminaire schedule

No	Area	Luminaire	Description	Mounting	Wattage (W)	Lumens	Manufacture	Part Number	Remarks	Driver	CCT	CRI	Controls	Voltage	Efficacy
1	Mechanical 203	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	122.5
2	Telecom	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	123.5
3	Commons	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	123.5
4	Cultural Activity Room	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	123.5

5	Kitchenette	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	123.5
6	Kitchenette	Recessed Luminaire	The ultra-efficient optical system of the Arc LED trac fixture maximizes efficiency while minimizing fixture depth. It approximates the light output and distribution of 60-75W PAR30 halogen lamps, utilizing about 20% of the energy and having a rated life of 50,000 hours	Ceiling Mounted	9	1057	Acuity Brands	ARC™ 9W LED T271L G2 27K 80CRI NFL	Compatible with Trac-Master 1- or 2-circuit tracing, Trac-Lites tracing, monopoints, and specialized mountings; also UL certified Suitable for ConTech® LT Series tracks; precise spring action from copper alloy contacts prevents arcing and takes up no set; on/off switch included; patented polarity arrows embossed on adapter bottom; spring-loaded positive latch with polarity arrows embossed secures trac light to trac; two-position power contact provided for two-circuit application.	• Dimmable using high quality reverse phase electronic low voltage (ELV) dimmers	2700K	80	Timer	120	117
7	Mechanical 117	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>80	Integral/Motion Sensor	120	123.5
8	Electrical Room	Recessed Luminaire	Long-life LED system coupled with electrical driver to deliver optimal performance. Projected life is 100,000 hours at 92% lumen output.	Ceiling Mounted	38	4656	Cooper Lighting Solutions	24EN-LD2-45-UNV-L835-CD1-U	For strength, stiffness, and the removal of gaps, end plates are firmly fastened with screws. For further security and ease, end plates offer an additional grid-lock feature. There are four extra places where the fixture end can be suspended. Big access plate for connecting supplies	0-10V dimming driver	3000K	>81	Integral/Motion Sensor	120	123.5
9	Classroom 121	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53

10	Classroom 101	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
11	Foyer	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
12	Jan	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
13	Staff	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
14	ED Office	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
15	Admin Office	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53

16	Yakuta	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
17	Info and Gift shop	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<85	Integral/Motion Sensor	120	122.53
18	Closet	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<86	Integral/Motion Sensor	120	122.53
19	Water Meter	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<87	Integral/Motion Sensor	120	122.53
20	Storage 114	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<88	Integral/Motion Sensor	120	122.53
21	Storage 111	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<89	Integral/Motion Sensor	120	122.53

22	Tea ceremony	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<90	Integral/Motion Sensor	120	122.53
23	Stair	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<91	Integral/Motion Sensor	120	122.53
24	Corr	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<92	Integral/Motion Sensor	120	122.53
25	Vestibule	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<93	Integral/Motion Sensor	120	122.53
26	Exhibit Gallery	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<94	Integral/Motion Sensor	120	122.53

27	Exhibit Gallery	Recessed Luminaire	The ultra-efficient optical system of the Arc LED trac fixture maximizes efficiency while minimizing fixture depth. It approximates the light output and distribution of 60-75W PAR30 halogen lamps, utilizing about 20% of the energy and having a rated life of 50,000 hours	Ceiling Mounted	9	1057	Acuity Brands	ARC™ 9W LED T271L G2 27K 80CRI NFL	Compatible with Trac-Master 1- or 2-circuit tracing, Trac-Lites tracing, monopoints, and specialized mountings; also UL certified Suitable for ConTech® LT Series tracks; precise spring action from copper alloy contacts prevents arcing and takes up no set; on/off switch included; patented polarity arrows embossed on adapter bottom; spring-loaded positive latch with polarity arrows embossed secures trac light to trac; two-position power contact provided for two-circuit application.	• Dimmable using high quality reverse phase electronic low voltage (ELV) dimmers	2700K	80	Timer	120	117
28	Snack Preparation	Recessed Luminaire	High performance efficacy up to 143 lumens per watt. Over 60% energy savings when compared to a fluorescent troffer	Ceiling Mounted	21	2571	Cooper Lighting Solutions	22EN-LD2-25-UNV-L835-CD1-U	Screws are used to firmly fasten end plates to provide strength, stiffness, and the absence of gaps. For convenience and safety, end plates offer an optional grid-lock mechanism. There are four spare fixture end suspension points available. Generous access plate for connecting the supply.	0-10V continuous dimming driver	3500K	<91	Integral/Motion Sensor	120	122.53

Power Layout Drawing

An extensive engineering design known as a "Power Layout Drawing" offers a thorough overview of the placement and physical configuration of different electrical components inside a building. Engineers, electricians, and other parties involved in the installation, upkeep, or change of the electrical system use this drawing, which is a crucial component of the electrical design documentation. Major electrical equipment locations, cable routing, and other relevant information are included in the drawing.

Service Sizing Calculation

In the context of electrical systems, "service sizing calculation" refers to figuring out the right size of electrical service that will supply electricity to a structure or facility. This entails figuring out how much capacity is required to meet the projected demand for electricity. The rated capacity, which is typically measured in amperes (A) or kilovolt-amperes (kVA), is used to express the service size.

For the calculation of basic load, or also known as non-continuous load, the formula below is utilised:

$$Basic\ Load\ (kW) = Area\ (m^2)\ x\ \frac{Watts\ (kW)}{m^2}$$

The basic load that was calculated is 40.781 kW. This basic load also includes a 30HP fire pump and will only be used in case of an emergency.

In order to calculate the continuous load, the formula below is used:

$$Total\ Continuous\ Load\ (kW) = \ \Sigma\ Rated\ Loads\ (kW)$$

The continuous load has a value of 72.415 kW. The continuous load includes mechanical equipment’s and lighting equipment’s. The reason why lighting is included as a continuous load because in a commercial building, lighting is generally used more that 3 hours.

The summation of the of the continuous and non-continuous load will be the total max operating load as shown below:

$$Total\ Max\ Operating\ Load\ (kW) =$$

$$\Sigma\ Non\ Continuous\ Loads\ (kW) + \ \Sigma\ Continuous\ Loads\ (kW)$$

$$= 72.415 + 40.787 = 113.2\ kW$$

In order to determine the Service Size Required (AMPS), the formula below is used:

$$Minimum\ Service\ Size\ Ampacity\ (A) =$$

$$\frac{Non\ Continuous\ Loads\ (W) + Continuous\ Loads\ (W) x\ 1.25}{Rated\ Voltage}$$

The calculated AMPS is 364.45A. Therefore, a 600A service to the building would be ideal to account for excess load.

Regarding the transformer kVA rating, the formula shown below is used:

$$S = \sqrt{3}\ x\ V\ x\ I$$

Which results in 216.15 kVA. Therefore, a 225 kVA would be recommended to be used for this project. Next would be the breaker size calculation. The breaker is important when there is an event of overcurrent, it will cut the circuit. In short, it protects the circuit. The formula would be as below:

$$I = \frac{S}{\sqrt{3}\ x\ V}$$

The current that was calculated is 750 A. Therefore, an 800A Molded Case Circuit Breaker (MCCB).

Next step is calculating conductor size transformer. The formula shown below is used:

$$No\ of\ conductors\ per\ \phi = \frac{Amps}{Ampacity}$$

By using this formula, the value calculated was close to 1 which means that it would be 1 conductor per phase. So there total of 4 conductors 3 for each phase and 1 conductor for neutral.

Mechanical Schedule

In the context of engineering and construction, a mechanical schedule is a document that provide comprehensive details of the mechanical systems and equipment that will be placed in a structure or facility. A vital component of the entire project paperwork, this schedule is used by a number of stakeholders, including facility managers, engineers, contractors, and architects. A mechanical schedule's contents aid in ensuring that mechanical components are appropriately planned, acquired, and installed.

Unit No.	Description	Location	Nameplate				Overcurrent Protection			Feeder			Fed From	Disconnect				Starter/VFD					Starter Control							Remarks
			Voltage (V)	Phase Ø	MCA (A)	Load (HP, FLA, kW)	Type	Rating	Poles	Conductors	Bond	Conduit		NEMA Rating	S	I	C	Type	NEMA Size	S	I	C	Type	Remote Type	N/O Contacts	N/C Contacts	S	I	C	
AIR CONDITIONING EQUIPMENT																														
CU-1	**CONDENSING UNIT**	**EXTERIOR - SOUTH CULTURAL ACTIVITY**	**208**	**3**	14.0	**14.0 FLA**	MCB	35	**3**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**INT**							**CONTROLLED BY FURNACE**
CU-2	**CONDENSING UNIT**	**EXTERIOR - SOUTH CULTURAL ACTIVITY**	**208**	**3**	18.0	**18**	MCB	45	**3**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**INT**							**CONTROLLED BY FURNACE**
CU-3	**CONDENSING UNIT**	**EXTERIOR - SOUTH CULTURAL ACTIVITY**	**208**	**3**	39.0	**39**	MCB	90	**3**	8 AWG	10 AWG	27 mm	M2C		-	-	-			-	-	-	**INT**							**CONTROLLED BY FURNACE**
CU-4	**CONDENSING UNIT**	**EXTERIOR - SOUTH CULTURAL ACTIVITY**	**208**	**3**	37.0	**37**	MCB	90	**3**	8 AWG	10 AWG	27 mm	M2C		-	-	-			-	-	-	**INT**							**CONTROLLED BY FURNACE**
AIR HANDLING																														
F-1	**FURNACE**	**MECHANICAL ROOM 117**	**208**	**3**	10	**10.0 FLA**	MCB	25	**3**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**
F-2	**FURNACE**	**MECHANICAL ROOM 117**	**208**	**3**	10	**10.0 FLA**	MCB	25	**3**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**

F-3	FURNACE	MECHANICAL ROOM 203	208	3	10	10.0 FLA	MCB	25	3	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
F-4	FURNACE	MECHANICAL ROOM 203	208	3	12	12.0 FLA	MCB	30	3	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
DOMESTIC HOT WATER																														
DHW T-1	DOMESTIC HOT WATER TANK	MECHANICAL ROOM 203	120	1	5	5.0 FLA	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	INT							
EXHAUST FANS																														
EF-1	EXHUAST FAN	MECHANICAL ROOM 203	120	1	2.5	0.25 HP	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	COMB							INTERLOCK LOCAL LIGHTING
EF-2	EXHUAST FAN	ROOM 120	208	3	6.6	1.5 HP	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	VFD							INTERLOCK LOCAL LIGHTING
BASEBOARD HEATERS																														
BB-1	BASEBOARD HEATER	KITCHENETTE 108	208	1	14.0	2.5 kW	MCB	20	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-2	BASEBOARD HEATER	KITCHENETTE 108	120	1	10.0	1.0 kW	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-3	BASEBOARD HEATER	COMMONS 109	120	1	10.0	1.0 kW	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-4	BASEBOARD HEATER	COMMONS 109	208	1	14.0	2.5 kW	MCB	20	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-5	BASEBOARD HEATER	COMMONS 109	120	1	10.0	1.0 kW	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-6	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1	14.0	2.5 kW	MCB	20	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-7	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1	14.0	2.5 kW	MCB	20	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT
BB-8	BASEBOARD HEATER	MENS 104	120	1	10.0	1.0 kW	MCB	15	1	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	LTST							CONTROLLED BY THERMOSTAT

BB-9	**BASEBOARD HEATER**	**COMMONS 109**	**120**	**1**	10.0	**1.0 kW**	MCB	15	**1**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**
FORCE FLOWS																														
FF-1	**FORCE FLOW FAN**	**FOYER 100**	**120**	**1**	6	**6.0 FLA**	MCB	15	**1**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**
FF-2	**FORCE FLOW FAN**	**ROOM 120**	**120**	**1**	14	**1.5 kW**	MCB	35	**1**	10 AWG	10 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**
FF-3	**FORCE FLOW FAN**	**MECHANICAL ROOM 117**	**120**	**1**	14	**1.5 kW**	MCB	35	**1**	10 AWG	10 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**
FF-4	**FORCE FLOW FAN**	**WATER METER 107**	**120**	**1**	6	**6.0 FLA**	MCB	15	**1**	12 AWG	12 AWG	21 mm	M2C		-	-	-			-	-	-	**LTST**							**CONTROLLED BY THERMOSTAT**

COMMON ABBREVIATIONS

E=ELECTRICAL CONTRACTOR M=MECHANICAL CONTRACTOR INT=INTEGRAL TO UNIT (BY MANUFACTURER) S=SUPPLIED BY I=INSTALLED BY C=CONNECTED BY NR=NOT REQUIRED

NAMEPLATE & FEEDER ABBREVIATIONS

FLA=FULL LOAD AMPACITY MCA=MINIMUM CIRCUIT AMPACITY HP=HORSE POWER FU=FUSE(S) P=POLES

STARTER TYPE ABBREVIATIONS

VFD=VARIABLE FREQUENCY DRIVE MAG=MAGNETIC FVNR MAN=MANUAL COM=COMBO BREAKER + MAG FVNR=FULL VOLTAGE NON-REVERSING FVR=FULL VOLTAGE REVERSING SOFT=SOFT STARTER TST=LINE VOLTAGE THERMOSTAT

STARTER CONTROL TYPE ABBREVIATIONS

BMS=BUILDING MANAGEMENT SYSTEM H,O,A=HAND,OFF,AUTO F,O,R=FORWARD,OFF,REVERSE O,O=ON,OFF LTST=LOW VOLTAGE THERMOSTAT R,J=RUN,JOG F,R=FORWARD,REVERSE O,C=OPEN,CLOSE

Cable Schedule

Panel	Ckt Number	Load Description	Vtg	Phase	Current (A)	CB Rating	Power Cable Type	Power Cable Size	Length(m)	VD allowed (%)
M2A	F01	12B	208	3	100A	110A	RW90	4C #3 AWG	28m	2%
M2A	F02	M2E	208	3	100A	110A	RW90	4C #3 AWG	28m	2%
M2A	F03	M2C	208	3	250A	250A	RW90	4C 000kcmil	20m	2%
M2A	F04	30 HP Fire Pump	208	3	88A	200A	RW90	3C #4 AWG + 1C #6 AWG	20m	2%
12B	F01-F03	Lighting	120	1	12A	15A	RW90	2C #10AWG	26m	2%
12B	F04-F11	Receptacle	120	1	20A	25A	RW90	2C #10AWG	26m	2%
M2E	F01-F02	Lighting	120	1	12A	15A	RW90	2C #10AWG	26m	2%
12B	F03-F05	Receptacle	120	1	20A	25A	RW90	2C #10AWG	26m	2%
M2C	F01	CU-1	208	3	14A	35A	RW90	4C #12AWG	22m	2%

M2C	F02	CU-2	208	3	18A	45A	RW90	4C #12 AWG	22m	2%
M2C	F03	CU-3	208	3	39A	90A	RW90	3C #8 AWG + 1C #10AWG	22m	2%
M2C	F04	CU-4	208	3	37A	90A	RW90	3C #8 AWG + 1C #10AWG	22m	2%
M2C	F05	F1	208	3	10A	25A	RW90	4C #12AWG	36m	2%
M2C	F06	F2	208	3	10A	25A	RW90	4C #12AWG	36m	2%
M2C	F07	F3	208	3	10A	25A	RW90	4C #12AWG	36m	2%
M2C	F08	F4	208	3	12A	30A	RW90	4C #12AWG	29m	2%
M2C	F09	DHWT-1	120	1	5A	15A	RW90	4C #12AWG	42m	2%
M2C	F10	EF1	120	1	2.5A	15A	RW90	4C #12AWG	84.2m	2%
M2C	F11	EF2	208	3	6.6A	15A	RW90	4C #12AWG	45.67m	2%
M2C	F12	BB1	208	1	14A	20A	RW90	4C #12AWG	22.83m	2%

M2C	F13	BB2	120	1	10A	15A	RW90	4C #12AWG	21m	2%
M2C	F14	BB3	208	1	14A	20A	RW90	4C #12AWG	22.83m	2%
M2C	F15	BB4	120	1	10A	15A	RW90	4C #12AWG	21m	2%
M2C	F16	BB5	120	1	10A	15A	RW90	4C #12AWG	21m	2%
M2C	F17	BB6	208	1	14A	20A	RW90	4C #12AWG	22.83m	2%
M2C	F18	BB7	208	1	14A	20A	RW90	4C #12AWG	22.83m	2%
M2C	F19	BB8	120	1	10A	15A	RW90	4C #12AWG	21m	2%
M2C	F20	BB9	120	1	10A	15A	RW90	4C #12AWG	21m	2%
M2C	F21	FF1	120	1	6A	15A	RW90	4C #12AWG	33m	2%
M2C	F22	FF2	120	1	14A	35A	RW90	4C #10AWG	21m	2%
M2C	F23	FF3	120	1	14A	35A	RW90	4C #10AWG	21m	2%
M2C	F24	FF4	120	1	6A	15A	RW90	4C #12AWG	33m	2%

Panel Schedule

A Panel Schedule is a written record or illustration that offers comprehensive details regarding the power distribution inside an electrical panel. To understand the arrangement, capability, and use of the panel's circuits requires knowledge of this timetable. Panel schedules are used by engineers, electricians, and maintenance staff to plan, schedule, and troubleshoot electrical work.

Summary Report: Generator Type, Location, Sizing

This section deals with the choice and dimensions of generators, as well as where best to put them and how to distribute the power they produce. Since gas generators are more expensive and generally advised for higher power requirements, we have given consideration to using a diesel generator for this project. The following methods were used by us to estimate the size of the generator:

Connected Load (CL): The sum of all the power requirements of critical loads.

$$CL = \Sigma\,(Power\ of\ Individual\ Loads)$$

Diversity Factor (DF): A factor to account for the likelihood that not all loads will operate simultaneously.

$$DF = \frac{Number\ of\ Loads\ in\ Operation\ Simultaneously}{Total\ Number\ of\ Loads}$$

Total Load after Diversity (TL): The total connected load adjusted for diversity.

$$TL = CL\ x\ DF$$

Power Factor (PF): A measure of how effectively electrical power is being converted into useful work output.

$$PF = \frac{Real\ Power\ (kW)}{Apparent\ Power\ (kVa)}$$

Apparent Power (S): The combination of real power and reactive power.

$$S = \sqrt{(Real\ Power)^2 + (Reactive\ Power)^2}$$

Generator Size (GS): The required size of the generator, accounting for power factor.

$$GS = \frac{TL}{PF}$$

Safety Margin (SM): Additional capacity added to the generator to handle unexpected peak loads.

$$SM = TL\ x\ Margin\ Percentage$$

Total Generator Capacity (TGC): The generator size with the safety margin included.

$$TGC = GS + SM$$

The foundation for sizing emergency generators is provided by these calculations. It's crucial to note that several factors such as starting currents, altitude modifications, and temperature changes based on project specifications and climatic conditions are not taken into account.

Summary Report: Distribution Options for the Site

- **Electricity Panel:**

The electricity panel functions as the central control hub for distributing electricity within a building, receiving power from the utility company, and dividing it into separate circuits. Each circuit serves a specific area or appliance, with circuit breakers acting as safety switches to prevent overloads or faults. The panel's main breaker allows for easy control of power supply, while neutral and ground bars ensure safe electrical grounding. Its uses include ensuring safe and reliable distribution of electricity, preventing electrical hazards, and facilitating convenient control and management of power for various appliances and devices within the building.

- **UPS System Integration:**

A UPS (Uninterruptible Power Supply) system is an electrical device that provides emergency power to a load when the primary power source fails or experiences voltage fluctuations. It acts as a bridge between the utility power supply and the load, ensuring continuous and uninterrupted operation of critical equipment, even during power outages. The UPS system is particularly suited for sites with critical operations, such as data centers, medical facilities, telecommunications networks, and security installations.

- **Transformer:**

The transformer is a crucial part of the power system that facilitates the safe transfer of energy from the power plant to our commercial buildings. One of the primary functions of transformers in power distribution is to transform voltage levels to match the requirements of different parts of the distribution network. Transformers are installed in distribution substations, which are key components of the distribution network. These substations receive high-voltage electricity from transmission lines and step it down to lower voltages suitable for distribution.

Transformers are used in various applications, including power distribution, voltage regulation, impedance matching, and electrical isolation.

- **Generators:**

Generators play a crucial role in power transmission and distribution systems, albeit primarily on the generation side rather than the transmission or distribution side. While not directly involved in transmission or distribution, generators are commonly employed as backup power sources in case of utility grid failures or outages.

While generators are primarily associated with power generation rather than transmission and distribution, their flexible operation and ability to provide localized power generation make them valuable assets in addressing grid challenges, ensuring reliability, and supporting the efficient operation of power systems.

- **ATS (Automatic Transfer Switch):**

An Automatic Transfer Switch (ATS) is a critical component of backup power systems, designed to automatically transfer electrical load between multiple power sources in the event of a primary power source failure. The primary function of an ATS is to ensure uninterrupted power supply to critical loads by seamlessly transferring them from the primary power source (typically utility power) to an alternate power source (such as a backup generator or an uninterruptible power supply) during a power outage or voltage irregularities.

- **LV Panel:**

An LV panel serves as a central point for distributing electrical power from a primary power source (such as a transformer or generator) to various circuits, equipment, and loads within a building, facility, or industrial setting**.** The LV panel designated for emergency use is typically connected to an alternate power source, such as a backup generator or an uninterruptible power supply (UPS). This alternate power source ensures that essential loads remain energized even if the primary power source fails.

Hence a distribution system of the building consists of various electrical panels, UPS panels, LV panels, transformers, and generators. The selection of these equipment is based on the connected and diversified load.

Recommendation from Milestone 1 for the Distribution Options of the Site

We are confident that the distribution system we have put in place will lay the groundwork for integrating renewable energy sources in the future. We have taken extensive measures to ensure that every component of the system is designed to meet the most rigorous industry standards, operates seamlessly, and is compatible with other systems.

- **In the case of normal power SLD:**

During emergencies or power loss occurrences, the electricity is directed to Automatic Transfer Switches, ensuring a continuous and uninterrupted power supply. Acting as the secondary side of the transformer for distributing three-phase power to panels 1 and 2, the building's LV panel receives the delivered power. Equipped with molded case circuit breakers, the system rapidly identifies and isolates faults or short circuits, ensuring that unaffected areas of the building maintain normal power. This distribution system significantly enhances the reliability of the building's power supply, ensuring seamless operation. Engineered to provide a dependable and efficient power source, the system guarantees uninterrupted functionality of the facility. The inclusion of state-of-the-art components like ATS switches and molded case circuit breakers ensures the swift and effective resolution of any potential issues.

- **In the case of emergency power SLD:**

The comprehensive master single-line diagram we've developed provides a detailed overview of the emergency power options available on-site, highlighting the various components of the system. The process begins with the incoming utility power supply, directed through transformers equipped with generation protection panels. During emergencies or power outages, electricity is seamlessly transferred to Automatic Transfer Switches (ATS), ensuring uninterrupted power supply. Additionally, a separate system comprising solar panels, a solar inverter, and a battery bank generates emergency power. Solar energy is converted into electrical energy by the solar panel and stored in the battery bank. The emergency panel, powered by the AC energy transformed by the solar inverter, is continuously supplied by a UPS system installed within it. Connected to the LV panel as the transformer's secondary side, the emergency panel ensures critical systems such as emergency lighting and fire alarms remain operational without interruption. This sustainable and environmentally friendly system incorporates cutting-edge components like solar panels, solar inverters, and battery banks to guarantee uninterrupted power supply during emergencies.

- **Lighting Layout Diagram:**

The lighting fixtures operate consistently and efficiently due to the reliable power supply from the utility. Furthermore, the inclusion of solar panels and a battery bank reduces the building's carbon footprint, offering a clean and sustainable energy source. Molded case circuit breakers safeguard the lighting system from disruptions by promptly isolating faults or short circuits. Continuous power from the UPS ensures that emergency lighting remains functional during power outages. This distribution system positively influences the lighting layout, providing a dependable, sustainable, and secure power source for the building's lighting fixtures.

- **Luminaire Schedule:**

The master single-line diagram delineates the utilization of utility power, solar generators, and UPS for the site. Utility power delivers a stable energy source for the luminaires, ensuring consistent performance. Solar generators and battery banks present environmentally friendly energy alternatives, diminishing the building's environmental impact. In case of a power outage, the UPS powers the emergency panel to maintain illumination. Molded case circuit breakers ensure uninterrupted operation, preventing short circuits or faults from affecting the lighting schedule. This distribution system significantly shapes the luminaire schedule by guaranteeing continuous luminaire operation through a blend of utility power, solar power, and UPS.

- **Power Layout Drawing:**

The adaptability of power outlets to draw power from various sources, including utility power, solar power, and UPS, is a notable feature. Integration of solar energy ensures a reliable and stable energy supply for the power outlets. Solar panels and battery banks offer eco-friendly energy options, while utility power serves as the primary energy source. Molded case circuit breakers maintain seamless operation by isolating faults or short circuits. This distribution system significantly impacts the power layout drawing, ensuring power outlets are backed by utility, solar generator, and UPS sources, ensuring uninterrupted functionality.

- **Mechanical Schedule:**

The ability to power mechanical devices from diverse sources, including utility power, solar power, and UPS, is a noteworthy aspect of this distribution system. Solar inverters, panels, and battery chargers will be powered by these sources. Solar inverters convert solar energy into usable AC power for building appliances, reducing reliance on traditional power sources. This distribution system profoundly influences the mechanical schedule by providing reliable and sustainable energy sources for critical mechanical equipment, enhancing the building's versatility and sustainability.

- **Panel Schedule:**

The utility, solar panels, and UPS contribute to the power supply ensuring the panels receive a steady and constant power supply necessary for normal operation. Automatic Transfer Switches (ATS) switches activate the backup power source from solar panels and UPS immediately in case of power loss or emergencies, minimizing downtime and potential damage. Molded case circuit breakers provide additional protection against faults and short circuits, ensuring uninterrupted operation. This distribution system ensures continuous and reliable power supply to the panels backed by utility, solar panels, and UPS, with ATS switches ensuring prompt activation of backup power during outages.

- **Service Sizing Calculations:**

The building's electrical load consumption determines the required service size, as well as the size and capacity of the solar panel and battery bank necessary to complement the utility's power supply. By utilizing clean energy from solar panels and a battery bank, the building reduces its carbon footprint and promotes sustainability. Proper estimation of service sizing is crucial to prevent overloading the electrical system, which could lead to power outages, equipment damage, and safety hazards. This estimation takes into account factors such as electrical power demand, distribution system layout, and the capacities of the utility, solar generator, and UPS. Circuit breakers play a vital role in ensuring electrical safety during faulty conditions, and it is important to consider the ratings of available circuit breakers on the market.

- MCB: 6, 10, 16, 20, 25, 32/30, 40, 50, 63.
- MCCB: 16, 20, 25, 32, 40, 50, 63, 80, 100, 150, 200, 250, 300, 400, 630, 800, 1000.
- ACB: 800, 1000, 1250, 1600, 2000, 3000, 4000, 5000, 6300 A.

Summary Report: Renewable Energy or Alternative Sources

Renewable energy sources have an increasing importance in this modern era. Because renewable energy sources are environmentally friendly and sustainable, they are regarded as an essential substitute for conventional fossil fuels. Renewable energy sources have fewer negative effects on the environment and can be naturally replenished, in contrast to fossil fuels, which are limited and contribute to climate change. Therefore, bigger buildings such as commercial building are starting to adapt to use renewable energy sources such as solar power. For this project, solar energy was chosen due to its many advantages for commercial buildings. The following are some major benefits of solar energy system integration for commercial buildings:

Cost savings would be the top consideration. Over time, solar panels can drastically lower electricity bills by producing electricity from sunlight, which is a free and renewable energy source. This results in a reduction of overall energy expenses. Incentives in money are also available. Businesses that embrace solar energy can offset the initial investment with financial incentives, tax credits, and rebates provided by numerous governments and regions.

The long-term stability is the second advantage. Over a prolonged length of time, solar energy systems offer businesses a consistent and reliable energy supply, with most of them lasting 20 to 30 years or longer.

The third advantage is environmental sustainability, which is becoming increasingly significant as nations recognize its connection to the environment. Solar energy is a clean, renewable energy source with low greenhouse gas emissions that can help a business fulfil its social responsibility and environmental sustainability goals.

Energy independence comes in at number four. We can infer that the word "independence" refers to reliance or dependence. Commercial buildings can lessen their reliance on outside energy sources and achieve some degree of energy security and independence by producing renewable energy on-site.

Aside from that, another crucial factor would be lower peak demand fees. Because solar energy systems provide electricity at times of high demand, they can assist businesses in managing peak demand charges. This may result in further cost reductions, particularly in areas where demand charges account for a sizeable amount of the electricity bill.

The final advantage is increased property value which is seldom discussed. The value of commercial premises that have solar panels may rise. Tenants and prospective buyers may find a building more appealing with sustainable elements.

Since solar energy requires less maintenance than conventional energy plants, low maintenance requirements are a critical factor. Solar panels require little upkeep because they don't require fuel, moving parts, or constant fuel use. Generally speaking, regular inspections and cleaning are enough to guarantee peak performance.

The Single Line Diagram (SLD) is added to portray the details of the components and their operation along with the connection schematics. 350 Watts PV panels are considering to be used for this building.

Recommendation from Milestone 1 for Renewable Energy or Alternative Sources

Normal Power Single Line Diagram

A renewable energy system may have a major influence on a single line diagram of a typical power system. A standard building single line diagram would just show the distribution of power from the utility to the different panels and circuits within the building. When a renewable energy system is added to a building, the single line diagram must be modified to accommodate the new components, such as the inverters, battery storage, and solar panels.

Initially, the PV solar panels are fixed to the roof or another suitable surface that gets enough of direct sunshine. The solar inverters are connected to the LV panel on the secondary side of the transformer, which supplies Panels 1 and 2 with three-phase electricity. The emergency panel always has electricity since it is connected to a UPS system that uses the battery bank as its source of power. By connecting the PV solar panels to the rest of the renewable energy system, the building can generate clean energy and reduce its dependency on the power provider. The master single line diagram ensures that the system is built, functions properly, and provides the building with energy that is sustainable and dependable.

Emergency Power Single Line Diagram

When incorporating a renewable energy system into a single line diagram for emergency power, solar panels, battery storage, and inverters must be added as extra components. To provide an emergency power system, PV solar panels are installed and linked to solar inverters, a battery bank, and a charge controller. The master single line diagram shows the whole setup, which includes connecting the solar inverters to the emergency panel. By allowing the facility to generate renewable energy during emergencies, this reduces dependency on power corporations. The system's effectiveness and dependability are guaranteed by the master single line diagram.

Lighting Layout Drawing

The impact of a renewable energy source must be taken into account while creating a lighting design drawing for a distribution station. By including solar panels and other renewable energy sources in the lighting system, the building's reliance on the power company can be lessened, and overall energy costs can be decreased. In order to produce sustainable energy, solar panels can be installed on the roof or in another suitable location where they will get direct sunshine.

The inverter, which is attached to the solar panels, transforms the DC power produced by the solar panels into AC power that the lighting system can use. A battery bank, which stores extra energy produced by the solar panels for usage when the panels are not producing enough, can also be linked to the inverter. Both the utility and the solar backup source can be used to power the lights, and the system will automatically transition between the two as necessary to maintain a steady and dependable power supply. The distribution location can cut its carbon footprint and save money on electricity by using renewable energy in its lighting system.

Luminaire Schedule

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Power Layout Drawing

When renewable energy sources are integrated in a distribution facility's power layout drawing, it can have a significant impact. By adding solar panels, battery storage, and inverters, the power setup can become less reliant on traditional power sources and more ecologically friendly. Through the integration of solar panels and battery storage into the power arrangement, the distribution facility can generate and store its own energy. Lowering the site's carbon footprint and overall energy expenses is another benefit of using solar energy. During times of heavy energy demand, the site can use its stored energy rather than depending solely on the utility grid. In the event of a power outage, the stored energy can also be used to power necessary appliances or lighting.

This could encourage the use of more sustainable energy sources and reduce the facility's overall energy costs. Incorporating renewable energy sources into a power layout design can have a substantial impact on a distribution site's energy usage, cost, and sustainability.

Mechanical Schedule

A distribution station's mechanical schedule may be significantly impacted by the installation of a renewable energy system. The mechanical schedule frequently includes a list of all the building's mechanical systems, including the HVAC units, pumps, and fans, along with information on each one's specific power requirements and control systems. As an alternative energy source, solar power may be able to power some tiny mechanical equipment, reducing dependency on the utility power grid and resulting in lower energy costs. Because of the control system's connection to the building's automation system, the equipment would be able to switch between the utility power supply and the solar alternative source based on the available power and energy demand.

By adding a solar alternative source to power small mechanical equipment, the building can reduce its energy usage, lower its carbon footprint, and save energy costs. The building's renewable energy system is suitably integrated with the mechanical equipment and operates as intended thanks to the adjusted mechanical schedule.

Panel Schedule

A distribution facility's panel scheduling might be significantly impacted by a renewable energy system. A panel schedule in a building or facility usually enumerates the circuits and electrical loads connected to a specific panel. When a renewable energy system is added, the panel schedule has to be adjusted to account for the additional circuits and loads it needs. To illustrate how adding a renewable energy system could impact a panel timetable, we can assume the following:

The facility may update the panel schedule to account for the renewable energy system, which would help it better control its electrical consumption and ensure stable backup power in the event of an outage.

Service Sizing Calculations

A solar system at a distribution location may have a major effect on calculations used to calculate service sizing. When calculating the service size for the location, the solar system's capacity must be included. This is because the solar system can power the location while reducing the demand on the electric grid as a whole. If the solar system is powerful and has a huge capacity, the size of the service might be decreased. Conversely, in the event that the solar system has a restricted capacity and can only generate a small amount of power, the service size may need to be expanded. Greater energy losses and increased installation costs could result from oversized systems. As a result, it is critical to carefully consider the solar system's capacity while determining service sizing. By doing this, you'll optimize the solar system's benefits, make sure the building is powered safely and consistently, and lessen the total load on the utility grid.

Summary Report: Renewable Zero-Carbon Initiatives, such as EVs

The term "zero carbon" describes the idea of reaching a situation in which the net carbon dioxide (CO2) emissions linked to a specific process, product, activity, or entity are successfully offset by acts that remove or remove a corresponding quantity of CO2 from the atmosphere. Reducing or completely eliminating the role that human activity plays in the build-up of greenhouse gases, especially carbon dioxide, in the Earth's atmosphere is the ultimate objective of zero carbon efforts. In order to achieve this, electric vehicle chargers will be built into the building. The infrastructure for charging electric vehicles (EVs) is essential to the success and broad use of EVs. Electric vehicle charging stations are becoming more prevalent as the automobile industry shifts to greener and more sustainable modes of transportation.

PV solar systems are an eco-friendly, zero-carbon power solution for commercial and industrial applications. Carbon-free, clean, renewable electricity is produced by solar photovoltaic systems. They can be used to provide heat and light, as well as to generate power for homes and businesses. PV solar systems are getting more and more well-liked since they are inexpensive, simple to install, and have no negative environmental effects. PV solar systems offer a dependable, carbon-free, renewable power source that can run for a long time. They are a crucial component of any industrial or commercial power system and are assisting in the reduction of reliance on fossil fuels.

As a green energy source, we have installed PV solar panels. PV solar panels are mounted on the roof to generate electricity.

Recommendation from Milestone 1 for Renewable Zero-Carbon Initiatives, such as EVs

Normal Power Single Line Diagram

In an attempt to encourage environmentally friendly building methods, lower energy usage, and increase energy efficiency, we have included the PV solar panel into the standard single line design and connected it to the master single line diagram Power SLD, Lighting layout drawing. It ensures that the power distribution system of the building is designed to maximize the usage of renewable energy, resulting in cost savings for the building owner and promoting a more sustainable future.

Emergency Power Single Line Diagram

Simultaneously, it is imperative that the emergency power Single Line Diagram (SLD) of a business building powered by solar energy exhibit zero carbon emissions. This ensures that the emergency power source is clean and renewable, thereby reducing the building's carbon footprint even in times of emergency. By offering a reliable emergency power supply independent of non-renewable energy sources, it fosters resilience. It makes emergency power system administration more effective and efficient, ensuring power availability when needed and reducing the chance of a system failure.

Lighting Layout Drawing

The lighting fixtures will be set up to maximize the utilization of the renewable energy source if a solar panel is included in the Luminaire schedule drawing as a backup power source. This lessens the facility's reliance on non-renewable energy sources and promotes green building practices.

Currently, it's crucial to take future modifications and advancements into account while constructing a building's lighting system. The lighting system is made to use a renewable energy source by inserting the solar panel in the Luminaire schedule drawing and connecting it to the master single line schematic. This strategy guarantees that the renewable energy source will be taken into consideration for any upcoming modifications or enhancements to the lighting system.

Luminaire Schedule

Making sure that the building's electrical system is set up to control the energy demands of the solar panels is another vital function of the power arrangement diagram. Switchboards and transformers, among other electrical equipment, are sized appropriately to ensure that the building uses the solar energy produced by the panel effectively.

The power layout design also includes backup systems in case of power interruptions. By using renewable energy sources to power these backup systems, the building will rely less on non-renewable energy and be able to support eco-friendly initiatives.

Power Layout Drawing

Making sure that the building's electrical system is set up to control the energy demands of the solar panels is another vital function of the power arrangement diagram. Switchboards and transformers, among other electrical equipment, are sized appropriately to ensure that the building uses the solar energy produced by the panel effectively.

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Mechanical Schedule

Not only may solar energy be used into mechanical equipment schedule drawings to promote sustainable building practises, but it can also lead to significant energy savings. The solar panel will be connected to the master single line diagram so that the mechanical system may be set up to maximize the use of renewable energy. This promotes a more sustainable future and lessens the building's reliance on non-renewable energy sources. To ensure optimal efficiency and sustainability, mechanical system upgrades and modifications are also planned with the alternative energy source in mind.

Panel Schedule

To guarantee that a commercial building's solar power system is securely and successfully integrated into the building's electrical system, panel scheduling is essential. The panel schedule ensures that the building's electrical system is designed to meet its energy needs without wasting energy by providing a comprehensive overview of the system, including the solar power system.

The building owner will save money by using a solar power system as a sustainable energy source, which also promotes sustainability. By reducing the building's reliance on non-renewable energy sources, the building owner will experience a reduction in energy expenses and long-term financial savings.

Service Sizing Calculations

Consideration of a solar system's capacity in service sizing estimates is critical for supporting the zero-carbon effort. The service size will be adjusted by considering the capacity of the solar system to guarantee that the building is given the appropriate infrastructure to manage the renewable energy source. This has important implications for energy efficiency and sustainability since it guarantees that the building is built to make the most use of renewable energy sources while reducing the building's dependency on non-renewable energy sources. Overall, including the capacity of the solar system in service size estimates is critical for supporting the zero-carbon effort, encouraging sustainable building practises, and reducing the carbon emission.

Summary Report: Consideration of Future Technologies

Our study focuses on handling the current technology along with predicting future technology in the ever-changing 21st-century landscape. We embrace the rapid advancements in sustainable energy and seek to analyze their effects on global accessibility and industry. For an example, companies such as TESLA, the largest electric car manufacturer in the world has revolutionized the vehicle industry with its electric vehicles. Many other companies have started to branch into the electric vehicle field, and this strongly suggests that the demand for electric vehicles will continue to increase in the future. To align with this aspect, more installation for electric vehicle charges will be incorporated while designing our electrical system for the building. Charging is always related to batteries. More buildings might include energy storage into their electrical systems as technologies for storing energy, such as batteries, continue to progress. This could provide backup power in case of power outages and reduce reliance on the grid.

Other than that, Energy-saving solutions are essential for cutting expenses, decreasing energy use, and lessening the impact on the environment. Here are a few energy-saving innovations which will be very beneficial for our building particularly for this project:

I. Smart Thermostats
Smart thermostats are programmable appliances that pick up on the routines and preferences of their users. By modifying temperatures according to occupancy, the time of day, and outside factors, they maximize the efficiency of heating and cooling systems. This keeps comfort levels constant while consuming less energy and paying less on electricity costs.

II. Energy-Efficient HVAC Systems
Building temperature regulation is optimized by Heating, Ventilation, and Air Conditioning (HVAC) systems using cutting edge technologies. With features like increased insulation, sophisticated sensors, and variable speed motors, these systems use less energy and have a less environmental impact.

III. Occupancy Sensors
When humans are present or absent from a space, occupancy sensors identify it and modify the lighting, heating, or cooling systems appropriately. These sensors significantly improve building energy efficiency by automatically shutting off or using less energy in vacant spaces.

IV. Building Energy Management Systems (BEMS)
A centralized control system employed in buildings to monitor, manage, and optimize energy consumption. By integrating with various building systems such as HVAC and lighting, BEMS enables real-time monitoring, automated controls, and data analysis to enhance energy efficiency. It adjusts heating, ventilation, and lighting based on factors like occupancy and external conditions, utilizes fault detection for maintenance, integrates with renewable energy sources, and participates in demand response

programs. Offering remote monitoring and control capabilities, BEMS contributes to substantial energy savings, cost reduction, and environmental sustainability, making it an integral component of modern building automation.

V. Energy-Efficient Appliances
The Environmental Protection Agency (EPA) has high energy efficiency standards that appliances with the ENERGY STAR certification must achieve. Compared to their non-certified counterparts, these appliances use less energy while offering the same or better performance, resulting in energy savings and a decrease in greenhouse gas emissions.

Recommendation from Milestone 1 for Consideration of Future Technologies

Normal Power Single Line Diagram

A typical normal power single line diagram uses a single line diagram to depict the electrical distribution system of a structure. The connections between the electrical components, such as distribution panels, transformers, switchgear, and circuit breakers, are shown in this diagram.

The electrical characteristics of the typical power system, such as voltage, current, power factor, and frequency, can be observed using a BMS. By optimizing the performance of the electrical system, a BMS can assist in lowering energy usage. By keeping track of the electrical system, this technology can spot problems and notify repair staff, cutting down on electrical system downtime. By monitoring and controlling the electrical system, a BMS can assist in preventing electrical dangers. The electrical system's data can be collected and stored by a BMS and used for research and optimization.

Emergency Power Single Line Diagram

Batteries are charged and discharged under the supervision and control of battery management systems, or BMS. By keeping an eye on and managing the battery backup system, as seen in the emergency power line single diagram, this may be utilized to ensure a consistent power supply in all situations. The emergency power line single diagram roughly depicts the electrical distribution system that supplies power to critical equipment during a crisis. The BMS is an essential component of the system since it is required for the battery backup system, which powers the vital equipment in an emergency.

The BMS can be made to interface with transfer switches, generators, inverters, and other control systems to provide a smooth and reliable emergency power supply. Overall, emergency power line single diagrams with BMS technology assure the dependable operation of critical machinery during emergencies.

Lighting Layout Drawing

BMS systems provide the ability to monitor and regulate lighting systems, which helps optimize energy use and reduce costs. Some uses for this technology in lighting plan drawings are listed below. The lighting systems of a whole building can be remotely controlled thanks to BMS technology. This makes it easier to monitor and control the lighting systems and ensure that they are being used efficiently. Lighting levels can be changed in accordance with usage and ambient light levels by applying BMS technology. This ensures that illumination is only used when necessary, reducing energy consumption and costs. Using BMS technology, lighting can be scheduled according to consumption and occupancy patterns. This guarantees that lighting is only used when it is required, cutting down on both energy use and expenses. Lighting system energy usage can be tracked using BMS technology. This assists in locating places where energy use can be cut, saving money. BMS technology can be used to find flaws in lighting systems, assisting in the early detection of problems before they become serious ones.

Luminaire Schedule

Using BMS (Building Management System) technology, luminaire scheduling allows for the management of a building's lighting system. For a single luminaire or groups of luminaires, the BMS may control the on/off and dimming settings based on various factors such as daylight sensors, occupancy sensors, and other inputs. Using a BMS, building managers can create lighting schedules that are specific to their area and meet its requirements. For example, lighting in offices can be set to dim or turn off when no one is there, while lighting in warehouses can be set to turn out completely after hours.

Utilizing BMS technology for luminaire scheduling has many benefits, such as lower energy costs, improved illumination quality, more control, and flexibility. By automating the lighting system, BMS technology can assist in lowering energy usage and utility costs. It can also help to create a more productive and comfortable environment for building inhabitants by making sure the lighting is suitable for the task at hand.

Power Layout Drawing

Power layout drawings, which are visual representations of an electrical system in a structure, can be produced using BMS technology. The first step is to collect data regarding the building's electrical system in order to make a power layout drawing using BMS technology. This contains details regarding the placement and nature of electrical panels, switches, plugs, and other parts. You might also need to learn more about the system's power, amperage, and other electrical properties. Using BMS software, you can make a graphical depiction of the electrical system after gathering the necessary data. This can include details about the voltage, ampere rating and other electrical properties of the system, as well as a diagram of the electrical panels, switches, and receptacles.

Mechanical Schedule

When it comes to mechanical scheduling, HVAC system scheduling can be managed and optimized with a BMS. By obtaining data on building occupancy, temperature, and other factors, a BMS may adjust the HVAC system to maintain a comfortable and energy-efficient facility. A BMS could be configured, for example, to adjust the temperature based on the outside weather and the time of day, or to switch off the HVAC system while a room is unoccupied. This could help reduce energy use and the price of electricity.

Panel Schedule

Using BMS technology, the panel schedule may be changed instantly upon modifications to the electrical system, minimizing errors and saving time. Additionally, BMS technology makes it possible to remotely monitor the electrical system, which is helpful for maintenance and troubleshooting tasks.

Service Sizing Calculations

BMS technology can assist in service sizing calculations by providing data on energy consumption of different building systems and equipment. BMS technology provides real-time data on the energy consumption and performance of lights, HVAC, and other equipment while tracking and managing them. By sizing services more efficiently with the use of this information, it will be possible to meet the building's requirements and avoid wasting energy. Electrical distribution systems, lighting systems, and heating and cooling systems are a few examples of these services.

BMS technology can also be used to forecast future energy consumption based on past data, weather patterns, and other factors.

Security System

The three parts of the building's security system are CCTV, access control, and fire alarm. Every element is positioned carefully to guarantee optimal safety. Every room has a fire alarm system built to identify potential fire hazards and notify residents. While access control systems are deployed in sensitive places, such mechanical rooms, to ensure restricted access, CCTV cameras are placed in public areas to monitor and record activity.