Project Report on

Course Code: ENEL 674 (L01)

Course Name: Industrial and Commercial Power Systems

Submitted By,

Group: 09

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Objective

The objective of this study is to develop the electrical design for a building by analyzing customer requirements. In the first milestone, the focus will be on performing load calculations to determine appropriate cable and panel sizes, designing the lighting layout and schedules based on lumen calculations, and preparing the mechanical schedule. Additionally, a single-line diagram will be created, including preliminary equipment sizing and placement.

Scope of Work

• **Requirement Analysis** – Assess customer needs for the electrical system.
• **Load Schedule** – Prepare a detailed load calculation for each room.
• **Lighting Schedule** – Design lighting based on lumen calculations and submit a lumen schedule.
• **Panel Schedule** – Develop a balanced load distribution across phases.
• **Power Layout** – Plan the placement of equipment, receptacles, and feeding panels.
• **Lighting Layout** – Determine the types and number of luminaires.
• **Single-Line Diagram (SLD)** – Create a diagram showing panel locations, breakers, utility connections, and backup systems.
• **Modification Proposal –** Present recommendations to the customer for any necessary changes.

Project Consideration

- ✓ The Project is based on a 10-acre land with 05 building plans, among which 01 building layout is the primary consideration.
- ✓ The utility supply is 112.5 KVA from 25 KV Delta connected feeder.
- ✓ The secondary voltage of transformer is considered 208 V 3phase Star connection.
- ✓ A generator with 125% of continuous load is considered to recover the power outage condition.
- ✓ The building will be used as a multipurpose hall for renting purpose so adequate receptacles has been considered for external equipment for sound and lighting.
- ✓ Loads are primarily calculated based on room requirement, lighting requirement, and additional receptacles for maintenance and external equipment.
- ✓ Panel has been designed with balanced load between 3 phases (15% max deviation) and load which require schedule maintenance has been taken from separate panels for not hampering daily operation.
- ✓ Security and fire protection has been considered but with bare minimum details as it's out of scope for milestone 1.
- ✓ Conductor and conduit sizing has been considered as per CEC regulation.
- ✓ The minimum conductor size was 12 AWG and minimum conduit size 21 mm.
- ✓ The generator and utility line will be operated through an Automatic transfer switch system.
- ✓ The total secondary cable from Transformer/Generator to electrical room is underground and no overhead cable is considered. From panels to room wiring will be in conduit and all sizing calculation is done based on this.
- ✓ Average ambient temperature in room is considered 30 deg.
- ✓ Additional features considered:
    - PA system
    - Water sprinkler system
    - WIFI at each corner
    - Card reader in sensitive entrance
    - Security camera
    - Barrier free switch
    - Fire exit lighting and Smoke detector
- ✓ All 20A receptacles are T type receptacles.
- ✓ Other receptacles are duplex receptacles.
- ✓ Receptacles close to water source like sinks are weather proof receptacles.
- ✓ A 30 HP motor with mechanical starter has been considered for fire pump.

- ✓ Breakers are rated with 125% of load.
- ✓ Cable sizing considered with 5% future growth and 125% of load current.
- ✓ For lighting, LED light is considered in most of the places considering high efficacy and long-life span. But in different room, different sorts of lighting has been considered based on the requirement.
- ✓ Lights for big room like Cultural activities or common are considered suspended lighting.
- ✓ Equipment like Generator and Transformer will be in a separate room outside the building to ensure fire safety and avoiding sound disturbance.

Process Flow

The following figure illustrates the process flow of this project. By analyzing customer's requirement, we have performed the electrical design of the building. We have done lumen calculation, receptacle calculation, load calculation, panel scheduling of every room in the base plan. After that, we have estimated conduit sizing for both continuous and non-continuous load. Finally based on all the calculations, we have conducted lighting design, power layout, normal and emergency SLD. The below figure displays the process flow:

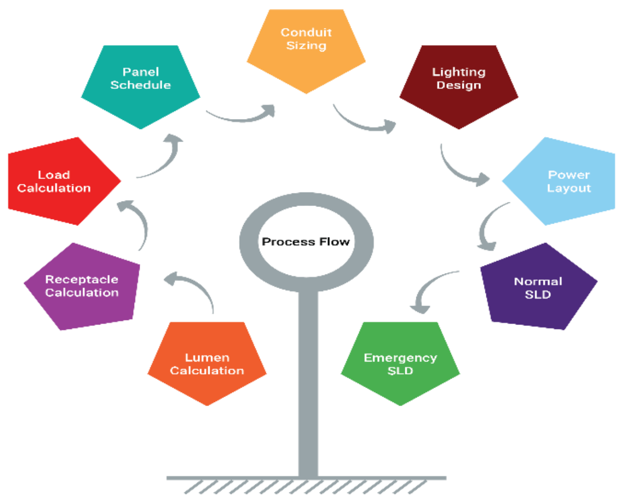

Fig: Process Flow

Technical Specification

Lumen Calculation

For calculation of number of luminaire, we have considered a light loss factor (LLF) of 0.9 and RCR = 10 if RCR is greater than 10 on luminaire cut sheets. We have used the following formula to determine the number of luminaire.

So, Number of luminaire = $\frac{illuminance*L*W}{lumen\ per\ luminiare*Cu*LLF}$

Here, for L & W, we have considered the base plan and we have calculated the Cu from spec sheet based on the RCR.

In this section, we have calculated number of luminaire for all the rooms displayed in the base plan. In the below figure, we have considered Room 101 classroom, Room 102 Closet, Room 103 W. Washroom, Room 104 M. Washroom, Room 105 Washroom Corridor, Room 106 Janitor and Room 107 Water Meter.

Lumeniare Feature	Room 100 Foyer	Room 101 Classroom	Room 102 Closet	Room 103 W. Washroom	Room 104 M. Washroom	Room 105 Washroom Corridor	Room 106 Janitor	Room 107 Water Meter
Illuminace	350	375	150	280	280	250	300	75
number of lumaniare	1	9	4	16	7	2	2	1
lumen per luminiare	4000	4000	300	1200	1200	270	600	1000
Luminaire type (LED)	Ceiling-mounted spot light	Flat Panel LED.	Recessed LED Downlight	LED Recessed Downlight.	LED Recessed Downlight.	LED Recessed Downlight	LED Recessed Downlight.	LED Utility Light
Description (Model No)	Hue White and Color Ambiance Centris 4-Spot Ceiling Light	Lithonia CPX 2X4 4000LM 40K M2	Energizer 4" LED Recessed Ceiling Light	Juno LED 6" Recessed Downlight	Juno LED 6" Recessed Downlight	Cree 4" LED Downlight	Halo RL560 Series LED	KT-WPLED10-840
mounting (Suspended Celling)	Ceiling-mounted	Recessed mounting	Recessed	Recessed ceiling installation.	Recessed ceiling installation.	Recessed Ceiling Mount	Recessed ceiling installation.	ceiling-mounted light
wattage(W)	40 W	40	6	12	12	3	9	10
lumens(lm)	4,600 lumens	4000	300	1200	1200	270	600	1000
manufacturer	Philips Hue	Lithonia Lighting	Energizer	Juno Lighting	Juno Lighting	Cree	Halo	Keystone
Remarks	Provides both functional and ambient lighting, with individual spot adjustability			ENERGY STAR certified, dimmable.	ENERGY STAR certified, dimmable	Energy-efficient, low-wattage	ENERGY STAR certified, smooth light distribution	
Driver	Integrated LED driver	constant current LED driver	Internal driver	Integrated driver	Integrated driver	Integrated LED driver	Integrated driver	internal constant-current LED driver.
CCT(K)	Adjustable from 2000K to 6500K	4000	4000	4000	4000	4000	5000	4000
CRI	80	80	>80	>90	>90	> 80	>90	>80
Controls(V)	Philips Hue app, Bluetooth, Alexa, Google Assistant, Hue Bridge integration	0-10	0-10	Compatible with dimmers	Compatible with dimmers	Non-dimmable		Non-dimmable
voltage(V)	24 V	120 - 277	120	120V.	120V.	120	120V.	120-277
Efficacy(lm/W)	115 lumens per watt (lm/W)	100	50-60	100	100	90	66.7	100

In the below figure, we have considered Room 108 Catering Kicthenette, Room 109 Commons, Room 110 Cultural Room, Room 111 Storage, Room 112 Snack, Room 113 Information, Room 114 and Room 115 Yukuta.

Lumeniare Feature	Room 108 Catering Kicthenette	Room 109 Commons	Room 110 Cultural Room	Room 111 Storage	Room 112 Snack	Room 113 Information	Room 114	Room 115 Yukuta
Illuminace	500	450	750	100	350	300	200	200
number of lumaniare	13	12	11	1	3	6	3	6
lumen per luminiare	4000	3600	21,000	2000	4000	4,000 lumens	400 lumens	800 lumens
Luminaire type (LED)	LED Recessed Panel	LED Panel Light	LED High Bay Light	LED Vapor Tight Fixture	LED Vapor Tight Fixture	LED Panel	LED Recessed Downlight	LED Recessed Downlight
Description (Model No)	Lithonia Lighting CPX 2X2	Philips CoreLine LED Panel 600x600	ps Ultra Efficient LED High Bay 1	SHARK2-22N	SHARK2-48N	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 5W	Philips CorePro LED Downlight 10W
mounting (Suspended Celling)	Recessed Ceiling Grid Mount	Surface Mount	Suspended	Ceiling or wall mount	Ceiling or wall mount	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Recessed (Ceiling Mount)
wattage(W)	40	36	150	24	48	40W	5W	10W
lumens(lm)	4000	3600	21000	2000	4000	4,000 lumens	400 lumens	800 lumens
manufacturer	Lithonia	Philips	Philips	RAB Lighting	RAB Lighting	Philips	Philips	Philips
Remarks	Glare-free design, high efficiency	Slim, energy-efficient	Ideal for high ceilings and large spaces	IP66-rated for dust and water resistance.	-rated for dust and water resista	Ideal for offices and workspaces, energy-efficient, uniform lighting	Suitable for small rooms, energy-efficient, compact	Suitable for minimalistic and serene settings, energy-efficient, long-lasting
Driver	Integrated Driver	LED Driver	high-efficiency driver	0-10V	0-10V	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver
CCT(K)	4000	3600	4000	4000	4000	4000K (Neutral White)	3000K (Warm White)	3000K (Warm White)
CRI	> 90	80+	80+	>80	>80	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)
Controls(V)	0-10	Compatible with dimmers	Compatible with dimmers	Dimmable with compatible switch	immable with compatible switc	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)
voltage(V)	120-277	120-277	120-277	120-277	120-277	120V	120V	120V
Efficacy(lm/W)	105	100	140	83	83	100 lm/W	80 lm/W	80 lm/W

In the below figure, we have considered Room 116 Education, Room 117 Mechanical, Room 118 Staff, Room 119 Administration, Room 120 Vestibule, Room 121 Classroom, Room 122 Exhibit and Room 123 Tea.

Lumeniare Feature	Room 116 Education	Room 117 Mechanical	Room 118 Staff	Room 119 Administration	Room 120 Vestibule	Room 121 Classroom	Room 122 Exhibit	Room 123 Tea
Illuminace	500	200	300	500	300	375	300	150
number of lumaniare	5	6	4	5	5	9	16	4
lumen per luminiare	4,000 lumens	800 lumens	2,000 lumens	4,000 lumens	800 lumens	400	1800 lumens	400
Luminaire type (LED)	LED Panel	LED Recessed Downlight	LED Panel	LED Panel	LED Recessed Downlight	flat panel LED	LED Recessed Downlight	recessed LED panel light
Description (Model No)	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 10W	Philips CorePro LED Panel 20W	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 10W	Lithonia CPX 2X4 4000LM 40K M2	Philips CorePro LED Downlight 20W	Philips CoreLine LED Panel 600x600 36W 4000K
mounting (Suspended Celling)	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Ceiling Surface Mount (Recessed option available)	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Recessed mounting	Recessed (Ceiling Mount)	Recessed
wattage(W)	40W	10W	20W	40W	10W	40	20W	36
lumens(lm)	4,000 lumens	800 lumens	2,000 lumens	4,000 lumens	800 lumens	4000	1800 lumens	4000
manufacturer	Philips	Philips	Philips	Philips	Philips	Lithonia Lighting	Philips	Philips
Remarks	Ideal for educational spaces, energy-efficient, uniform lighting	Ideal for low to medium height spaces, energy-efficient, long-lasting	Ideal for general spaces, provides even lighting, energy-efficient	Ideal for office spaces, energy-efficient, provides uniform lighting	Suitable for general illumination, energy-efficient, long-lasting		Suitable for general illumination in galleries, energy-efficient, long-lasting	
Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	constant current LED driver	Integrated LED Driver	Integrated LED driver
CCT(K)	4000K (Neutral White)	4000K (Neutral White)	4000K (Neutral White)	4000K (Neutral White)	3000K (Warm White)	4000	4000K (Neutral White)	4000
CRI	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	80	≥80 (Good color rendering)	85
Controls(V)	Non-dimmable (Dimmable versions available)	Non-dimmable (dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	0-10	Non-dimmable (Dimmable versions available)	0-10
voltage(V)	120V	120V	120V	120V	120V	120 - 277	120V	120V - 277V
Efficacy(lm/W)	100 lm/w	80 lm/W	100 lm/W	100 lm/W	80 lm/W	100	90 lm/W	110

In the below figure, we have considered Room 200 Stairewell, Room 202 Electrical, Room 203 Mechanical and Room 204 Telecom.

Lumeniare Feature	Room 200 Stairwell	Room 202 Electrical	Room 203 Mechanical	Room 204 Telecom
Illuminace	150	500	250	750
number of lumaniare	2	27	13	31
lumen per luminiare	800 lumens	7,000 lumens	8,000 lumens	7200 lumens
Luminaire type (LED)	LED Recessed Downlight	LED Linear Strip	Vapor-Tight LED	LED Panel Light (2x4 ft)
Description (Model No)	Philips CorePro LED Downlight 10W	**Philips Ledalite TruGroove 4ft LED Strip**	**Philips Day-Brite Vapor-Tight LED (VT1)**	Philips Ledalite TruGroove
mounting (Suspended Celling)	Recessed (Ceiling Mount)	**Surface-mounted or suspended**	Surface-mounted or suspended	Recessed, surface-mounted, or suspended
wattage(W)	10W	55W	65W	56W
lumens(lm)	800 lumens	7,000 lm	8,000 lm	7200 lm
manufacturer	Philips	**Philips (Ledalite TruGroove Series)**	**Philips (Day-Brite)**	**Philips (Ledalite TruGroove Series)**
Remarks	Suitable for indoor spaces such as stairwells, energy-efficient, long-lasting	**Glare-free, uniform illumination, ideal for electrical rooms**	**IP65-rated**, dust & moisture resistant, ideal for mechanical rooms	Uniform illumination, glare-free, ideal for telecom environments
Driver	Integrated LED Driver	Philips Advance Xitanium	Philips Advance Xitanium	Philips Advance Xitanium
CCT(K)	3000K (Warm White)	4000K (Neutral White)	4000K (Neutral White)	5000K (Cool White)
CRI	≥80 (Good color rendering for residential and commercial areas)	>80	>80	>80
Controls(V)	Non-dimmable (available dimmable versions)	0-10V Dimmable, Motion & Daylight Sensor Compatible	0-10V Dimmable, Motion & Daylight Sensor Compatible	0-10V Dimmable, Motion & Daylight Sensor Compatible
voltage(V)	120V	120-277V AC	120-277V AC	120-277V AC
Efficacy(lm/W)	80 lm/W	~127 lumens per watt	~123 lumens per watt	~128 lumens per watt

Receptacle Calculation

The below table illustrate the number of receptacles we have used in every room in this project:

Room name	Room no.	Equipment	Quantity
Foyer	Room 100	Receptacles (2-15A)	2
Classroom	Room 101	Receptacles (4-15A)	4
Closet	Room 102	Receptacles	2
W. Washrrom	Room 103	Receptacles waterproof (3-15A)	3
M. Washroom	Room 104	Receptacles waterproof (1-15A)	1

Janitor	Room 106	Receptacles (1-20A)	1
Catering Kicthenette	Room 108	Receptacles Waterproof (4-20A/ 1-30A/1-15A)	6
Commons	Room 109	Receptacles (3-15A)	3
Cultural Room	Room 110	Receptacles (5-15A)	5
Storage	Room 111	Receptacles (2-15A)	2
Snack	Room 112	Receptacles (1-15A/ 3-20A)	4
Information	Room 113	Receptacles (3-15A)	3
Room 114	Room 114	Receptacles (2-15A)	2
Yukuta	Room 115	Receptacles (1-15A)	1
Education	Room 116	Receptacles (3-15A/ 1-15A)	4
Mechanical	Room 117	Receptacles (1-20A/1-15A)	2
Staff	Room 118	Receptacles (3-15A)	3
Administration	Room 119	Receptacles (1-20A/2-15A)	3
Vestibule	Room 120	Receptacles (2-15A)	2
Classroom	Room 121	Receptacles (4-15A)	4
Exhibit	Room 122	Receptacles (3-15A)	3
Tea	Room 123	Receptacles (1-15A)	1
Electrical	Room 202	Receptacles (2-15A)	2
Mechanical	Room 203	Receptacles (2-15A)	2
Telecom	Room 204	Receptacles (3-15A)	3

Table: Receptacle Calculation (Room wise)

Equipment List

Equipment	Model
Access Control System	HID VertX V1000
Barrier-Free Access	Openpath OP-ABP
CC Camera	Hikvision DS-2CD2142FWD7
Coffee Machine	Keurig K1500
Commercial Oven	Blodgett DFG-100
Computer	Dell OptiPlex 7070
Digital Display	Samsung QB65R
Dishwasher	Bosch SHX878ZD5N
Emergency Light and Exit Sign	Lithonia ELM2 LED
Espresso Machine	La Marzocco Linea Mini
Fire Alarm System	Honeywell MS-9200UDLS
Firefighter Access Point	Motorola APX 6000XE
Flat Top Grill	Vulcan VCRG36-M
Fridge	LG LTCS20020S
Hand Dryer (Automatic)	Dyson Airblade V
Intercom	Aiphone LEF-3L
Microwave	Panasonic NE-1054F
Microwave	Panasonic NN-SN686S
Printer/Scanner/Copier	HP LaserJet Pro MFP M428

Projector	Epson PowerLite 2250U
Push Switch	Legrand 93151
Receptacles	Leviton 5362-W
Smoke Detector	System Sensor 2W-B0.5
Warming Oven	Nemco 6150-36
Water Purifier	Brita Total 360
Wifi	Cisco Aironet 2802i

Table: Equipment List

Load Calculation

For load calculation, we have considered PF = 0.95. From the data sheet, we have find out the power (KW) and voltage (V). Then we have calculated the current (A) and apparent power S (KVA) based on the below formula:

Current, I (A) = $\frac{P\ (KW)*1000}{PF*V\ (v)}$

Apparent Power, S (KVA) = $\frac{P\ (KW)}{PF}$

Sl.	Room name	Room no.	Total Load (Per Room KW)	Total Load (Building kW)
1	Foyer	Room 100	4.8445	250.63975
2	Classroom	Room 101	8.467	
3	Closet	Room 102	3.624	
4	W. Washroom	Room 103	7.2605	
5	M. Washroom	Room 104	3.0725	
6	Washroom Corridor	Room 105	0.0275	
7	Janitor	Room 106	1.818	
8	Water Meter	Room 107	0.75	
9	Catering Kicthenette	Room 108	22.34775	
10	Commons	Room 109	12.2775	
11	Cultural Room	Room 110	53.4695	
12	Storage	Room 111	3.624	
13	Snack	Room 112	11.556	
14	Information	Room 113	5.9235	
15	Room 114	Room 114	3.615	
16	Yukuta	Room 115	1.91	
17	Education	Room 116	8.447	
18	Mechanical	Room 117	8.624	
19	Staff	Room 118	5.4985	
20	Administration	Room 119	6.647	
21	Vestibule	Room 120	6.317	
22	Classroom	Room 121	9.0525	
23	Exhibit	Room 122	6.9525	
24	Tea	Room 123	1.9675	
25	Stairwell	Room 200	0.0635	
26	Electrical	Room 202	29.0575	
27	Mechanical	Room 203	16.006	
28	Telecom	Room 204	7.4195	

Table: Load Calculation (Room Wise)

Panel Schedule

Here, we have done panel for A, B, C, D, E, F, G and H.

Panel A load distribution:

Here Panel ID is 12A. 1 for 1st floor, 2 for 208V and A for Panel A. In Panel A, we have connected Room 100 Foyer, Room 101 Classroom, Room 102 Closet, Room 103 W. Washroom, Room 104 M. Washroom, Room 106 Janitor, Room 107 Water Meter and Room 200 Stairwell.

Panel Schedule

Date		Panel ID	12A	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit		ISC Rating	
Location		Voltage (V)	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit No	Room No
	1	Receptacles (15A)	1	1.85	1	20	A	40	1	3.789473684	2	Receptacles (20A)	2	
	3	Receptacles (15A)	2	3.7	1	39	B	1	1	0.021052632	1	Sprinkler Flow Switch and Temper Switch1	4	
	5	Receptacles (15A)	5	9.25	1	97	C	8	1	0.757894737	1	FF-4 120V 1phase 6FLA	6	
	7	Light	23	1.44	1	15	A	1	1	0.021052632	1	Access Control	8	101-107, 200
	9	Wifi	6	0.082105263	1	1	B						6	
	11	Intercom	4	0.021052632	1	1	C						8	
	13	Close Circuit Camera	4	0.023157895	1	1	A						10	
	15	Barrier free access	3	0.052631579	1	1	B						12	
	17	Emergency light and exit sign	5	0.018421053	1	1	C						14	
	19	Push switch	6	0.012631579	1	1	A						16	
101-107, 200	21	120V 6FLA FF-1	1	0.757894737	1	8	B						18	
	23	Annunciator Panel used as Fire fighter access point	1	0.421052632	1	5	C						20	
	25	Projector	1	0.421052632	1	5	A						26	
	27	Computer	1	0.273684211	1	3	B						36	
	29	Speaker	1	0.231578947	1	3	C						38	
	31	Receptacles waterproof (15A)	2	3.78	1	40	A							
	33	Light / Sensor light	32	6.4672	1	68	B							
	35	Hand Dryer Automatic	2	0.252631579	1	3	C							
	37	Barrier free Access	1	0.052631579	1	1	A							
	39	Barrier free Access	1	0.052631579	1	1	B							
	41	BBH-8 120V 1phase, 1KW	1	1.052631579	1	11	C							

Load Balance Summary		
Sl	Phase	Total Load (KVA)
1	A	11.38
2	B	11.4
3	C	11.95

Panel B load distribution:

Here Panel ID is 12B. 1 for 1st floor, 2 for 208V and B for Panel B. In Panel B, we have connected Room 108 Catering Kicthenette.

Panel Schedule

Date		Panel ID	12B	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	44	ISC Rating	
Location		Voltage (V)	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Descriptio	Circuit No	Room No
	1	Receptacles Waterproof (2-20A)	2	3.7600	1	40.000	A	1	1	0.0053	1	Intercom	2	108
	3	Receptacles Waterproof (1-30A/1-15A)	2	3.7600	1	40.000	B						4	
	5	Receptacles Waterproof (2-20A)	2	3.76	1	40.000	C						6	
	7	Light	13	0.5474	1	6.000	A						8	
	9	Fridge	1	0.7632	1	8.000	B						10	
	11	Dishwasher	1	1.37	1	15.000	C						12	
	13	Espresso Machines	1	1.5789	1	17.000	A						14	
	15	Digital Display	1	0.1158	1	2.000	B						16	
	17	Flat top grill	1	0.94	3	10.000	C						18	
	19	Flat top grill	1	0.9400	3	10.000	A						20	
Room 108	21	Flat top grill	1	0.9400	3	10.000	B						22	
	23	Water Purifier	1	0.06	1	1.000	C						24	
	25	Commercial Oven	1	0.3800	3	4.000	A						26	
	27	Commercial Oven	1	0.3800	3	4.000	B						28	
	29	Commercial Oven	1	0.38	3	4.000	C						30	
	31	Wifi	1	0.0137	1	1.000	A						32	
	33	BBH-1	1	2.6316	1	28.000	B						34	
	35	Close Circuit Camera	2	0.01	1	1.000	C						36	
	37	Emergency light and exit sign	1	0.0037	1	1.000	A						38	
	39	Exhaust Fan	1	0.0003	1	1.000	B						40	
	41	BBH-2	1	1.05	1	11.000	C						42	

Load Balance Summary		
Sl	Phase	Total Load (KVA)
1	A	7.23
2	B	8.59
3	C	7.58

Panel C load distribution:

Here Panel ID is 12C. 1 for 1st floor, 2 for 208V and C for Panel C. In Panel C, we have connected Room 110 Cultural Room.

Panel Schedule

Date		Panel ID		Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type		Total Circuit		ISC Rating	
Location		Voltage		BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase		No. Wire			

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Descriptio	Circuit No	Room No
Room 110	1	Receptacles (5-15A)	5	9.473684211	1	99	A						2	
	3	Light Proper for spotting	11	1.736842105	1	19	B						4	
	5	Wifi	1	0.013684211	1	1	C						6	
	7	Intercom	1	0.005263158	1	1	A						8	
	9	Close Circuit Camera	4	0.023157895	1	1	B						10	
	11	Emergency light and exit sign	1	0.003684211	1	1	C						12	
	13	Projector	2	0.842105263	1	9	A						14	
	15	Barrier free access	1	0.052631579	1	1	B						16	
	17	Push button	1	0.001052632	1	1	C						18	
	19	Egress Door	1	0.052631579	1	1	A						20	
	21	Microphone	2	0.004210526	1	1	B						22	
	23	Speaker	1	0.231578947	1	3	C						24	
	25	BBH-6 1phase 2.5 KW 208 V	1	2.631578947	1	28	A						26	
	27	BBH-7 1phase 2.5 KW 208 V	1	2.631578947	1	28	B						28	
	29	Condensing unit,208,3ph,14fla	1	5.043157895	3	53	C						30	
	31	Condensing unit,208,3ph,18fla	1	6.484210526	3	68	A						32	
	33	Condensing unit,208,3ph,39fla	1	13.68421053	3	143	B						34	
	35	Condensing unit,208,3ph,37fla	1	13.36842105	3	140	C						36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	19.33
2	B	18.59
3	C	18.66

Panel D load distribution:

Here Panel ID is 12D. 1 for 1st floor, 2 for 208V and D for Panel D. In Panel D, we have connected Room 109 Commons, Room 111 Storage and Room 112 Snack.

Panel Schedule

Date		Panel ID		Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type		Total Circuit		ISC Rating	
Location		Voltage		BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase		No. Wire			

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Phase	Breaker Size	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Circuit No	Room No
109	1	Receptacles (15A)	3	5.6893	1	A	60	Warming Oven	1	1.052631579	1	11	A	2	112
109	3	Light	12	0.454736842	1	B	5	Wifi	1	0.013684211	1	1	B	4	112
109	5	Wifi	1	0.013684211	1	C	1	Intercom	1	0.005263158	1	1	C	6	112
109	7	Intercom	1	0.005263158	1	A	1	Close Circuit Camera	1	0.005789474	1	1	A	8	112
109	9	Close Circuit Camera	4	0.023157895	1	B	1	Emergency light and exit sign	1	0.003684211	1	1	B	10	112
109	11	Emergency light and exit sign	1	0.003684211	1	C	1	Receptacles (15A)	1	1.8974	1	20	C	14	112
109	13	Projector	2	0.842105263	1	A	9							16	
109	15	Barrier free access	1	0.052631579	1	B	1							18	
109	17	Push button	2	0.002105263	1	C	1							20	
109	19	Egress Door	1	0.052631579	1	A	1							22	
109	21	BBH-3 120 V	1	1.052631579	1	B	11							24	
109	23	BBH-4 208 V	1	2.631578947	1	C	28							26	
109	25	BBH-5 120 V	1	1.052631579	1	A	11							28	
109	27	BBH-9 120V	1	1.052631579	1	B	11							30	
111	29	Receptacles (15A)	2	3.789384211	1	C	40							32	
111	31	Light	1	0.025263158	1	A	1							34	
112	33	Receptacles (20A)	3	5.6893	1	B	60							36	
112	35	Light	3	0.151578947	1	C	2							38	
112	37	Microwave	1	1.052631579	1	A	11							40	
112	39	Coffee Machine	1	1.536842105	1	B	17							42	
112	41	Fridge	1	0.763157895	1	C	8							44	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	9.772
2	B	9.812
3	C	9.324

Panel E load distribution:

Here Panel ID is 12E. 1 for 1st floor, 2 for 208V and E for Panel E. In Panel E, we have connected Room 113 Information, Room 114, Room 115 Yukuta, Room 116 Education, Room 118 Staff and Room 119 Administration.

Panel Schedule

Date		Panel ID	12E	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit No	Room No
Room - 113	1	Receptacles (3-15A)	3	5.684210526	1	60	A	40	1	3.789473684	2	Receptacles (2-15A)	2	Room - 114
Room - 113	3	Light	6	0.252631579	1	3	B	1	1	0.015789474	3	Light	4	Room - 114
Room - 113	5	Wifi	1	0.013684211	1	1	C	20	1	1.894736842	1	Receptacles (1-15A)	6	Room - 115
Room - 113	7	Intercom	1	0.005263158	1	1	A	1	1	0.063157895	6	Light	8	Room - 115
Room - 113	9	Close Circuit Camera	1	0.005789474	1	1	B	1	1	0.052631579	1	Climate Controlled	10	Room - 115
Room - 113	11	Computer	1	0.273684211	1	3	C	79	1	7.578947368	4	Receptacles (4-15A)	12	Room - 116
Room - 118	13	Light	4	0.084210526	1	1	A	3	1	0.210526316	5	Light	14	Room - 116
Room - 118	15	Receptacles (3-15A)	3	5.684210526	1	60	B	1	1	0.013684211	1	Wifi	16	Room - 116
Room - 118	17	Wifi	1	0.013684211	1	1	C	1	1	0.005263158	1	Intercom	18	Room - 116
Room - 118	19	Close Circuit Camera	1	0.005789474	1	1	A	1	1	0.005789474	1	Close Circuit Camera	20	Room - 116
Room - 119	21	Receptacles (1-20A/2-15A)	3	5.684210526	1	60	B	1	1	0.003684211	1	Emergency light and exit sign	22	Room - 116
Room - 119	23	Light	5	0.210526316	1	3	C	6	1	0.547368421	2	Computer	24	Room - 116
Room - 119	25	Printer, Scanner, Copier	1	0.526315789	1	6	A	6	1	0.526315789	1	Printer, Scanner, Copier	26	Room - 116
Room - 119	27	Intercom	1	0.005263158	1	1	B	1	1	0.005789474	1	Close Circuit Camera	28	Room - 119
Room - 119	29	Wifi	1	0.013684211	1	1	C	1	1	0.003684211	1	Emergency light and exit sign	30	Room - 119
Room - 119	31	Computer	2	0.547368421	1	6	A	0	1				32	
Room - 119	33												34	
Room - 119	35												36	
Room - 119	37												38	
Room - 119	39												40	
Room - 119	41												42	
Room - 119	43												44	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	11.45
2	B	11.72
3	C	10.56

Panel F load distribution:

Here Panel ID is 12F. 1 for 1st floor, 2 for 208V and F for Panel F. In Panel F, we have connected Room 117 Mechanical.

Panel Schedule

Date		Panel ID	12F	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Descriptio	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker	Pole	Load (KVA)	Quantity	Equipments Descriptio	Circuit N	Room No
117	1	force flow fan,120V,1ph,1.5k	1	1.578947368	1	17	A						2	
	3	Receptacles (1-20A)	1	1.89	1	20	B						4	
	5	Receptacles (1-15A)	1	1.89	1	20	C						6	
	7	force flow fan,120V,1ph,1.5k	1	1.578947368	1	17	A						8	
	9	Light	6	0.063157895	1	1	B						10	
	11	Access Control	1	0.021052632	1	1	C						12	
	13	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	A						14	
	15	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	B						16	
	17	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	C						18	
	19	Wifi	1	0.013684211	1	1	A						20	
	21	Intercom	1	0.005263158	1	1	B						22	
	23	Emergency light and exit sig	1	0.003684211	1	1	C						24	
	25												26	
	27												28	
	29												30	
	31												32	
	33												34	
	35												36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	4.37
2	B	3.15
3	C	3.11

Panel G load distribution:

Here Panel ID is 12G. 1 for 1st floor, 2 for 208V and G for Panel G. In Panel G, we have connected Room 120 Vestibule, Room 121 Classroom and Room 122 Exhibit.

Panel Schedule

Date		Panel ID	12G	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit N	Room No
Room - 120	1	Light	5	0.052631579	1	1	A	79	1	7.578947368	4	Receptacles (4-15A)	2	Room - 121
Room - 120	3	Receptacles (2-15A)	2	3.789473684	1	40	B	1	1	0.013684211	1	Wifi	4	Room - 121
Room - 120	5	Wifi	1	0.013684211	1	1	C	4	1	0.378947368	9	Light	6	Room - 121
Room - 120	7	Intercom	1	0.005263158	1	1	A	1	1	0.005263158	1	Intercom	8	Room - 121
Room - 120	9	Close Circuit Camera	1	0.005789474	1	1	B	1	1	0.003684211	1	Emergency light and exit sign	10	Room - 121
Room - 120	11	Emergency light and exit sign	1	0.003684211	1	1	C	3	1	0.273684211	1	Computer	12	Room - 121
Room - 120	13	Access Control	1	0.021052632	1	1	A	1	1	0.011578947	2	Close Circuit Camera	14	Room - 121
Room - 120	15	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	B	5	1	0.421052632	1	Projector	16	Room - 121
Room - 120	17	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	C	9	1	0.842105263	1	Sound System	18	Room - 121
Room - 120	19	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	A	2	1	0.126315789	6	Spot Light	20	Room - 122
Room - 120	21	force flow fan,120V,1ph, 1.5KW FF-2	1	1.578947368	1	17	B	4	1	0.336842105	16	Light	22	Room - 122
Room - 123	23	Light Minimal	4	0.151578947	1	2	C	60	1	5.684210526	3	Receptacles (3-15A)	24	Room - 122
Room - 123	25	Wifi	1	0.013684211	1	1	A	1	1	0.013684211	1	Wifi	26	Room - 122
Room - 123	27	Receptacles (1-15A)	1	1.894736842	1	20	B	1	1	0.005263158	1	Intercom	28	Room - 122
Room - 123	29	Sound System	1	0.842105263	1	9	C	1	1	0.011578947	2	Close Circuit Camera	30	Room - 122
Room - 123	31	Close Circuit Camera	1	0.005789474	1	1	A	5	1	0.421052632	1	Projector	32	Room - 122
Room - 122	33	Intercom	1	0.005263158	1	1	B	1	1	0.003684211	1	Emergency light and exit sign	34	Room - 122
	35				1		C						36	
	37				1		A						38	
	39				1		B						40	
	41				1		C						42	

Load Balance Summary

SI	Phase	Total Load (KVA)
1	A	8.65
2	B	8.45
3	C	8.59

Panel H load distribution:

Here Panel ID is M2H. M for Mezzanine floor, 2 for 208V and H for Panel H. In Panel H, we have connected Room 202 Electrical, Room 203 Mechanical and Room 204 Telecom.

Panel Schedule

Date		Panel ID	M2H	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit N	Room No
Room - 202	1	Close Circuit Camera	2	0.011578947	1	1	A	10	1	0.889473684	13	Light	2	Room - 203
Room - 202	3	Light	27	1.563157895	1	17	B	3	1	0.196842105	1	Exhaust Fan,120,1ph,0.25HP	4	Room - 203
Room - 202	5	Wifi	1	0.013684211	1	1	C	13	3	1.2	1	Furnace,208,3ph,12FLA	6	Room - 203
Room - 202	7	Fire Alarm Control Panel	1	1.010526316	1	11	A	13	3	1.2	1	Furnace,208,3ph,12FLA	8	Room - 203
Room - 202	9	Receptacles (2-15A)	2	3.789473684	1	40	B	13	3	1.2	1	Furnace,208,3ph,12FLA	10	Room - 203
Room - 202	11	Intercom	1	0.005263158	1	1	C	50	1	4.736842105	1	Domestic hot water tank,120V,1ph 5FLA	12	Room - 203
Room - 202	13	Fire Pump (30 HP)	1	7.85	3	82	A	1	1	0.013684211	1	Wifi	14	Room - 203
Room - 202	15	Fire Pump (30 HP)	1	7.85	3	82	B	1	1	0.005263158	1	Intercom	16	Room - 203
Room - 202	17	Fire Pump (30 HP)	1	7.85	3	82	C	1	1	0.011578947	2	Close Circuit Camera	18	Room - 203
Room - 202	19	Fire Alarm Booster panel	1	0.631578947	1	7	A	60	1	5.684210526	3	Receptacles (3-15A)	20	Room - 204
Room - 202	21	Emergency light and exit sign	1	0.003684211	1	1	B	20	1	1.827368421	31	Light	22	Room - 204
Room - 203	23	Receptacles (2-15A)	2	3.789473684	1	40	C	1	1	0.013684211	1	Wifi	24	Room - 204
Room - 203	25	Furnace,208,3ph,10FLA	1	1.2	3	13	A	1	1	0.005263158	1	Intercom	26	Room - 204
Room - 203	27	Furnace,208,3ph,10FLA	1	1.2	3	13	B	1	1	0.005789474	1	Close Circuit Camera	28	Room - 204
Room - 203	29	Furnace,208,3ph,10FLA	1	1.2	3	13	C	3	1	0.273684211	1	Computer	30	Room - 204
	31												32	
	33												34	
	35												36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

SI	Phase	Total Load (KVA)
1	A	18.5
2	B	17.64
3	C	19.1

Power Supply

A Power Factor Improvement (PFI) panel is used to improve the power factor by adding capacitor banks, reducing reactive power (KVAR) and improving system efficiency.

- **Active Power (P)** = 250.74 kW
- **Assumed Existing Power Factor (PF_{old})** = 0.95
- **Desired Power Factor (PF_{new})** = 0.98

The relationship between active power, reactive power, and apparent power is:

$Q_{old} = P * \tan * \cos^{-1} (PF_{old})$
$= 250.74 * \tan * \cos^{-1} (0.95) = 82.41$

$Q_{new} = P * \tan * \cos^{-1} (PF_{new})$
$= 250.74 * \tan * \cos^{-1} (0.98) = 50.91$

The required capacitor bank size $Q_c = Q_{old} – Q_{new}$ = 31.5 KVAR
So, we need 32 KVAR capacitor bank.

Service Sizing

For conductor sizing, we have assumed ambient temperature is 30 deg. We have considered Cu conductor with an insulating temperature 60 deg. For conductor sizing, as per CEC code, any load which run more than 3 hours is continuous load.

For Continuous load $_{\text{rated current}}$ = 1.25 * load current

Total Rated current = Discontinuous load $_{\text{rated current}}$ + Continuous load $_{\text{rated current}}$

Power (KW) Continous	Power (KW) Discontinous	Voltage (V)	Pf	Current (A) Continous	Current (A) Discontinous	Rated Current(A)	Conductor Sizing (Kcmil)
110.49	140.74	208	0.95	404.0172825	411.7034471	815.7207297	800

Table: Service Sizing (Whole Building)

From, Table 2, we have found the conductor size. Here, 800 continuous current (A) 404.0172825, we need conductor of 800 Kcmil size.

The below figure illustrate the conductor size and conduit size of every room in the base plan. From Table 6A, we have measured the conduit size based on the conductor size.

Room Name	Load (KW)	Panel	Current (A) Room	Required Ampacity	Conductor Size	Conduit size (mm)
Room 100 Foyer	4.84	12A	24.54112159	30.67640199	8 AWG	21
Room 101 Classroom	8.46	12A	42.89625799	53.62032248	6 AWG	27
Room 102 Closet	3.624	12A	18.37541831	22.96927289	10 AWG	21
Room 103 W. Washrrom	7.26	12A	36.81168239	46.01460298	6 AWG	27
Room 104 M. Washroom	3.07	12A	15.56637258	19.45796572	12 AWG	21
Room 105 Washroom Corridor	0.0275	12A	0.139438191	0.174297739	12 AWG	21
Room 106 Janitor	1.81	12A	9.177568198	11.47196025	12 AWG	21
Room 200 Stairwell	0.063	12A	0.319440219	0.399300274	12 AWG	21
Room 107 Water Meter	0.75	12A	3.802859751	4.753574688	12 AWG	21
Room 108 Catering Kicthenette	22.34	12B	113.27	141.59	2/0	41
Room 110 Cultural Room	53.46	12C	271.06	338.83	600 kcmil	78
Room 109 Commons	12.27	12D	62.21478552	77.7684819	3 AWG	27
Room 111 Storage	5.42	12D	27.4819998	34.35249975	10 AWG	21
Room 112 Snack	11.55	12D	58.56404016	73.2050502	3 AWG	27

Room 113 Information	5.92	12E	30.01723963	37.52154954	8 AWG	21
Room 114	3.61	12E	18.3044316	22.8805395	10 AWG	21
Room 115 Yukuta	1.91	12E	9.684616165	12.10577021	12 AWG	21
Room 116 Education	8.44	12E	42.79484839	53.49356049	6 AWG	27
Room 118 Staff	5.49	12E	27.83693337	34.79616672	8 AWG	21
Room 119 Administration	6.64	12E	33.66798499	42	6 AWG	27
Room 117 Mechanical	8.64	12F	43.8	54.76	6 AWG	27
Room 120 Vestibule	6.317	12G	32.03022006	40.03777507	6 AWG	27
Room 121 Classroom	9.05	12G	45.88784099	57.35980124	4 AWG	27
Room 122 Exhibit	6.95	12G	35.23983369	44.04979211	6 AWG	27
Room 123 Tea	1.96	12G	9.938140148	12.42267519	12 AWG	21
Room 202 Electrical	29.05	M2H	147.2974343	184.1217929	4/0	53
Room 203 Mechanical	16	M2H	81.12767468	101.4095933	1 AWG	35
Room 204 Telecom	7.41	M2H	37.57225434	46.96531792	6 AWG	27

Table: Service Sizing (Room wise)

Lightening Layout Diagram:

For lightening layout, we have used DIALux software to design it. The below figures illustrate main floor lightening layout, mezzanine floor lightening layout alongside each room’s layout individually.

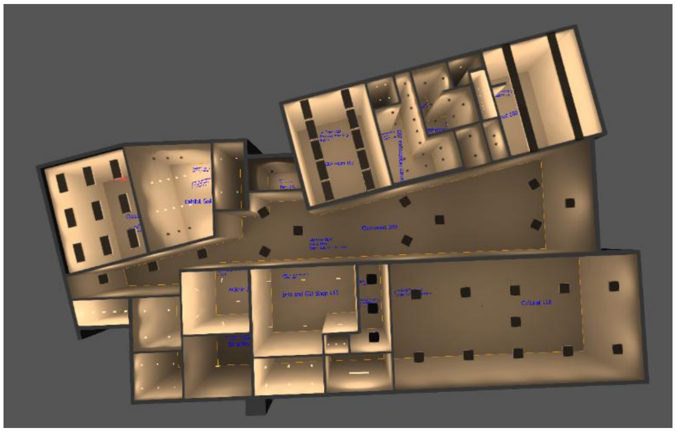

Fig: Main Floor Lightening Layout.

Fig: Mezzanine Floor Lightening Layout.

Fig: Foyer 100 Layout

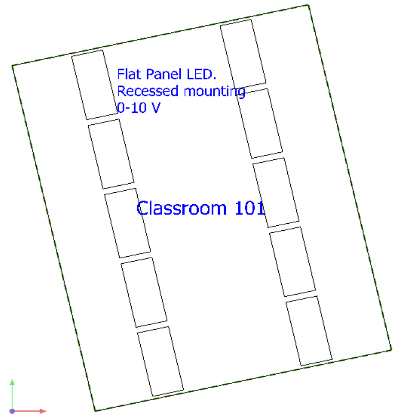

Fig: Classroom 101 Layout

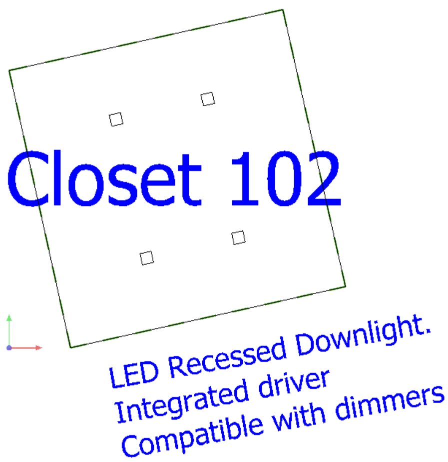

Fig: Closet 102 Layout

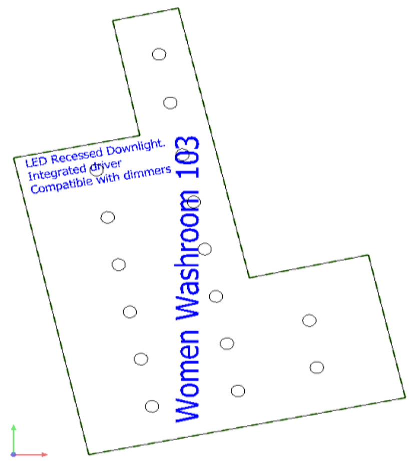

Fig: Women Washroom 103 Layout

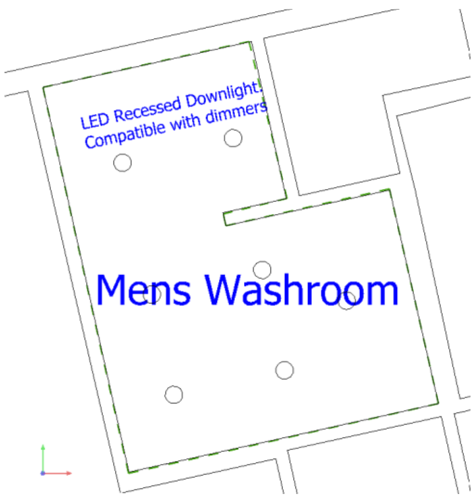

Fig: Men's Washroom Layout

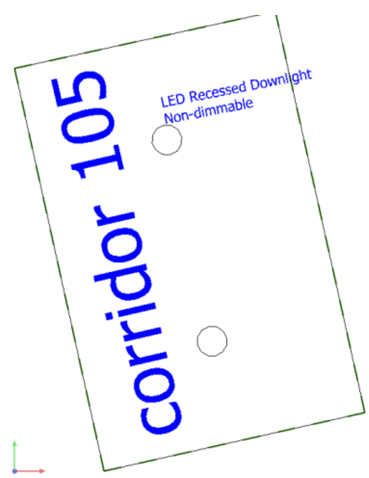

Fig: Corridor 105 Layout

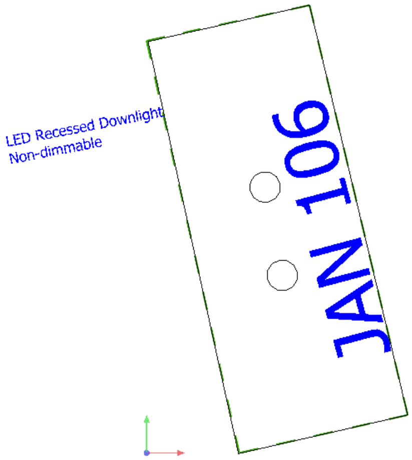

Fig: Room 106 Layout

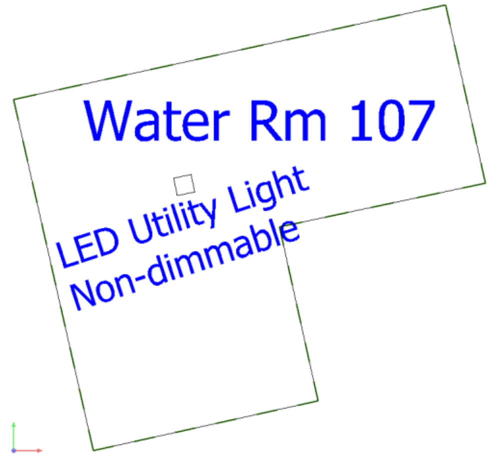

Fig: Room 107 Layout

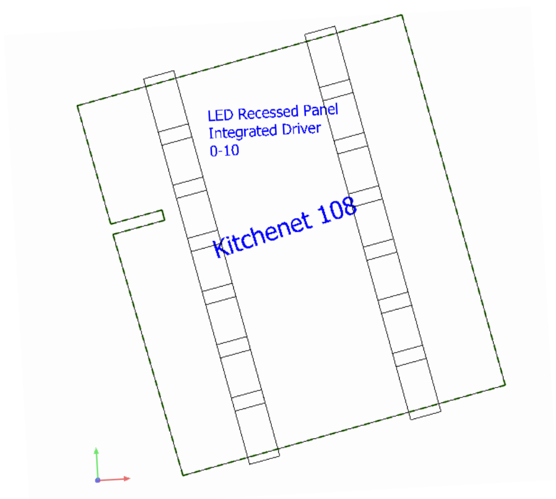

Fig: Kitchenette 108 Layout

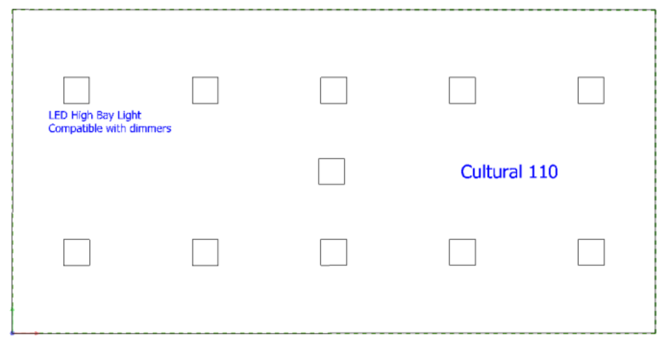

Fig: Cultural 110 Layout

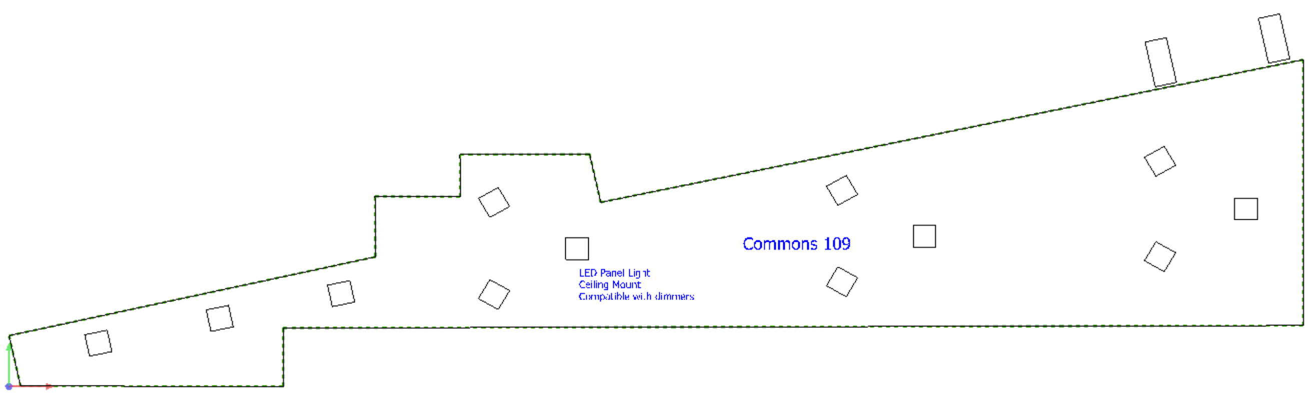

Fig: Common 109 layout

Fig: Storage 111 Layout

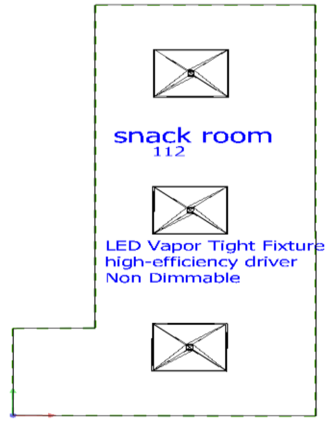

Fig: Snack Room 112 Layout

Fig: Gift Shop 113 Layout

Fig: Storage 114 Layout

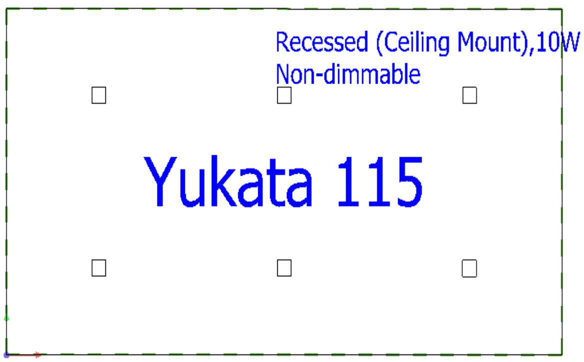

Fig: Yukata 115 Layout

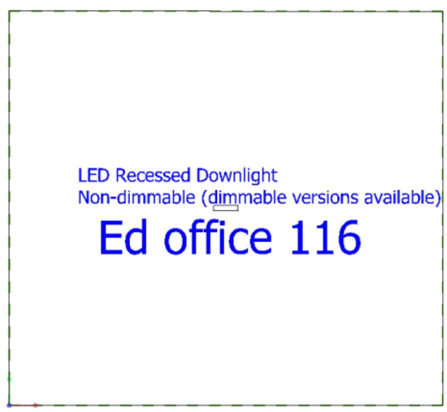

Fig: Ed Office 116 Layout

Fig: Mechanical 117 Layout

Fig: Staff 118 Layout

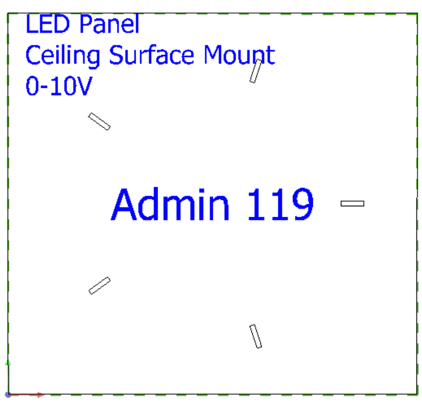

Fig: Admin 119 Layout

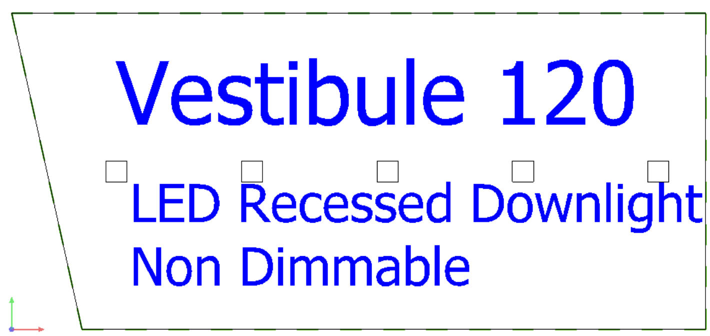

Fig: Vestibule 120 Layout

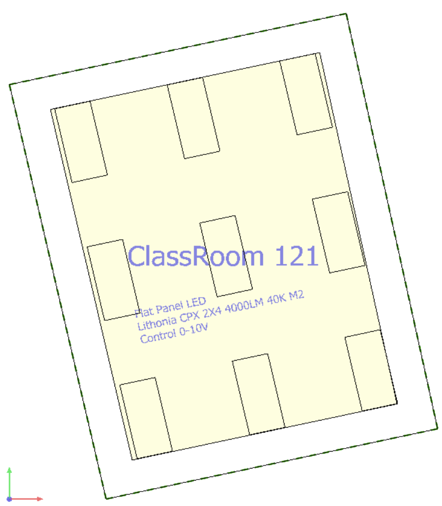

Fig: Classroom 121 Layout

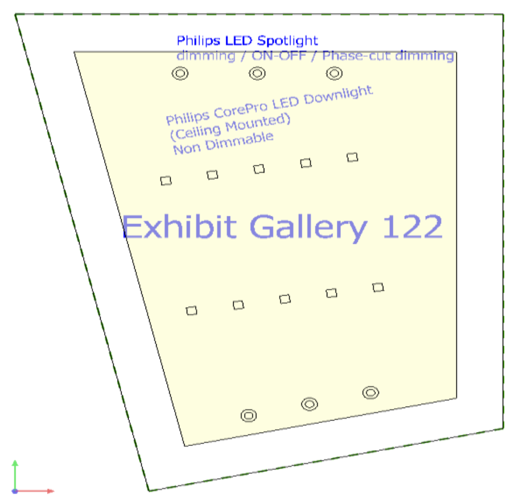

Fig: Exhibit Gallery 122 Layout

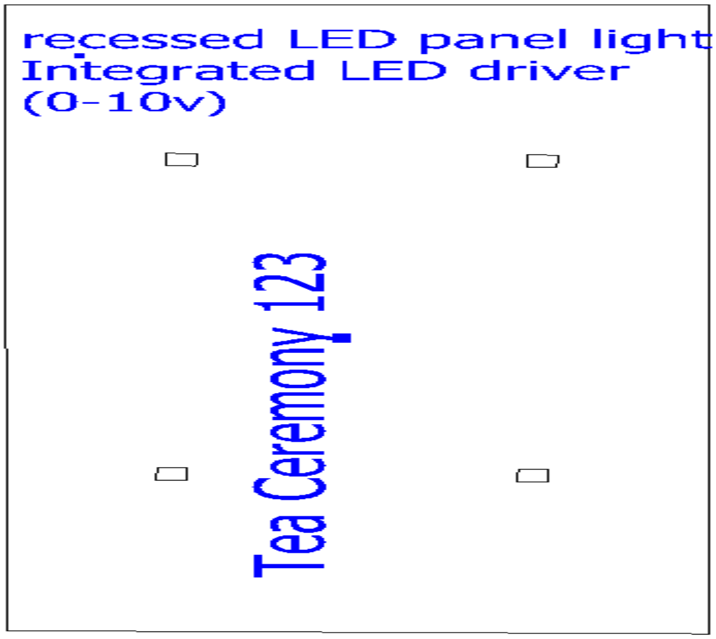

Fig: Tea Ceremony 123 Layout.

Feedback: A good practice to use DIALux software for design. However, switching zones could be marked more clearly. Also, the lighting layout in the single expected PDF report is not clear to be read. Some fixtures and their control types are not well labeled.

Answer: In this milestone-2, we have marked switching zone very clearly this time. Also, we have labeled fixtures and their control types to every room individually. For better understand, we have attached snap from every room in this report.

Power Layout Diagram:

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.

Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L. In this milestone-2, we have added generator just beside the kitchenette in our power layout drawing.

The below figure illustrates the updated power layout diagram for the given base plan of this project:

Feedback from Milestone-2: Use different colors in diagrams for fire safety and security elements to improve clarity.

Answer: In this milestone-3, we have used different colors in the diagram for fire safety and security elements. For better view, we have attached .dwg file alongside with our report in D2L.

Fig: Power Layout Diagram

Mechanical Schedule:

The below figure illustrates the mechanical schedule for the given base plan of this project:

MECHANICAL EQUIPMENT SCHEDULE

Printed on Feb 17, 2023 at 1:48 PM

Unit No.	Description	Location	Nameplate Voltage (V)	Nameplate Phase Ø	Nameplate MCA (A)	Nameplate Load (HP, FLA, kW)	Overcurrent Protection Type	Overcurrent Protection Rating	Overcurrent Protection Poles	Feeder Conductors	Feeder Bond	Feeder Conduit	Fed From	Disconnect NEMA Rating	Disconnect S	Disconnect I	Disconnect C	Starter/VFD Type	Starter/VFD NEMA Size	Starter/VFD S	Starter/VFD I	Starter/VFD C	Starter Control Type	Starter Control Remote Type	Starter Control N/O Contacts	Starter Control N/C Contacts	Starter Control S	Starter Control I	Starter Control C	Remarks
AIR CONDITIONING EQUIPMENT																														
CU-1	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		14.0 FLA	MCC	40	3	8 AWG		21	Panel 12C										INT							CONTROLLED BY FURNACE
CU-2	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		18.0	MCC	40	3	8 AWG		21	Panel 12C										INT							CONTROLLED BY FURNACE
CU-3	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		39.0	MCC	90	3	2 AWG		35	Panel 12C										INT							CONTROLLED BY FURNACE
CU-4	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		37.0	MCC	90	3	2 AWG		35	Panel 12C										INT							CONTROLLED BY FURNACE
AIR HANDLING																														
F-1	FURNACE	MECHANICAL ROOM 117	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel 12F										LTST							CONTROLLED BY THERMOSTAT
F-2	FURNACE	MECHANICAL ROOM 117	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel 12F										LTST							CONTROLLED BY THERMOSTAT
F-3	FURNACE	MECHANICAL ROOM 203	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel M2H										LTST							CONTROLLED BY THERMOSTAT
F-4	FURNACE	MECHANICAL ROOM 203	208	3		12.0 FLA	MCC	25	3	10 AWG		21	Panel M2H										LTST							CONTROLLED BY THERMOSTAT
DOMESTIC HOT WATER																														
DHWT-1	DOMESTIC HOT WATER TANK	MECHANICAL ROOM 203	120	1		5.0 FLA		15	1	12 AWG		21	Panel M2H					VFD					INT							
EXHAUST FANS																														
EF-1	EXHAUST FAN	MECHANICAL ROOM 203	120	1		0.25 HP	MCC	15	1	12 AWG		21	Panel M2H					Mag					COM		2	2				INTERLOCK LOCAL LIGHTING
MOTOR	30Hp fire pump motor	Electrical ROOM 202	208	3		30HP	MCC	200	3	2/0		41	Panel M2H					Mag					VFD		2	2				pressure or flow switches
EF-2	EXHAUST FAN	ROOM 120	208	3		1.5 HP	MCC	15	3	12AWG		21	Panel 12G					Mag							2	2				INTERLOCK LOCAL LIGHTING
BASEBOARD HEATERS																														
BB-1	BASEBOARD HEATER	KITCHENETTE 108	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12B										LTST							CONTROLLED BY THERMOSTAT
BB-2	BASEBOARD HEATER	KITCHENETTE 108	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12B										LTST							CONTROLLED BY THERMOSTAT
BB-3	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-4	BASEBOARD HEATER	COMMONS 109	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-5	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-6	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12C										LTST							CONTROLLED BY THERMOSTAT
BB-7	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12C										LTST							CONTROLLED BY THERMOSTAT
BB-8	BASEBOARD HEATER	MENS 104	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12A										LTST							CONTROLLED BY THERMOSTAT
BB-9	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
FORCE FLOWS																														
FF-1	FORCE FLOW FAN	FOYER 100	120	1		6.0 FLA	MCC	15	1	12 AWG		21	Panel 12A					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-2	FORCE FLOW FAN	ROOM 120	120	1		1.5 kW	MCC	20	1	12 AWG		21	Panel 12G					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-3	FORCE FLOW FAN	MECHANICAL ROOM 117	120	1		1.5 kW	MCC	20	1	12 AWG		21	Panel 12F					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-4	FORCE FLOW FAN	WATER METER 107	120	1		6.0 FLA	MCC	15	1	12 AWG		21	Panel 12A					Mag					LTST		2	2				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

GENERAL NOTES

a. IN MOST CASES THE FLA'S AND ASSOCIATED BRANCH CIRCUITS ARE BASED ON THE CANADIAN ELECTRICAL CODE. CONFIRM THE ACTUAL FLA'S OF MOTORS WITH THE MECHANICAL CONTRACTOR [1] - PRIOR TO ORDERING EQUIPMENT (BREAKERS, OVERLOADS, ETC.), AND INSTALLATION OF BRANCH CIRCUITS. APPROVAL OF DISTRIBUTION SHOP DRAWINGS IS BASED ON THE ASSUMPTION THAT FLA'S OF MOTORS HAVE BEEN CONFIRMED. NO ADDITIONAL COSTS WILL BE CONSIDERED FOR FAILURE TO CONFIRM THE FLA'S OF MOTORS PRIOR TO SUBMISSION OF DISTRIBUTION EQUIPMENT [2] - SHOP DRAWINGS. [3] -

b. IF MOTOR FEEDER SIZES ARE NOT SHOWN, REFER TO SINGLE LINE DIAGRAM.

c. ELECTRICAL CONTRACTOR IS TO UPDATE ALL INFORMATION IN THIS SCHEDULE PRIOR TO SUBMITTING AS-BUILT DRAWINGS. THE OVERCURRENT PROTECTION AND MOTOR NAMEPLATE COLUMNS ARE TO BE FILLED IN BY THE CONTRACTOR.

d. WHERE INDICATED, PROVIDE ROOFTOP GFCI RECEPTACLES AS PER CEC RULE 26-704.

e. UNLESS NOTED OTHERWISE, ALL EQUIPMENT TEMPERATURE RATINGS ARE ASSUMED TO BE 75°C (CONDUCTOR TEMPERATURE). FOR EXISTING EQUIPMENT, CONFIRM THAT THE TEMPERATURE RATINGS ARE 75°C. IF THE EQUIPMENT IS UNMARKED AND RATED 100 A OR LESS, ASSUME THE TEMPERATURE RATING IS 60°C AND INCREASE THE CONDUCTOR SIZE APPROPRIATELY (CEC RULE 4- 006).

REFERRAL NOTES

Fig: Mechanical Schedule

Normal SLD

The below figure is the Normal single line diagram for 25 KV voltage (Underground)

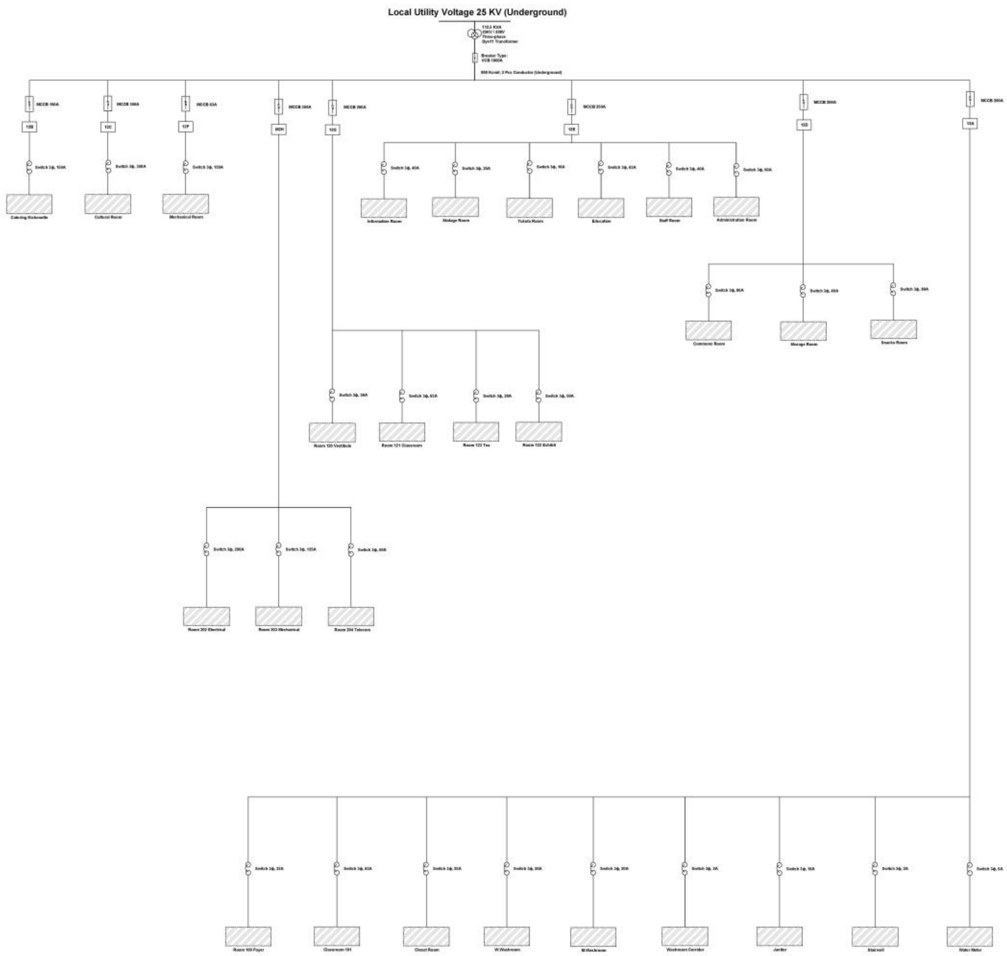

Fig: Normal SLD

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.

Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L.

Emergency SLD

The below figure is the updated Emergency single line diagram for 25 KV voltage (Underground). Here, in this updated emergency SLD, we have added UPS in our drawing.

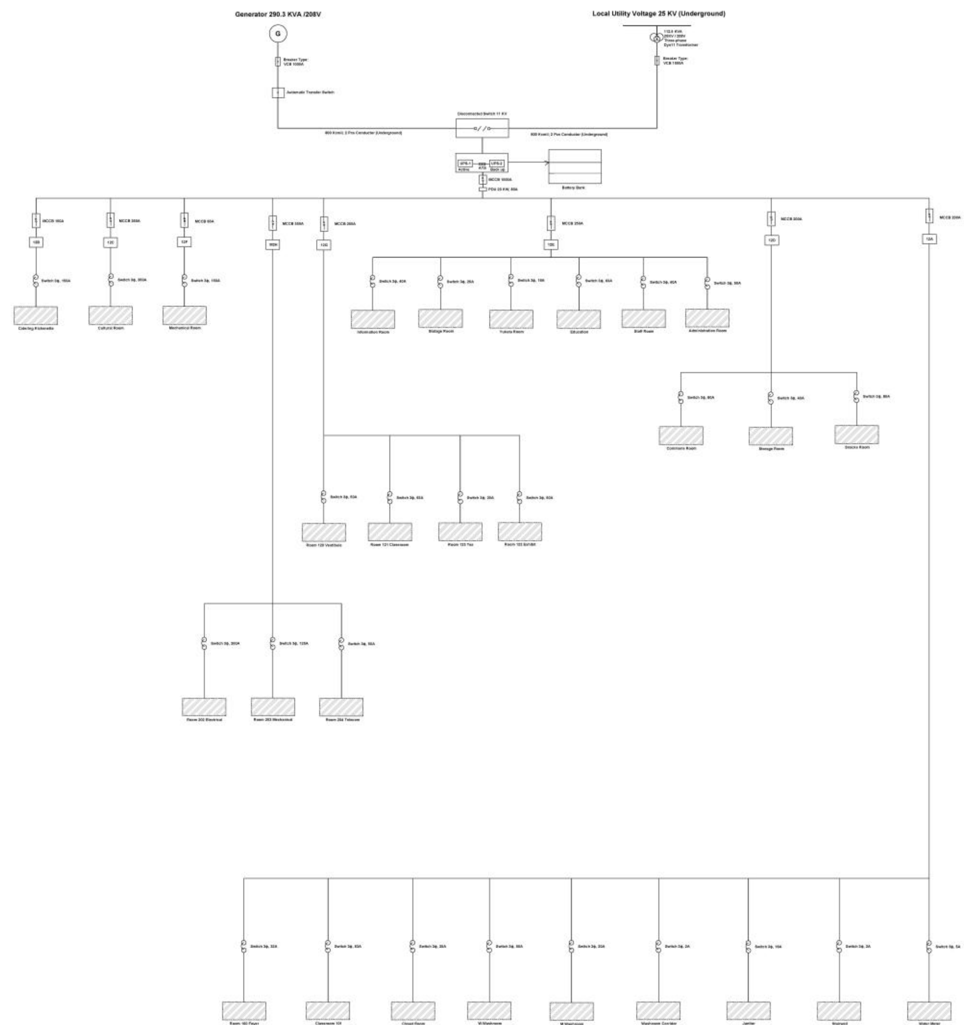

Fig: Emergency SLD

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.

Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L.

Generator Type, Location, Sizing

We are recommending Kohler 250REOZJD Diesel Generator for this project. It is capable to handle our total load. Their type, sizing and other specifications are given below:

Kohler 250 REOZJD Diesel Generator Specifications [1]

Parameter	Specification
Model	Kohler 250REOZJD
Rated Power	250 kW
Voltage	208V, 3-phase
Frequency	60 Hz
Phase	3-Phase
Fuel Type	Diesel
Engine	Kohler KDI 3404-TCR
Alternator	Kohler KTA 250C (brushless, self-excited)
Fuel Tank Capacity	180 gallons (nominal)
Runtime at 75% Load	Approx. 10-12 hours
Cooling System	Air-cooled
Noise Level	69-72 dBA (sound-attenuated)
Enclosure	Soundproof, weatherproof, enclosed
Transfer Switch (ATS)	Automatic Transfer Switch (optional)
Oil Capacity	10.5 gallons
Starting System	12V DC starting system, 24V optional
Dimensions (L x W x H)	118" x 54" x 72"
Weight	Approx. 4,800 lbs
Air Intake	1,900 cfm
Exhaust System	4" exhaust pipe with flexible connection
Lubrication	Full-pressure lubrication system
Rated Current	870 Amps at 208V
Control Panel	Kohler KLCB-2000 or equivalent (with monitoring options)
Coolant Capacity	10 gallons

Service Interval	500 hours (for oil change)
Vibration Isolation	Rubber mountings for vibration reduction
Warranty	1-year or 2,000 hours (whichever comes first)

Inclusion of UPS Equipment

In this project milestone-2, we have used UPS for emergency equipment's. We have calculated total load for all emergency equipment's to measure the UPS rating and Battery sizing.

Emergency Equipment Details for UPS Capacity and Battery Specification Calculation:

Sl	Equipment List (Emergency)	Quantity	Avg.Load Per Quantity (W)	Total Load (KW)	Apparent (KVA	Phase	Power factor
1	Wifi	22	13	0.29	0.30	1	0.95
2	Close Circuit Camera	30	5.5	0.17	0.17	1	0.95
3	Barrier free access	5	50	0.25	0.26	1	0.95
4	Emergency light and exit sign	16	3.5	0.06	0.06	1	0.95
5	Push switch	6	1	0.01	0.01	1	0.95
6	Projector	7	400	2.80	2.95	1	0.95
7	Computer	8	260	2.08	2.19	1	0.95
8	Speaker	2	220	0.44	0.46	1	0.95
9	Sprinkler Flow Switch and Temper	1	20	0.02	0.02	1	0.95
10	Push button	2	1	0.00	0.00	1	0.95
11	Egress Door	2	50	0.10	0.11	1	0.95
12	Access Control	3	20	0.06	0.06	1	0.95
13	Sound System	2	800	1.60	1.68	1	0.95
14	Fire Alarm Control Panel	1	960	0.96	1.01	1	0.95
15	Fire Alarm Booster panel	1	600	0.60	0.63	1	0.95
16	Light	180	28.08	7.13	7.50	1	0.95
Total		**288**	**3432.08**	**16.55**	**17.43**		

Parameters

- **Real Power (P):** 16.55 kW
- **Apparent Power (S):** 17.43 kVA
- **Power Factor (PF):** 0.95

We have assumed Backup time is around 1 hour.

UPS Sizing:

To ensure reliability and accommodate potential future expansions, we consider a UPS with a capacity **25-30% higher** than the current load.

Recommended UPS Rating:

UPS Rating = (17.43 kVA×1.25) = 21.79 kVA. Rounding up, **25 kVA** UPS.

So, we are recommending **Schneider Electric Galaxy VS 25kVA** for UPS. We are recommending two UPS where one will be active and others will be standby.

Cost:

The price of **Schneider Electric Galaxy VS 25kVA** is $19,866.99 (Canadian Doller) [2].
So, for 2 UPS, the total cost will be = ($19,866.99 × 2) = $39733.98 (Canadian Doller).

Battery Sizing:

Step 1: Calculate Total Energy Requirement
Energy (Wh) = Real Power (kW)×Backup Time (hours) \ {Energy (Wh)}
=16.55 Kw × 1 hour =16,550 Wh

Step 2: UPS Efficiency
Assuming a UPS efficiency of **90%** (0.9):
Adjusted Energy (Wh) = 16,550 Wh / 0.9 = 18,389 Wh

Step 3: Determine Battery Bank Voltage
Larger UPS systems, like the Schneider Electric Galaxy VS (25 kVA), typically operate on a DC bus voltage of 208V.

Step 4: Calculate Required Battery Capacity
Battery Capacity (Ah) = Battery Voltage / DC Power Required
= 18,389 / 208 = 88.04 ≈ 90 Ah
Battery capacity of 90Ah is required.

Step 5: Determine Number of Batteries
Each **battery voltage is 12V**, so the number of batteries needed in series:
Number of Batteries =Battery Bank Voltage / Battery Voltage
=208/12 =17.33 ≈ 18
So, **18 batteries** of **12V, 90Ah** are required in series.
So, we are recommending **Trojan J185H-AC 12V 85Ah Battery** here.

Cost:

As per the latest data, the price of each battery is $760.97 [3]
So, the cost for 18 batteries: 18 × $760.97 = $13,697.46 (Canadian Doller)

We have recommended 2 UPS. So, basically we need 36 batteries of 12V, 90Ah each.
So, the cost for 36 batteries: 36 × $760.97 = $27394.92 (Canadian Doller)

Distribution Options for the Site

The following things are the overview of power distribution

- Total Load: 250.63 kW
- Total Number of Rooms: 28
- Number of Distribution Panels: 8 (fed from the grid)
- Backup Systems: Generator and UPS for emergency power
- Renewable Energy Source: Solar PV system
- Transformer: 112.5 kVA, 25/208V

- Breaker Sizes:

  VCB: 1000A

  MCCBs: 200A (3), 250A, 350A, 150A, 63A

  Switches (3ϕ): 150A, 350A, 63A, 200A, 125A, 50A, 40A, 25A, 16A, 80A, 32A, 20A, 2A, 5A

Option 1. Grid-based with Emergency Backup Power Sources and Distribution

Grid Supply

- Primary source supplying all 8 panels.
- Reliable but subject to utility costs and potential outages.

Generator Backup

- Ensures emergency power in case of grid failure.

Uninterruptible Power Supply (UPS)

- Rated at 25 kVA to support 16.55 kW of critical loads.
- Backup time: 1 hour (with a 90 Ah battery bank).

Option 2. Grid with Solar with Emergency Backup Power Sources and Distribution

Grid Supply

- Primary source supplying all 8 panels.
- Reliable but subject to utility costs and potential outages.

Generator Backup

- Ensures emergency power in case of grid failure.

Uninterruptible Power Supply (UPS)

- Rated at 25 kVA to support 16.55 kW of critical loads.
- Backup time: 1 hour (with a 90 Ah battery bank).

Solar PV System

- Installed 176 kW capacity.
- Reduces dependence on grid power and lowers carbon emissions.

Overall, Pros

- Reliable power supply.
- No major infrastructure changes required.
- UPS ensures smooth transition during power outages.

Cons

Still dependent on grid electricity, which increases costs.

Cost Benefit Analysis:

- Grid electricity: \$0.10 – \$0.15/kWh (varies based on usage).
- Solar savings: Reduces peak demand charges.

Electricity Cost Saving between option 1 and 2:

1. Annual Energy Consumption

E_{load} = Power ×Operating Hours

- **Power Load** = 110 kW
- **Operating Hours** = **8 hours/day** × 365 days/year = **2,920 hours/year**
- **Annual Energy Demand** = 110 kW × 2,920 hours

$$E_{load} = 321{,}200 \text{ kWh/year}$$

As per recent data of 2025, Alberta's default electricity rate, known as the Rate of Last Resort (RoLR), has been set for \$0.126 per kwh(on average) [9]

2. Cost Without Solar

Cost without solar $= E_{load} \times$ Rate

$$= 321{,}200 \times 0.126 = 40{,}471.2 \text{ CAD/year}$$

3. Cost With Solar

Using the **solar energy generation** formula:

$E_{solar} = P_{solar} \times H_{sun} \times \eta$

- **Solar System Capacity** = **176 kW**
- **Sun Hours per Year** = **1,825 hours/year**
- **System Efficiency** = **20% (0.20)**

$E_{solar} = 176 \times 1{,}825 \times 0.20 = 64{,}240$ kWh/year

Electricity still needed from the grid:

$E_{grid} = E_{load} - E_{solar}$

$= 321{,}200 - 64{,}240 = 256{,}960$ kWh/year

Cost with Solar:

Cost with solar $= E_{grid} \times$ Rate

$$= 256{,}960 \times 0.126 = 32{,}376.96 \text{ CAD/year}$$

So, by using solar during peak hours, the total savings in electricity cost is

(40,471.2 - 32,376.96) = 8,094.24 CAD per year.

Renewable Energy or Alternative sources

For renewable energy source, we are recommending Solar panel. To feed our continuous load, we need to calculate the number of panel we will require.

1. Project Overview:

- **Building Dimensions:** 832 m^2 (Roof Area)
- **Land Dimension:** 10 acre = 40468.6 m^2 (approx.)
- **Total Building Load:** 110 kW (Continuous Load)
- **Location:** Existing land after constructing buildings

2. Solar Panel Selection: We have taken **Canadian Solar HiKu6 Mono PERC 500W** in our solar panel selection. Based on [4] we get the below features:

- **Assumed Panel Efficiency:** 20%
- **Typical Panel Size:** 2.2m × 1.1m (2.42 m^2 per panel)
- **Rated Power Output per Panel:** 500W (0.5 kW)

3. Available Land Space and Panel Capacity: In this project, the owner has 10 acre of land. The owner constructed a building which dimension is 832 m^2. But the owner will develop 4 other buildings of similar sizes.

- **Total Existing Land Area:** 40468.6 m^2 – (4 × 832 m^2) = 36308.6 m^2
- **Total Usable Land Area:** Assume 70% usability due to parking space, walkway, driving path and others. So, usable area = 36308.6 m^2 × 0.70 = 25416.02 m^2
- **Maximum Number of Panels we can accommodate:** = 25416.02 m^2 / 2.42 m^2 per panel = 10502 panels (approx.)

4. Required Solar Capacity to Meet Load:

- **Daily Load:** Assuming 110 kW is the peak demand, estimate daily consumption:

  Daily Energy Demand: 110 kW × 8 hours (avg. working hours) = 880 kWh/day

- **Solar Irradiance:** For Southern Alberta, we assume 5 peak sun hours per day
- **Required Solar Capacity:**

  Required Power = 880 kWh / 5 hours = 176 kW

  Number of Panels needed = 176 kW / 0.5 kW per panel = 352 panels

  Required Land Area = 352 × 2.42 m^2 = 887.04 m^2 (well within the available space)

Cost Analysis:

As of recent data, the average price per watt for monocrystalline panels in Canada ranges from $2.50 to $3.50 [5]. We are taking an approximate value of $3.00 here.

Cost Per Panel: $3.00/W × 500W = $1500 per panel

Overall Cost: 352 × \$1500 = \$528000

So, overall cost for 352 panel is around \$528000 (Canadian Doller)

Renewable Zero Carbon Initiatives

By using Solar panel instead of using Grid Electricity, we can save much more Carbon emission. To calculate the **carbon emissions** for a **110 kW load** powered by the Alberta grid, we use the following formula [6]:

Carbon Emissions = $E_{load} \times$ Emission Factor

Step 1: Calculate Annual Energy Consumption

$E_{load} = P_{load} \times H_{operation}$

Where:

- P_{load} = 110 kW (load power)
- $H_{operation}$ = 8 hours/day × 365 days/year = **2920 hours/year**

E_{load} = 110×2920 = 321200 kWh/year

Step 2: Use Grid Emission Factor

- Alberta grid emission factor = **0.52 kg CO_2/kWh**

Step 3: Calculate Carbon Emissions

Carbon Emissions = 321200×0.52 =167024 kg CO_2/year ≈ 167 metric tons CO_2/year

A **110 kW load running for 8 hours per day in Alberta emits approximately 167 metric tons of CO_2 per year** when powered by the grid.

When using solar panels, **carbon emissions are nearly zero** during operation. However, to account for lifecycle emissions (manufacturing, transportation, and installation), we use an estimated **lifecycle emission factor** for solar energy.

The energy generated by the solar system is [8]:

$E_{solar} = P_{solar} \times H_{sun} \times \eta$

- P_{solar} = 176 kW (installed capacity)
- H_{sun} = 1825 hours/year (sunlight hours)
- η =20% (system efficiency = 0.20)

E_{solar} =176 ×1825×0.20 = 64240 kWh/year

Solar panels have a **lifecycle emission factor** of **20-50 g CO_2/kWh** (depending on manufacturing and installation) [7]. Taking an average value of **35 g CO_2/kWh (0.035 kg CO_2/kWh)**:

Solar Carbon Emissions = 64240×0.035 = 2248.4 kg CO_2/year ≈ 2.25 metric tons CO_2/year

If we use solar, we can reduce carbon emission up to = (167 - 2.25) metric tons CO_2/year
= 164.75 metric tons CO_2/year

Safety Measures

In this project, we have considered multiple safety measure in our electrical design. For 24/7 monitoring, we have given CCTV in every room. Furthermore, we have used fire protection & detection system in every room. Also, we have used smoke detector, sprinkler to detect fire detect. Besides that, we have used MCCB (Molded Case Circuit Breaker) to protect the electric circuit from overload and short circuit in every room. In the building main panel, we have used VCB (Vacuum Circuit Breaker) to protect against overload and short circuits. Finally, we have set emergency exit sign in some of the room.

Consideration for Future Technology

These are some future consideration we have considered in this project:

- ✓ Smart Sensors & IoT Integration – Enables real-time monitoring of energy use, lighting, and HVAC (Heating, Ventilation, and Air Conditioning) for efficiency.
- ✓ AI-Driven Building Management Systems (BMS) – Uses machine learning to optimize energy consumption and occupant comfort.
- ✓ Automated Climate Control – Adjusts heating and cooling based on occupancy patterns and external weather conditions.
- ✓ Battery Energy Storage Systems (BESS) – Stores excess renewable energy for use during peak demand or outages.
- ✓ Hydrogen & Fuel Cell Integration – Provides an alternative clean energy source for heating and electricity.

Summarization of the Impact on Following Based on Stage-2 Recommendation

In this section, we have summarized the impact on various technical specifications such as normal power SLD, emergency power SLD, power layout diagram, lighting layout diagram, luminaries schedule, mechanical schedule, panel schedule and service sizing calculation, based on our milestone-2 recommendation. We have conducted short summary in separate Excel file which is also attached in D2L. Detail analysis are given below:

Inclusion of UPS equipment

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For inclusion of UPS equipment, there will be no changes at Normal Power SLD.

Emergency Power SLD: For inclusion of UPS equipment, there will be an impact at Emergency SLD.
Here, Real Power (P): 16.55 kW, Apparent Power (S): 17.43 kVA and Power Factor (PF): 0.95
We have assumed that, Backup Time: 1 hour
So, UPS Rating = (17.43 kVA×1.25) = 21.79 kVA. Rounding up, 25 kVA UPS.
We have used two UPS here where one is active, another one is standby. We have already drawn 2 UPS in our emergency SLD diagram in our milestone-2.

Lighting layout drawing: For inclusion of UPS equipment, there will be a slight changes at lighting layout drawing. Emergency lighting circuits may be powered by the UPS, requiring changes in the lighting layout to identify UPS-backed lights.

Luminaire schedule: For inclusion of UPS equipment, there will be no changes at luminaire schedule.

Power layout drawing: In our milestone-2, we have already incorporated 2 UPS in our power layout diagram.

Mechanical schedule: For inclusion of UPS equipment, there will be an impact on mechanical schedule. If the UPS requires cooling (for large UPS systems), the mechanical schedule must include the additional heat load and HVAC modifications.

Panel Schedule: As we have used two UPS here where one is active, another one is standby and both are connected via a static bypass switch for the continuous and non-continuous load. Also the UPS are connected with a dedicated MCCB breaker for protection. Considering the scenario of this architecture panel schedule will be impacted.

Service sizing calculation: We have incorporated 2 UPS (Each of 25 KVA) in our design. There will be an impact to the overall service sizing calculation.

Generator type, location, sizing

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For generator type, location and sizing, there will be no changes at Normal Power SLD.

Emergency Power SLD: In our milestone-2, we have used 290 KVA, 3 phase, 208 V generator as per demand load. This generator has been connected with UPS through vacuum circuit breaker rated at 1000 A. This vacuum circuit breaker has been connected with automated circuit switch and a disconnected circuit switch rated at 11 kV. We have used 2 pc, 800 kcmil underground cable for wiring from disconnected switch to the generator. This has been already incorporated in our Emergency SLD diagram.

Lighting layout drawing: In our milestone-2, we have fit the generator in separate room beside electrical room. We have already drawn the room layout in our power layout diagram. As it is a separate room, there will be an impact in our lighting layout drawing.

Luminaire schedule: In our milestone-2, we have selected Kohler 250REOZJD as our generator where the size is 118” x 54” x 72”. To fit this generator, we need the room size at least 190" (L) x 126" (W) x 108" (H) which is equivalent to 15.83 feet long, 10.5 feet wide, and 9 feet high. But in our drawing, we have drawn 16 feet long, 10.5 feet wide and 10.5 feet high. As it is a separate room, there will be an impact in our luminaire schedule.

We know,

# of luminaries = $\frac{illuminance \times L \times W}{(lumen\ per\ luminaires) \times Cu \times LLF}$

Here, we have assumed that,
LLF = 0.9, Cu = 0.4, illuminance = 375, lumen per luminaries = 2000

Based on the room’s length and width, we get that,

# of luminaries = $\frac{375 \times 4.826 \times 3.2}{2000 \times 0.4 \times 0.9}$ = 8.041

So, we need 9 luminaries in that generator room.

Power layout drawing: In our milestone-2, we have fit the generator in separate room beside electrical room. We have already drawn the room layout sizing at 16 feet long, 10.5 feet wide and 10.5 feet high in our power layout diagram.

Mechanical schedule: For generator type, location and sizing, there will be an impact at Mechanical schedule. Generators produce significant heat during operation. Proper ventilation is required to prevent overheating. The mechanical schedule must include air intake and exhaust fans, louvers, or an HVAC system to maintain proper airflow in the generator room. Diesel or gas-powered generators require a fuel storage and supply system, which affects mechanical planning. The mechanical schedule should include fuel tank capacity, fuel piping layout, and ventilation requirements for fuel storage areas.

Panel Schedule: As we have fit the generator in a separate room, there will be an impact on panel schedule.

The generator is acted here at an emergency device. Generator will be connected with the bus bar with an automated circuit switch. Whenever, the grid doesn't provide electricity, the generator will do. So, we don't need to consider generator for panel schedule. But as it lies in a separate room, we have to consider the light designed here for scheduling the panel.
Based on lumen calculation, we have found that 9 luminaries need in the generator room.
Here,
We have assumed the load of light = 0.547 KVA
Quantity = 9
Total load = $(0.547 \times 1000 \times 9)$ W = 4923 W
So, breaker needed = $(4923 \times 1.25)/120 = 51.28$ A => 60A breaker is needed.

Service sizing calculation: As we have fit the generator in a separate room, there will be an impact on service sizing calculation. As the load is tiny (0.547 KVA), there will be a minimal changes in the service sizing.

Distribution options for the site

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For distribution option for the site, there will be an impact in the Normal Power SLD diagram. In normal SLD, it need to depict the distribution network, including feeders, subpanels, and connection points. It need to show how loads are balanced across the distribution system. Also, it should indicate how renewable energy sources (solar, BESS, fuel cells) connect to the distribution network.

Emergency Power SLD: For distribution option for the site, there will be an impact in the Emergency Power SLD diagram. It need to highlight how critical loads are powered during outages (e.g., via BESS, fuel cells, or micro grids). It need to show how the system can isolate and power critical loads independently.

Lighting layout drawing: For distribution option for the site, there will be no impact in our existing Lighting layout drawing.

Luminaire schedule: For distribution option for the site, there will be no impact in our existing Luminaire schedule.

Power layout drawing: For distribution option for the site, there will be an impact for our existing power layout drawing. The layout must reflect the chosen distribution method (centralized feeders, decentralized micro grids, or hybrid systems) and the locations of transformers, switchgear, and distribution panels. It need to show how power is distributed from sources to loads.

Mechanical schedule: For distribution option for the site, there will be an impact for mechanical schedule. We need to allocate space for distribution equipment (e.g., transformers, switchgear, distribution panels). Also, we need to include pathways for power cables and conduits.

Panel schedule: The distribution option for the site impacts the panel schedule by determining the number of panels, breaker sizes, and load distribution. With a decentralized distribution option, the panel schedule will include multiple subpanels, each with its own schedule for local loads, reducing individual breaker sizes and ensuring balanced load distribution across the site.

Service sizing calculation: In the milestone-2, we have proposed decentralized distribution option. There will be a slight impact in the service sizing calculation. Since power is distributed among multiple panels, we need to ensure the transformer can handle peak loads while considering diversity factors. Feeder cables must be sized appropriately for each distribution panel, considering voltage drop and fault current levels. A decentralized system requires selective coordination among breakers to ensure faults are isolated at the right levels.

Renewable Energy or alternative sources

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: In our milestone-2, we have considered solar panel as a renewable energy. In normal power SLD, there will be an impact for installing solar panel. The SLD must show solar inverter (DC to AC conversion) and solar panel connecting to the main panel.

Emergency Power SLD: The emergency power Single-Line Diagram (SLD) will need to incorporate the solar system and its components. The SLD must show how the solar system powers critical loads during a grid outage.

Lighting layout drawing: In our project, we proposed to install solar panel outside the building in an open existing land. So, there will be no impact in our Lighting layout drawing.

Luminaire schedule: As we have planned to install solar panel outside the building in an open existing land, there will be no impact in the luminaire schedule.

Power layout drawing: Integrating solar panels into the electrical system will significantly impact the power layout drawing. The solar panel array must be shown on the layout, indicating its physical location (ground-mounted). The solar inverter location should be included, typically near the main panel or electrical room.

Mechanical schedule: For inclusion of Solar panel, there will be an impact at Mechanical schedule. The mechanical schedule must include cooling fans or HVAC requirements for the inverter. The mechanical schedule should include structural support for ground-mount racking systems.

Panel schedule: Integrating solar panels in an open area typically does not impact the panel schedule, as solar systems are connected upstream of the distribution panels and do not directly affect the individual circuit loads or breaker assignments within the panel.

Service sizing calculation: Installing solar panels outside can impact the service sizing calculation for your electrical system. When we install solar panels, they generate electricity that offsets the power we need from the grid. This reduces the load on your electrical service. As a result, your service size (e.g., the main breaker or service panel capacity) may not need to be as large as it would without solar. As we know,

$$\text{Net Load} = \text{Total Electrical Load} - \text{Solar Generation}$$

Zero carbon initiatives

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: In our milestone-2, for reducing carbon, we have considered Solar panel instead of using Grid Electricity. In normal power SLD, there will be an impact for installing solar panel. The SLD must show solar inverter (DC to AC conversion) and solar panel connecting to the main panel.

Emergency Power SLD: In our project, we haven’t considered solar as an emergency source when it is fully integrated in place of grid electricity. Hence, there will be no changes at Emergency Power SLD.

Lighting layout drawing: The lighting layout may be impacted by solar integration due to power limitations, requiring optimized fixture placement to reduce energy consumption. Emergency and critical lighting zones must be prioritized based on battery backup capacity. Additionally, smart lighting controls (dimmers, motion sensors) may be needed to improve energy efficiency.

Luminaire schedule: Integrating fully solar panels instead of grid electricity will have an impact on luminaire schedule. Energy-efficient lighting (e.g., LED) is often paired with solar systems to reduce power consumption, and daylight harvesting strategies may be incorporated.

Power layout drawing: Integrating solar panels instead of grid electricity, will significantly impact the power layout drawing. The utility power source will be removed from the power layout. The main distribution panel (MDP) will now receive power only from the solar inverter & battery storage. Solar panels and their array layout must be added to the drawing. A solar inverter and a DC combiner box must be included. Solar panel to inverter wiring (DC cables) must be shown. Inverter to main panel wiring (AC cables) must be sized properly.

Mechanical schedule: Integrating solar panels instead of grid electricity, will significantly impact the mechanical schedule. The mechanical schedule must include cooling fans or HVAC requirements for the inverter. The mechanical schedule should include structural support for ground-mount racking systems.

Panel schedule: Replacing grid electricity with solar power does not directly impact the panel schedule, as the solar system connects upstream of the distribution panels and does not alter the individual circuit loads or breaker assignments within the panel.

Service sizing calculation: For service sizing calculation, there will be a significant impact if we use solar panel instead of grid electricity. Grid service sizing calculations will be eliminated, and all calculations will be based on solar power availability and battery storage capacity. The total service size is:

$$\text{Total Load Demand} = \text{Building Load} - \text{Solar Generation}$$

Consideration of future technologies

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: Based on my consideration of future technologies, there will be an impact of Normal Power SLD. Normal SLD should show connections for solar, BESS, and hydrogen/fuel cells. It must include AI-driven BMS and IoT-controlled loads. It should indicate how the system interacts with the grid (e.g., net metering, peak shaving).

Emergency Power SLD: Based on my consideration of future technologies, there will be an impact of Emergency Power SLD. It should highlight how BESS and fuel cells provide backup power during outages. It should show how critical loads are powered during emergencies. It include automatic transfer switches for seamless transition to backup power.

Lighting layout drawing: Based on my consideration of future technologies, there will be an impact of lighting layout drawing. In the drawing, IoT-enabled lighting controls, occupancy sensors, and daylight harvesting systems should be added. We need to optimize lighting layouts to reduce energy consumption and align with renewable energy availability. Zoning and dimming controls must be included for better power management.

Luminaire schedule: Based on my consideration of future technologies, there will be a slightly impact of luminaire schedule. The lumen schedules need to be aligned with AI-driven energy management strategies.

Power Layout drawing: Based on my consideration of future technologies, there will be an impact of power layout drawing. The drawing must include IoT devices, smart sensors, BESS, hydrogen/fuel cell systems, and their connections. It must add wiring for IoT and sensor networks and show how renewable energy sources (solar, BESS, fuel cells) integrate with the main power distribution system.

Mechanical schedule: Based on my consideration of future technologies, there will be an impact of mechanical schedule. Battery energy storage (BESS) may require cooling which requires HVAC modifications. Apart from this, structural reinforcements is needed for ground-mounted racks. Also, smart climate control systems integrated to optimize power consumption. These all impacts the mechanical schedule.

Panel schedule: Based on my consideration of future technologies, there will be an impact of panel schedule. The panel schedule will need to account for IoT devices, smart sensors, and AI-driven BMS by including dedicated circuits for these systems. Additionally, it must integrate BESS and hydrogen/fuel cell connections, ensuring proper breaker sizing and load distribution for optimized energy management.

Service sizing calculation: Based on my consideration of future technologies, there will be an impact of service sizing calculation. Here, account for renewable energy generation and storage, will reduce the required grid service size. Also, we need AI-driven load optimization and BESS for peak shaving. In the service sizing calculation, hydrogen/fuel cell output in the total power capacity should be included.

Recommendations

The project electrical calculation is done at preliminary stage considering client's requirement. Firstly, in the design, there is no male washroom. So, we have designed a male washroom and calculated all the technical aspects. Secondly, after considering only the continuous current, we need 800 Kcmil conductor. But, if we consider both the continuous and discontinuous current, then we will need 2 conductor of 800 Kcmil size.

Conclusion

In this project, we have developed the electrical layout for a building situated on a 10-acre site. As part of Milestone 1, we performed lumen calculations, receptacle placement analysis, load assessment, and panel scheduling for each room based on the base plan. Following these calculations, we determined the appropriate conduit sizing for both continuous and non-continuous loads. Using these data points, we proceeded with the lighting design, power distribution layout, and single-line diagrams (SLD) for both normal and emergency systems. As part of Milestone 2, we rectify the mistake we have done. Also, as a part of this milestone, we have done summary report with the inclusion of UPS, the inclusion of generator and their type & size, summary report for renewable energy and zero carbon initiative. Finally, we implemented safety measures and provided recommendations for this project.

Scientific Reference

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