



**UNIVERSITY OF  
CALGARY**

**Project Report on**

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**Submitted By,**

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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.

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

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.

Luminaire 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
Illuminance	350	375	150	280	280	250	300	75
number of luminaire	1	9	4	16	7	2	2	1
lumen per luminaire	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	Haio RL560 Series LED	KT-WPLED10-840
mounting (Suspended Ceiling)	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	Haio	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.

Luminaire 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
Illuminance	500	450	750	100	350	300	200	200
number of luminaire	13	12	11	1	3	6	3	6
lumen per luminaire	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	Philips Ultra Efficient LED High Bay 3	SHARK2-22N	SHARK2-48N	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 5W	Philips CorePro LED Downlight 10W
mounting (Suspended Ceiling)	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.	IP66-rated for dust and water resistance	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	Dimmable with compatible switch	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.

Luminaire 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
Illuminance	500	200	300	500	300	375	300	150
number of luminaire	5	6	4	5	5	9	16	4
lumen per luminaire	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 Ceiling)	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 Stairwell, Room 202 Electrical, Room 203 Mechanical and Room 204 Telecom.

Luminaire Feature	Room 200 Stairwell	Room 202 Electrical	Room 203 Mechanical	Room 204 Telecom
Illuminance	150	500	250	750
number of luminaire	2	27	13	31
lumen per luminaire	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 Ceiling)	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

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

Table: Receptacle Calculation (Room wise)

## Equipment List

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

<b>Projector</b>	Epson PowerLite 2250U
<b>Push Switch</b>	Legrand 93151
<b>Receptacles</b>	Leviton 5362-W
<b>Smoke Detector</b>	System Sensor 2W-B0.5
<b>Warming Oven</b>	Nemco 6150-36
<b>Water Purifier</b>	Brita Total 360
<b>Wifi</b>	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:

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

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

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 1<sup>st</sup> 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
101-107, 200	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	
	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		
SI	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 1<sup>st</sup> floor, 2 for 208V and B for Panel B. In Panel B, we have connected Room 108 Catering Kitchennette.

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
Room 108	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	
	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		
SI	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 1<sup>st</sup> 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 Description	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			
SI	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 1<sup>st</sup> 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 Siz	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Siz	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	0.454739842	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		
SI	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 1<sup>st</sup> 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														
SI	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 1<sup>st</sup> 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 Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker	Pole	Load (KVA)	Quantity	Equipments Description	Circuit No	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 sign	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														
SI	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 1<sup>st</sup> 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	Fumace,208,3ph,10FLA	1	1.2	3	13	A	1	1	0.005263158	1	Intercom	26	Room - 204
Room - 203	27	Fumace,208,3ph,10FLA	1	1.2	3	13	B	1	1	0.005789474	1	Close Circuit Camera	28	Room - 204
Room - 203	29	Fumace,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	
												</		

## 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<sub>old</sub>)** = 0.95
- **Desired Power Factor (PF<sub>new</sub>)** = 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  $rated\ current = 1.25 * load\ current$

Total Rated current = Discontinuous load  $rated\ current$  + Continuous load  $rated\ current$

Power (KW) Continuous	Power (KW) Discontinuous	Voltage (V)	Pf	Current (A) Continuous	Current (A) Discontinuous	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 Kichenette	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.

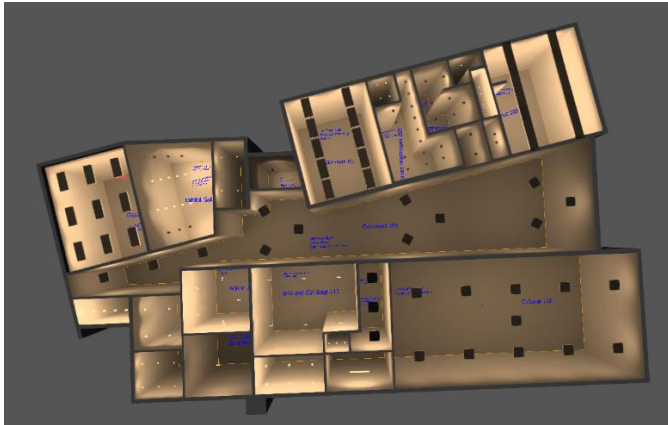


Fig: Main Floor Lightening Layout.

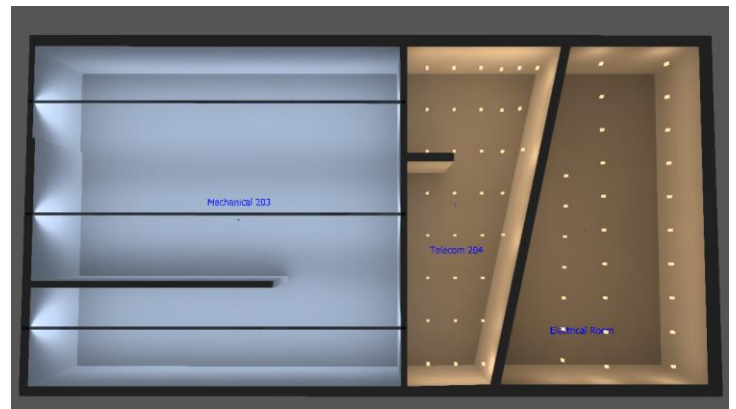


Fig: Mezzanine Floor Lightening Layout.



Fig: Foyer 100 Layout

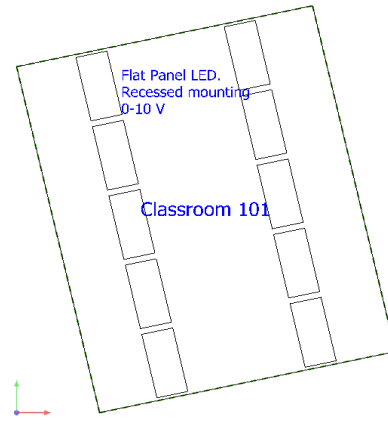


Fig: Classroom 101 Layout

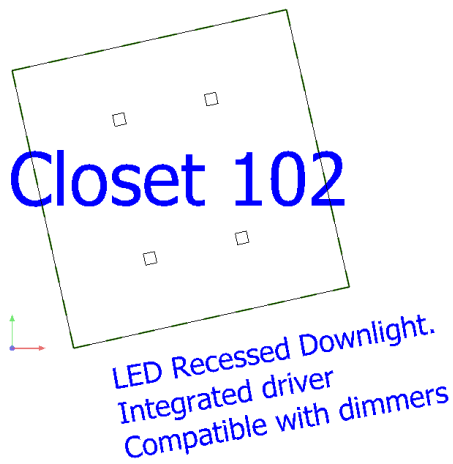


Fig: Closet 102 Layout

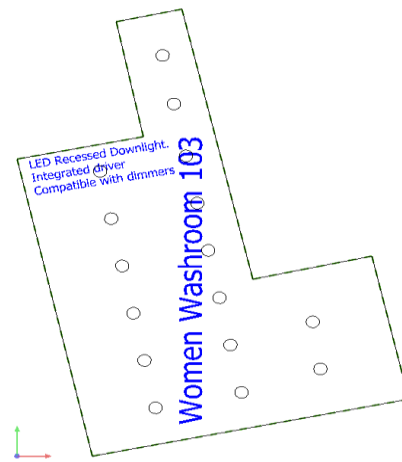


Fig: Women Washroom 103 Layout

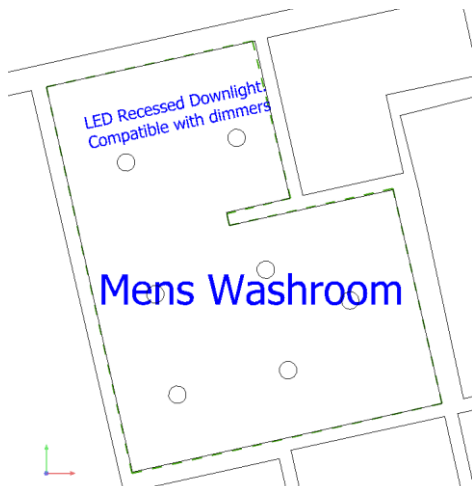


Fig: Men's Washroom Layout

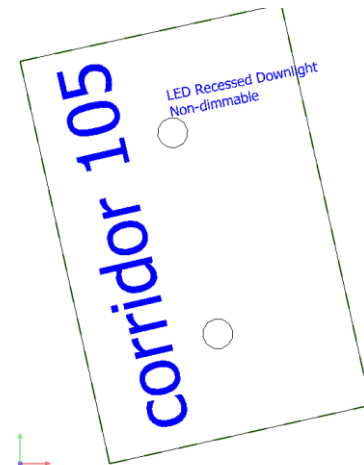


Fig: Corridor 105 Layout

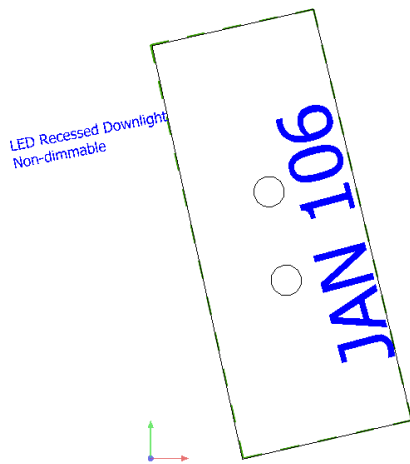


Fig: Room 106 Layout

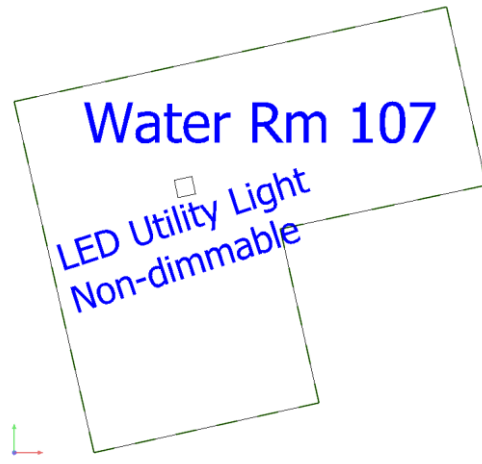


Fig: Room 107 Layout

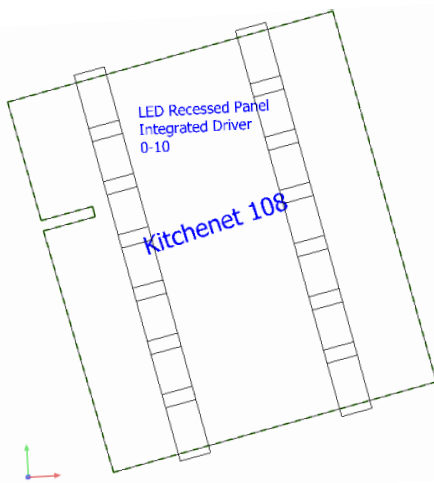


Fig: Kitchenette 108 Layout

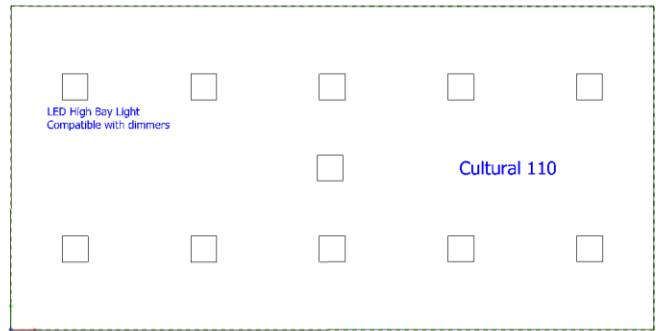


Fig: Cultural 110 Layout

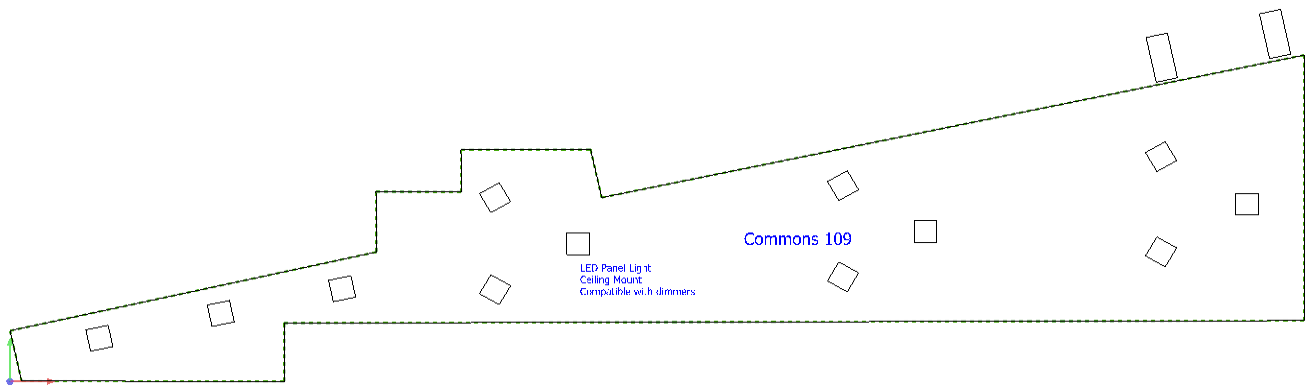


Fig: Common 109 layout





Fig: Storage 111 Layout

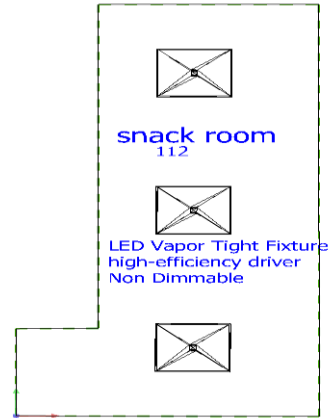


Fig: Snack Room 112 Layout

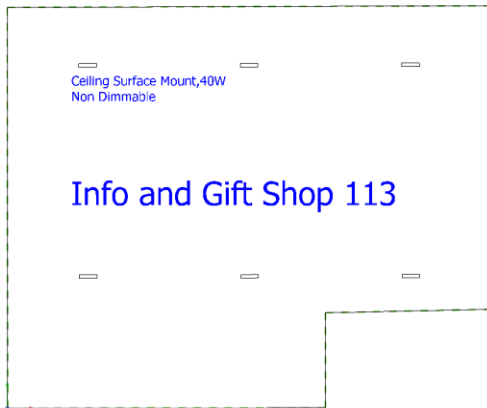


Fig: Gift Shop 113 Layout



Fig: Storage 114 Layout

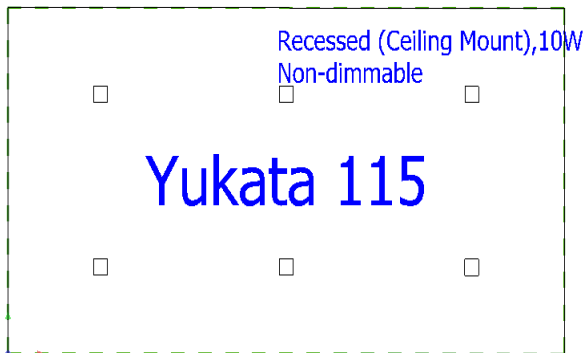


Fig: Yukata 115 Layout

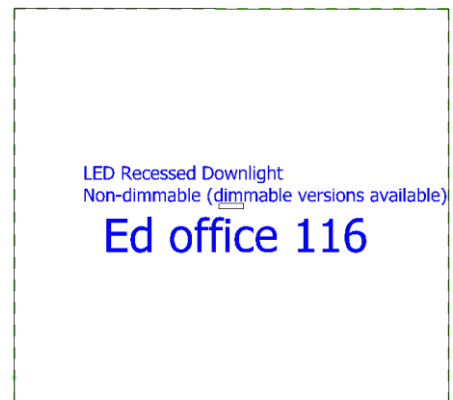


Fig: Ed Office 116 Layout

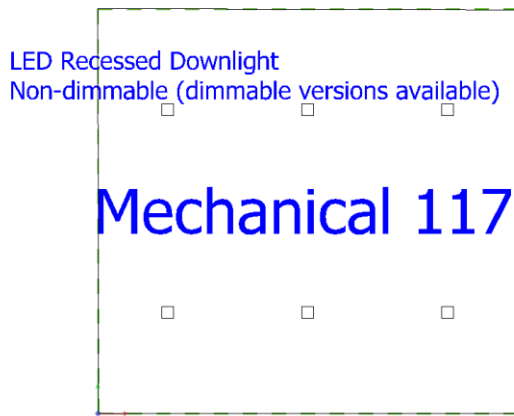


Fig: Mechanical 117 Layout

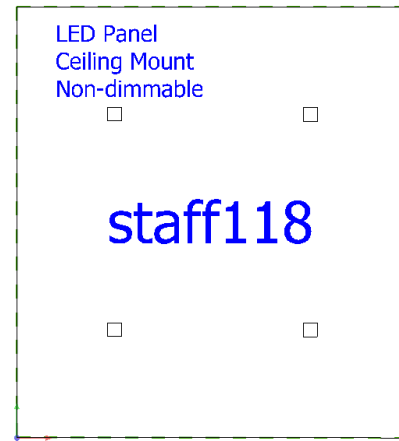


Fig: Staff 118 Layout

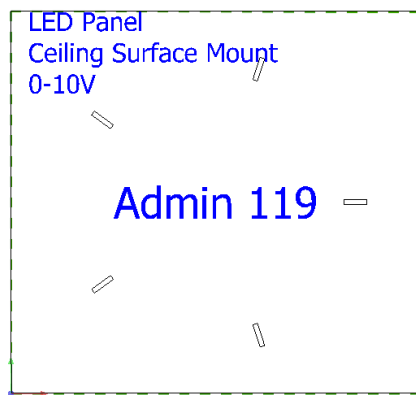


Fig: Admin 119 Layout

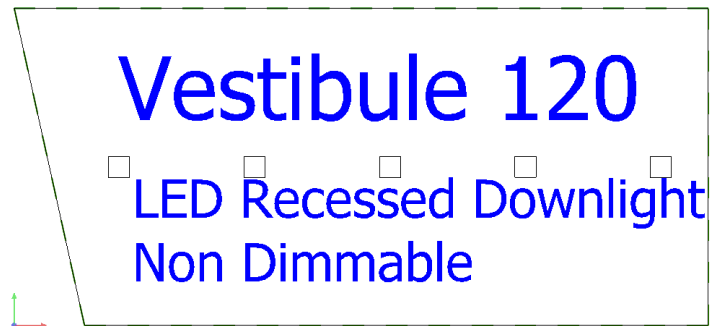


Fig: Vestibule 120 Layout

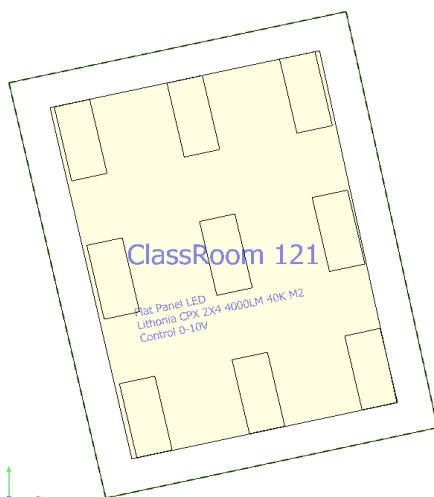


Fig: Classroom 121 Layout

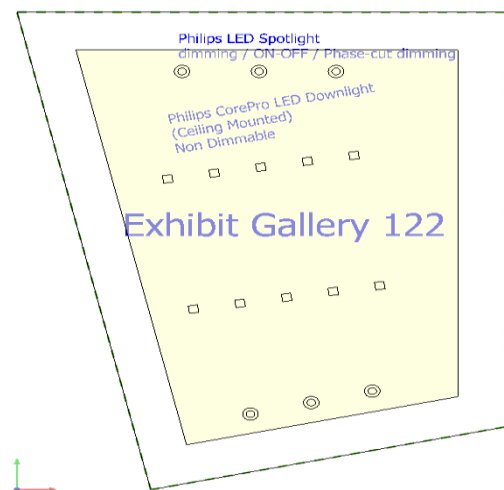


Fig: Exhibit Gallery 122 Layout

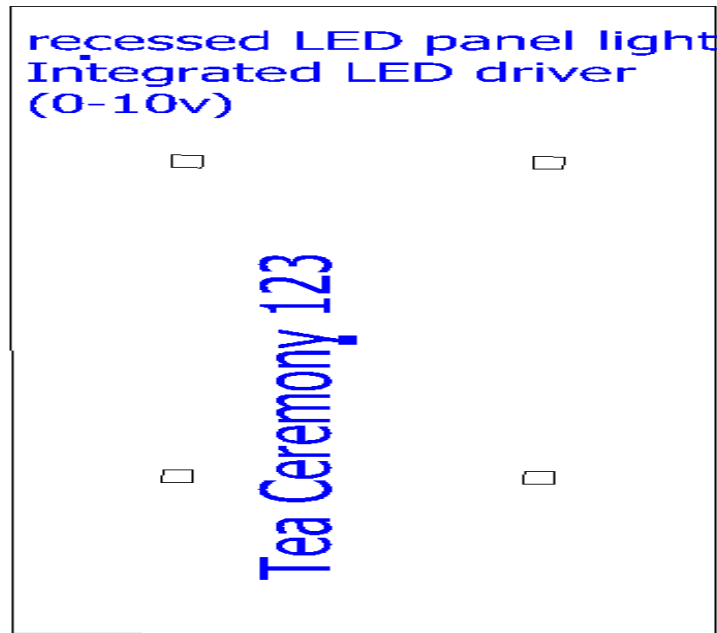


Fig: Tea Ceremony 123 Layout.

**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:

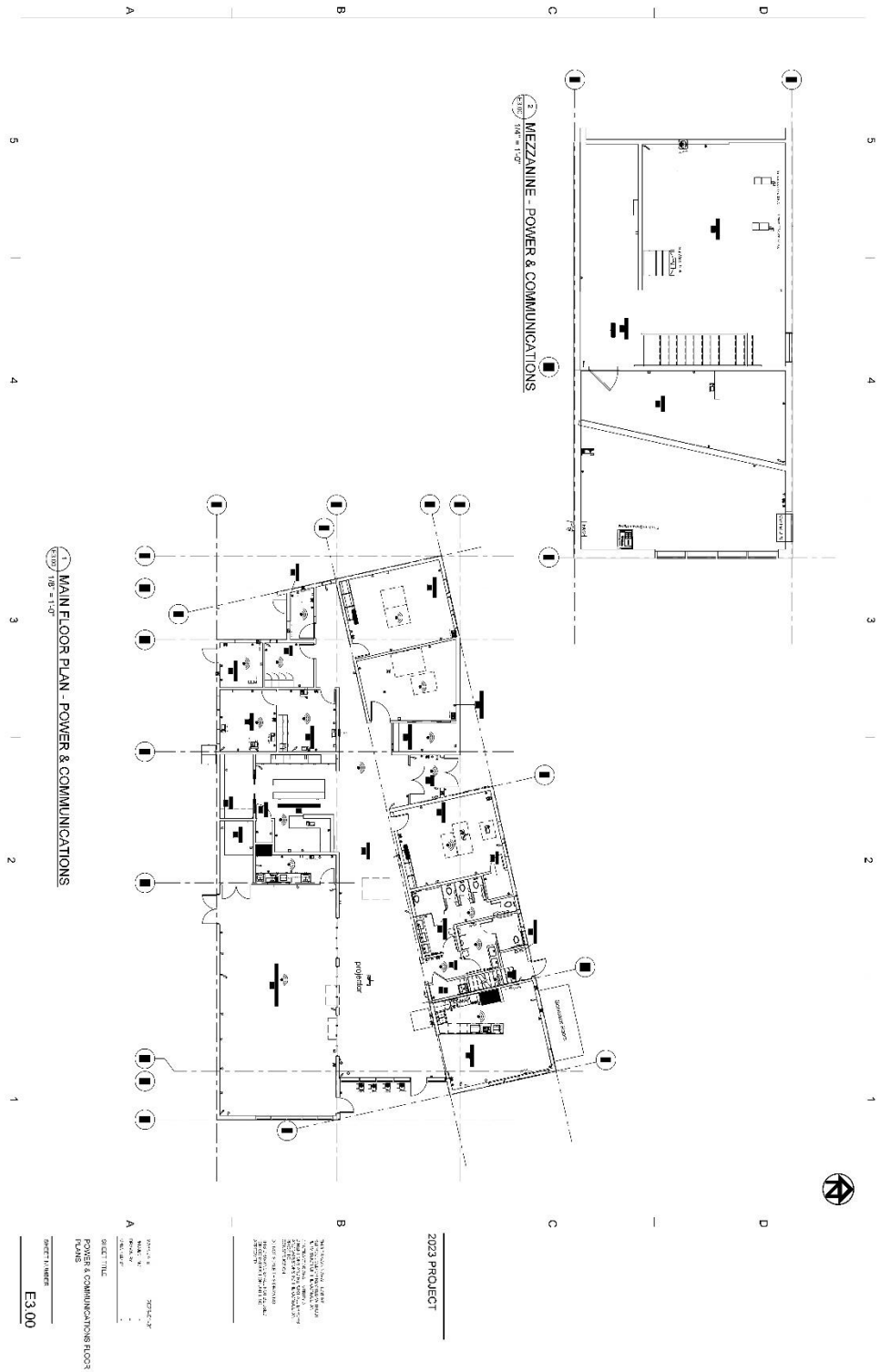


Fig: Power Layout Diagram

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

Fig: Mechanical Schedule

## Normal SLD

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

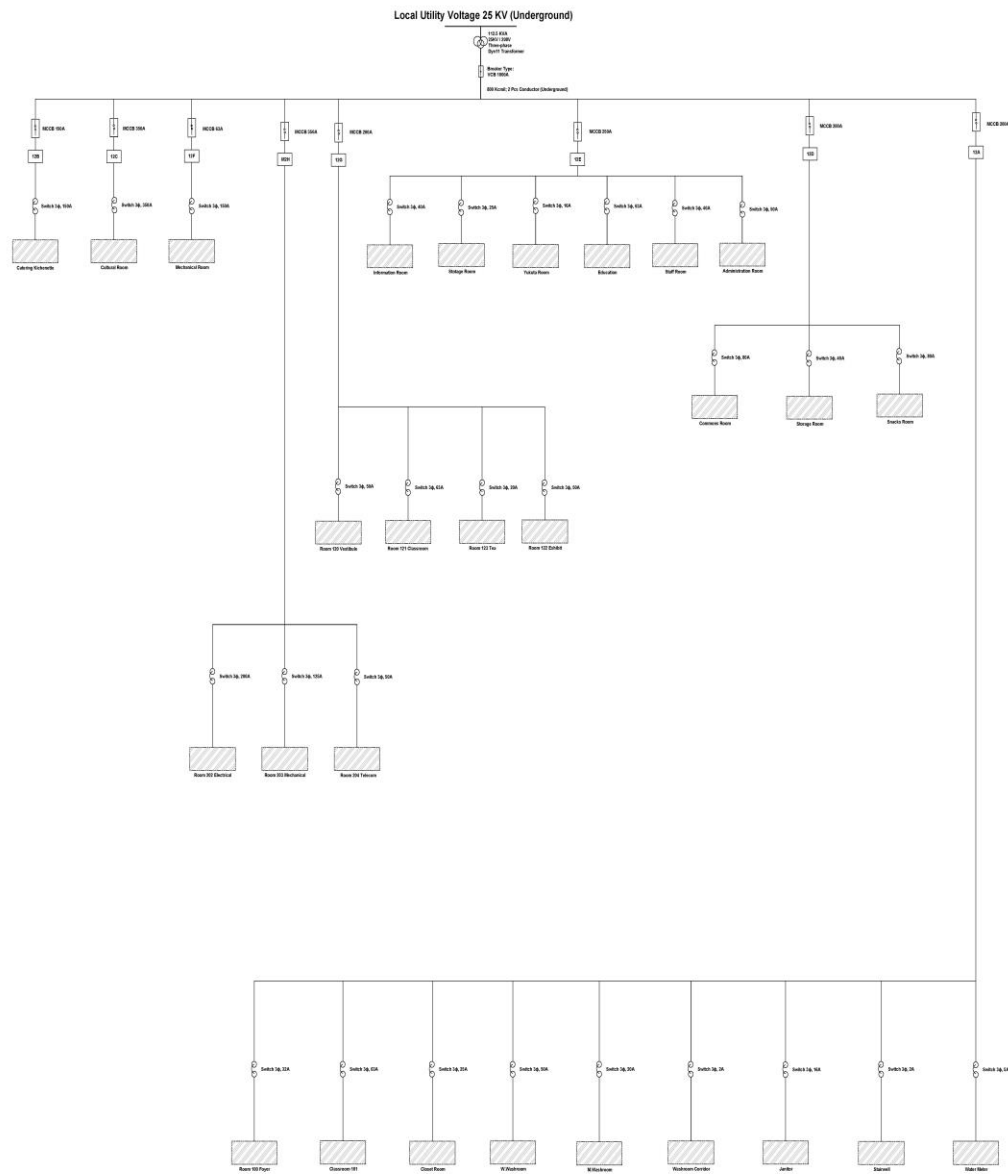


Fig: Normal SLD

**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.

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)



<b>Coolant Capacity</b>	10 gallons
<b>Service Interval</b>	500 hours (for oil change)
<b>Vibration Isolation</b>	Rubber mountings for vibration reduction
<b>Warranty</b>	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
<b>Total</b>		<b>288</b>	<b>3432.08</b>	<b>16.55</b>	<b>17.43</b>		

### 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 =  $(17.43 \text{ kVA} \times 1.25) = 21.79 \text{ kVA}$ . 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 Dollar) [2].  
So, for 2 UPS, the total cost will be =  $(\$19,866.99 \times 2) = \$39,733.98$  (Canadian Dollar).

### Battery Sizing:

#### Step 1: Calculate Total Energy Requirement

Energy (Wh) = Real Power (kW) × Backup Time (hours) \ {Energy (Wh)}  
 $= 16.55 \text{ kW} \times 1 \text{ hour} = 16,550 \text{ Wh}$

#### Step 2: UPS Efficiency

Assuming a UPS efficiency of **90%** (0.9):  
Adjusted Energy (Wh) =  $16,550 \text{ Wh} / 0.9 = 18,389 \text{ Wh}$

#### 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  
 $= 18,389 / 208 = 88.04 \approx 90 \text{ Ah}$

**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  
 $= 208 / 12 = 17.33 \approx 18$

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:  $18 \times \$760.97 = \$13,697.46$  (Canadian Dollar)

We have recommended 2 UPS. So, basically we need 36 batteries of 12V, 90Ah each.  
So, the cost for 36 batteries:  $36 \times \$760.97 = \$27,394.92$  (Canadian Dollar)

### 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 (3 $\phi$ ): 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

$$E_{\text{load}} = \text{Power} \times \text{Operating Hours}$$

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

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

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

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

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

#### 3. Cost With Solar

Using the **solar energy generation** formula:

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

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

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

### Electricity still needed from the grid:

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

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

### Cost with Solar:

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

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

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

$$(40,471.2 - 32,376.96) = 8,094.24 \text{ CAD per year.}$$

## 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<sup>2</sup> (Roof Area)
- **Land Dimension:** 10 acre = 40468.6 m<sup>2</sup> (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<sup>2</sup> 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<sup>2</sup>. But the owner will develop 4 other buildings of similar sizes.

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

### 4. Required Solar Capacity to Meet Load:

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

$$\text{Daily Energy Demand: } 110 \text{ kW} \times 8 \text{ hours (avg. working hours)} = 880 \text{ kWh/day}$$

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

$$\text{Required Power} = 880 \text{ kWh} / 5 \text{ hours} = 176 \text{ kW}$$

$$\text{Number of Panels needed} = 176 \text{ kW} / 0.5 \text{ kW per panel} = 352 \text{ panels}$$

$$\text{Required Land Area} = 352 \times 2.42 \text{ m}^2 = 887.04 \text{ m}^2 \text{ (well within the available space)}$$

### 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:  $\$3.00/\text{W} \times 500\text{W} = \$1500$  per panel

Overall Cost:  $352 \times \$1500 = \$528000$

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

## 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]:

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

### Step 1: Calculate Annual Energy Consumption

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

Where:

- $P_{\text{load}} = 110 \text{ kW}$  (load power)
- $H_{\text{operation}} = 8 \text{ hours/day} \times 365 \text{ days/year} = \mathbf{2920 \text{ hours/year}}$

$$E_{\text{load}} = 110 \times 2920 = 321200 \text{ kWh/year}$$

### Step 2: Use Grid Emission Factor

- Alberta grid emission factor = **0.52 kg CO<sub>2</sub>/kWh**

### Step 3: Calculate Carbon Emissions

$$\text{Carbon Emissions} = 321200 \times 0.52 = 167024 \text{ kg CO}_2/\text{year} \approx 167 \text{ metric tons CO}_2/\text{year}$$

**A 110 kW load running for 8 hours per day in Alberta emits approximately 167 metric tons of CO<sub>2</sub> 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]:

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

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

$$E_{\text{solar}} = 176 \times 1825 \times 0.20 = 64240 \text{ kWh/year}$$

Solar panels have a **lifecycle emission factor** of **20-50 g CO<sub>2</sub>/kWh** (depending on manufacturing and installation) [7]. Taking an average value of **35 g CO<sub>2</sub>/kWh (0.035 kg CO<sub>2</sub>/kWh)**:

$$\text{Solar Carbon Emissions} = 64240 \times 0.035 = 2248.4 \text{ kg CO}_2/\text{year} \approx 2.25 \text{ metric tons CO}_2/\text{year}$$

If we use solar, we can reduce carbon emission up to =  $(167 - 2.25) \text{ metric tons CO}_2/\text{year}$   
= 164.75 metric tons CO<sub>2</sub>/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.

## 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

1. <https://www.csdieselgenerators.com/Images/Generators/2657/Kohler-250REOZJD-spec-sheet.pdf>
2. <https://www.cdw.com/product/apc-by-schneider-electric-galaxy-vs-25kva-tower-ups/5974248>
3. [https://shop.frankensolar.ca/trojan-battery-j185h-ac/?srsltid=AfmBOooTvCx4598p0M\\_avgT5Dz59J2CuxPFM8mJCCJe3Jb97YTNCb1dQ](https://shop.frankensolar.ca/trojan-battery-j185h-ac/?srsltid=AfmBOooTvCx4598p0M_avgT5Dz59J2CuxPFM8mJCCJe3Jb97YTNCb1dQ)
4. <https://www.canadiansolar.com/hiku6/>
5. <https://www.sunvalue.com/posts/cost-of-solar-panels-canada>
6. <https://ghgprotocol.org/sites/default/files/2022-12/AppendixD.pdf>
7. [https://en.wikipedia.org/wiki/Life-cycle\\_greenhouse\\_gas\\_emissions\\_of\\_energy\\_sources](https://en.wikipedia.org/wiki/Life-cycle_greenhouse_gas_emissions_of_energy_sources)
8. <https://www.sunbasedata.com/blog/how-to-calculate-solar-panel-output>
9. <https://www.enmax.com/customer-support/understanding-the-rate-of-last-resort>