Electrical Depth | Tiered Classroom

Spatial Description:

The Tiered Classroom is located in the middle of the South Tower on the second floor and is a simple rectangular plan. Four 4" curved tiers increase the elevation in the back of the room 16". The room is wider (in the direction of the rows) than it is long (the direction the speaker will give lectures). The teacher will be located at the front of the room with two exits on either side. The ceiling mimics the tiered seating and will surely affect acoustic performance in the space. The ceiling has four sections, front, two middle, and a back; these are symmetrical if looking at the side walls. The front panel slants up away from the speaker, the middle two create a "pyramid" and the back slants down from the ceiling to the back of the room. A drop ceiling surrounds these panels and is a few inches lower than their bottom.

List of Activities:

Students will receive lectures which would be presented with the use of white boards and video projectors at the front of the room. The use of laptops to keep notes is possible.

Dimensions:
L x W: 64' x 36'-10"
Floor Area: 2256.75 SF
Ceiling Height (front): 9'-2" A.F.F.
Ceiling Height (back): 7'-10" A.F.F.
Approx. Ceiling Height (center): 8'-6" A.F.F.

Below in Figure 3, can be seen the existing panelboard HLP2S2 which serves the Tiered Classroom Lighting; circuit 9 highlighted.

PANEL ID:	HLP2S2	MAIN:	100A–3P	VOLTAGE:	480Y/277V,3ø,4W
SECTION:	1 OF 1	BUS RATING	225A–3P	LOAD (KVA):	
POLES:	30	AISC RATING	14,000	MOUNTING:	SURFACE
NOTES:					

CKT/BKR #	POLE	TRIP AMPS	NOTES	LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	NOTES	TRIP AMPS	POLE	CKT/BKR #
1	1	20		EXIT SIGNS	1.50	2.37	LTG–REF STACKS #A203		20	1	2
3	1	20		LTG–REF STACKS #A203	.80	1.40	LTG–STUDY ROOMS		20	1	4
5	1	20		LTG–REF STACKS #A203	.70	2.50	LTG–CALSSRMS/OFFICES		20	1	6
7	1	20		LTG–CORRIDOR	.60	1.50	LTG–CLASSRMS #A201.1&2		20	1	8
9	1	20		LTG–TIERED CLASSRM	2.10	2.23	LTG–DISCUSS AREA		20	1	10
11	1	20		LTG–LIB STAFF WORKRM	2.34	2.16	LTG–LIB CIR. AREA		20	1	12
13	1	20							20	1	14
15	1	20		SPARE			SPARE		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	20		SPARE			SPARE		20	1	22
23	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	24
25	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	26
27	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	28
29	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	30

Table 2 Existing Panelboard Schedule serving Tiered Classroom

Taking into account the new luminaires and the new loads associated with their ballast, I calculated the total load (in kVA) for the room. Seen below in Table 3

20 A cct (12.8A allowable) @ 277 volt		Volts	Amps	Total VA
KVA	C1	277	0.12	797.76
3.5456	C2	277	0.12	797.76
(= 20 * .8 * .8 * 277)	C3	277	0.12	232.68
	C4	277	0.07	426.58
	C5	277	0.13	1296.36
			Total kVA	3.55114

Table 3 Total kVA for new Tiered Classroom Circuit (9)

Once found, I inserted these new loads into the supplied panelboard worksheet. This can be seen in Table 4 below.

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 100A/3P C/B

PANEL TAG: HLP2S2
PANEL LOCATION: South Tower
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Exit Signs		1425	20A/1P	1	*			2	20A/1P	2252		LTG-ref stack #a203
LTG-ref stack #a203		760	20A/1P	3		*		4	20A/1P	1330		LTG Study Rooms
LTG-ref stack #a203		665	20A/1P	5			*	6	20A/1P	3420		LTG Corridor
LTG Classrms/ offices		2375	20A/1P	7	*			8	20A/1P	1425		LTG Class A201
LTG Tiered Class		3420	20A/1P	9		*		10	20A/1P	2119		LTG Discuss Area
LTG LIB Staff Workrm		2225	20A/1P	11			*	12	20A/1P	2052		LTG LIB Circ Area
		0	20A/1P	13	*			14	20A/1P	0		
Spare		0	20A/1P	15		*		16	20A/1P	0		Spare
Spare		0	20A/1P	17			*	18	20A/1P	0		Spare
Spare		0	20A/1P	19	*			20	20A/1P	0		Spare
Spare		0	20A/1P	21		*		22	20A/1P	0		Spare
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	7.48	TOTAL DESIGN LOAD (KW)	28.16
CONNECTED LOAD (KW) - B	7.63	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	8.36	TOTAL DESIGN LOAD (AMPS)	36

Table 4 Redesigned Panelboard Schedule

Adding in 25% spare capacity to the redesigned panelboard load (amps) I the new amps would be 36 x 1.25 = 45 A. This would then be sized up to a 50A C/B. Sizes for branch circuiting and feeders can be seen below.

WIRE SIZE

PANEL	CCT	MAX AMPACITY	TYPE	# AND BRANCH CCT SIZE	# AND GROUND SIZE	CONDUIT SIZE
HLP2S2	9	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT

FEEDER SIZE

PANEL	CB RATING (AMPS)	TYPE	# AND SIZE OF CCC	# AND GROUND SIZE	CONDUIT SIZE
HLP2S2	50	THWN	(4) #8 AWG	(1) # 8 AWG	3/4" EMT

Electrical Depth | Library

Spatial Description:

The Library has a "quartered circle" plan that extends up to the fourth floor. It has two floors, the first which connects to computer stations and the stacks housed by the library. The second connects to more stacks, service desk, and also has an opening in the center where people can see through to the two story height space on the floor above. A curving staircase mimics the curve of the exterior curtain wall which extends the whole height of the expansive room. Louvers have been added to reduce direct sun penetration.

List of Activities:

Used in addition to other parts of the library, the reading room is home to other stacks located on the first floor. Like its name implies, the space is primarily used for reading, studying and various homework activities, but also has computer stations positioned around the stairs on the second floor.

Below in Table 10, can be seen the existing panelboard HLP1S2 which serves the first floor of the Library.

PANEL ID:	HLP1S2	MAIN:	100A–3P	VOLTAGE:	480Y/277V,3ø,4W
SECTION:	1 OF 1	BUS RATING	225A–3P	LOAD (KVA):	22.3KVA
POLES:	30	AISC RATING	14,000	MOUNTING:	SURFACE
NOTES:					

CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		EXIT SIGNS		.32	LTG–STAIR A		20	1	2
3	1	20		LTG–STAIR B	.32	.32	LTG–STAIR C		20	1	4
5	1	20		LTG–STAIR D	.32	.32	LTG–STAIR J		20	1	6
7	1	20		LTG–CORRIDOR #A100.1	.97	1.58	LTG–COPY RM #A101.11		20	1	8
9	1	20		LTG–LIBRARY	.87	.96	LTG–LIB. STACKS		20	1	10
11	1	20		LTG–LIB. STACKS	2.68	2.37	LTG–CULINARY ARTS		20	1	12
13	1	20		LTG–LIB. PERIODICALS	2.24	2.72	LTG–SSFO #A102.16		20	1	14
15	1	20		LTG–CHILD DEVELOPMENT #A103	1.56	2.50	LTG–AEROBICS #A108		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	20		SPARE			SPARE		20	1	22
23	1	20		SPARE			SPARE		20	1	24
25	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	26
27	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	28
29	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	30
REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION											

Table 10 As-Designed HLP1S2

PANEL ID:	HLP3S2	MAIN:	100A–3P	VOLTAGE:	480Y/277V,3ø,4W
SECTION:	1 OF 1	BUS RATING	225A	LOAD (KVA):	
POLES:	42	AISC RATING	14,000	MOUNTING:	SURFACE
NOTES:					

CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		LTG–LAB SCULPTURE #A301	1.00	1.50	LTG–UNDER CABINET		20	1	2
3	1	20		LTG–CLASSRM #A303	1.54	1.00	LTG–PAINTING LAB #A304		20	1	4
5	1	20		LTG–ART MAC LAB #A303	3.20	1.10	LTG–CORRIDOR #B300.1		20	1	6
7	1	20		LTG–LIBRARY	1.81	2.60	LTG–		20	1	8
9	1	20		LTG–LIBRARY	2.70	.60	LTG–CORRIDOR		20	1	10
11	1	20		LTG–LIBRARY	3.08	.70	LTG–OPEN SPACE		20	1	12
13	1	20		SPARE			SPARE		20	1	14
15	1	20		SPARE			SPARE		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	22
23	1	–							–	1	24
25	1	–							–	1	26
27	1	–							–	1	28
29	1	–							–	1	30
REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION											

Table 11 As Designed Panel HLP3S2

On panel HLP1S2, circuits 9 and 13 provide power to the original luminaires specified for the first floor. Circuits 7,9, and 11 on panel HLP3S2 serve the original luminaires on the third floor. After redesigning the new lighting scheme for the space, analyzed the change in power supply and circuits needed. Seen below in Table 1 are the Luminaire types and quantities. I then calculated the circuits that would be needed to serve this space. I applied the following equation to find the total kVA for the Library:

$$kVA = (quantity) \times (A\ max) \times (277\ V)$$

Maximum amperage needed to run the ballast and a voltage of 277, were used to calculate each luminaire type's associated kVA. These values can be seen below in Table 12.

20 A cct (12.8A allowable) @ 277 volt		Volts	Amps	Total VA
KVA	L1	277	0.67	7052.42
3.5456	L1B	277	0.67	371.18
(= 20 * .8 * .8 * 277)	L2A	277	0.23	573.39
	L2B	277	0.23	573.39
	L2C	277	0.23	509.68
	L3	277	0.23	1911.3
	L4	277	0.12	631.56
	L5	277	0.12	299.16
	L6	277	0.12	465.36
	L7A	277	0.26	216.06
	L7B	277	0.26	216.06
	L7C	277	0.26	216.06
	L8	277	0.26	648.18
	L9A	277	13	600
	L9B	277	13	600
	L9C	277	13	600
			Total kVA	15.4838
			Minimum CCTs Needed	5

Table 12 Circuit Quantities for Library

Once found, I inserted these new loads into the supplied panelboard worksheet. Seen below in Table 13.

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 50A/3P C/B

PANEL TAG: HLP1S2
PANEL LOCATION: South Tower
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
EXIT SIGNS		1425	20A/1P	1	*			2	20A/1P	304		LTG-STAIR A
LTG-CULINARY ARTS		2252	20A/1P	3		*		4	20A/1P	912		LTG-LIB. STACKS
LTG-STAIR D		304	20A/1P	5			*	6	20A/1P	304		LTG-STAIR J
LTG_CORRIDOR #A100.1		922	20A/1P	7	*			8	20A/1P	1501		LTG_COPY ROOM #A101.11
LTG-CHILD DEVELOPMENT #A103		1482	20A/1P	9		*		10	20A/1P	2375		LTG-AEROBICS #A108
LTG-LIB. STACKS		2546	20A/1P	11			*	12	20A/1P	3489		LTG LIB
Spare		0	20A/1P	13	*			14	20A/1P	[illegible]		[illegible]
Spare		0	20A/1P	15		*		16	20A/1P	0		Spare
LTG-STAIR B		304	20A/1P	17			*	18	20A/1P	304		LTG-STAIR C
-		0	20A/1P	19	*			20	20A/1P	0		-
-		0	20A/1P	21		*		22	20A/1P	0		-
-		0	20A/1P	23			*	24	20A/1P	0		-
Spare		0	20A/1P	25	*			26	20A/1P	0		-
Spare		0	20A/1P	27		*		28	20A/1P	0		Spare
Spare		0	20A/1P	29			*	30	20A/1P	0		Spare
Spare		0	20A/1P	31	*			32	20A/1P	0		Spare
		0	20A/1P	33		*		34	20A/1P	0		Spare
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	6.74	TOTAL DESIGN LOAD (KW)	25.21
CONNECTED LOAD (KW) - B	7.02	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	7.25	TOTAL DESIGN LOAD (AMPS)	32

Table 13 Re-designed Panel HLP1S2

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: HLP3S2	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 225A	PANEL LOCATION: South Tower	OPTIONS:
SIZE/TYPE MAIN: 50A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG LAB SCULPTURE #A301		950	20A/1P	1	*			2	20A/1P	950		LTG OPEN SPACE
LTG CLASS #A303		1463	20A/1P	3		*		4	20A/1P	1425		LTG UNDER CABINET
LTG ART MAC LAB		3040	20A/1P	5			*	6	20A/1P	2945		LTG LIBRARY
LTG LIBRARY		2594	20A/1P	7	*			8	20A/1P	2717		LTG LIBRARY
LTG LIBRARY		2907	20A/1P	9		*		10	20A/1P	1045		LTG CORRIDOR #B300.1
LTG CORRIDOR		570	20A/1P	11			*	12	20A/1P	665		LTG OPEN SPACE
		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
Spare		0	20A/1P	23			*	24	20A/1P	0		
Spare		0	20A/1P	25	*			26	20A/1P	0		Spare
Spare		0	20A/1P	27		*		28	20A/1P	0		Spare
Spare		0	20A/1P	29			*	30	20A/1P	0		Spare
Spare		0	20A/1P	31	*			32	20A/1P	0		Spare
		0	20A/1P	33		*		34	20A/1P	0		Spare
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	7.21	TOTAL DESIGN LOAD (KW)	25.52
CONNECTED LOAD (KW) - B	6.84	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	7.22	TOTAL DESIGN LOAD (AMPS)	32

Table 14 Re-designed Panel HLP3S2

Sizing for the feeders serving the panels, dedicated branch circuits serving the Library lighting loads, and conduit size can be seen in Table 8 and 9 below. Sizing charts used were from the 2008 National Electric Code (Tables 10 and 11).

WIRE SIZE

PANEL	CCT	MAX AMPACITY	TYPE	# AND BRANCH CCT SIZE	# AND GROUND SIZE	CONDUIT SIZE
HLP1S2	12	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP3S2	6	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP3S2	7	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP3S2	8	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP3S2	9	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT

Table 15 Wire and Conduit Size of Branch Circuits

FEEDER SIZE

PANEL	CB RATING (AMPS)	TYPE	# AND SIZE OF CCC	# AND GROUND SIZE	CONDUIT SIZE
HLP1S2	50	THWN	(4) #8 AWG	(1) # 8 AWG	3/4" EMT
HLP3S2	50	THWN	(4) #8 AWG	(1) # 8 AWG	3/4" EMT

Table 16 Wire and Conduit Size for Feeders

Electrical Depth | Roof Garden

Spatial Description:

Located on the roof of the Reading Lounge, the Roof Garden serves as an escape to the outdoors. The Student Gathering space leads directly to the garden which is on the fourth floor. The students will be greeted by a piece of custom art-work (sculpture). Benches surround round planters that hold trees, which are also surrounded by a pathway that leads around the exterior façade of the lounge below.

List of Activities:

Transition through the space (mostly walking) is the main activity. Others could potentially include reading (books), face-to-face interactions, and computer use.

Dimensions: North Wall Length: 73'-2" West Wall Length: 73'-10"	Parapet Length: 99'-6" Area: 4319 SF

No panelboard can be located that serves the Roof Garden. Therefore I am theorizing that panel HLP4S2 serves the Roof Garden, mainly due to the close proximity. Below is the current panel layout.

PANEL ID:	HLP4S2			MAIN:	100A–3P		VOLTAGE:		480Y/277V,3ø,4W		
SECTION:	1 OF 1			BUS RATING	225A		LOAD (KVA):				
POLES:	42			AISC RATING	14,000		MOUNTING:		SURFACE		
NOTES:											
CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		EXIT SIGNS	1.00	2.38	LTG – RM A403		20	1	2
3	1	20		LTG ATRIUM	2.60	1.67	LTG – ATRIUM		20	1	4
5	1	20							20	1	6
7	1	20							20	1	8
9	1	20							20	1	10
11	1	20		SPARE			SPARE		20	1	12
13	1	20		SPARE			SPARE		20	1	14
15	1	20		SPARE			SPARE		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	22
23	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	24
25	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	26
27	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	28
29	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	30
REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION											

Table 17 As-Design Layout for Panel HLP4S2

Please see tables below for lighting power density and circuits needed.

TRADABLE

Allowable LPD walk <10ft (by Ashrae 90.1):	1	per sq ft
Area:	1022	
Allowable Watts (by Ashrae 90.1):	511	

Allowable LPD Entrance (by Ashrae 90.1):	30	per ft
Area:	30	
Allowable Watts (by Ashrae 90.1):	450	

Allowable LPD Overhangs (by Ashrae 90.1):	1.25	per sq ft
Area:	789	
Allowable Watts (by Ashrae 90.1):	493.125	

Allowable LPD Plazas (by Ashrae 90.1):	0.2	per sq ft	5	per ft
Area:	3019		89.6	
Allowable Watts (by Ashrae 90.1):	301.9	OR	336.00	

Total Wattage to Consume (not including façade)	1756.025

Designed Wattage Consumption			
Luminaire Type	Quantity	Ballast Watts	Total Watts
R1	16	16	256
R2	10	22	220
R3	10	46	460
R4	3	36	108
R5			
		936	PASS
		Watts to consume	820.03

NOT TRADABLE

Allowable LPD Facade(by Ashrae 90.1):	0.2
Area:	2297
Allowable Watts (by Ashrae 90.1):	229.7

Designed Wattage Consumption			
Luminaire Type	Quantity	Ballast Watts	Total Watts
R5	132.5	1	132.5
			0
			0
		132.5	PASS
		Watts to consume	97.2

20 A cct (12.8A allowable) @ 277 volt		Volts	Amps	Total VA
KVA	R1	277	0.36	1595.52
3.5456	R2	277	0.08	221.6
(= 20 * .8 * .8 * 277)	R3	277	0.78	2160.6
	R4		Not Used	
	R5	220	2.525	555.5
			Total kVA	4.53322
			Needed CCTs	2

Table 18 Roof Garden Lighting Power Density and Circuit Sizing

By using these spreadsheets, I have found that two circuits are needed to supply power to the roof garden. Please see the panel worksheet on the next page for layout of Roof Garden circuits.

PANELBOARD SCHEDULE													
VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 100A/3P C/B			PANEL TAG: HLP4S2 PANEL LOCATION: South Tower PANEL MOUNTING: SURFACE							MIN. C/B AIC: 10K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION	
Exit Signs		950	20A/1P	1	*			2	20A/1P	2470		Ltg Atrium	
Ltg Rm A403		2261	20A/1P	3		*		4	20A/1P	1292		Ltg Atrium	
Ltg Roof Garden		2280	20A/1P	5			*	6	20A/1P	2090		Ltg Roof Garden	
0		0	20A/1P	7	*			8	20A/1P	0		0	
0	0	0	20A/1P	9		*		10	20A/1P	0		0	
0		0	20A/1P	11			*	12	20A/1P	0		0	
SPARE		3340	20A/1P	13	*			14	20A/1P	3340		SPARE	
SPARE		3340	20A/1P	15		*		16	20A/1P	3340		SPARE	
SPARE		3340	20A/1P	17			*	18	20A/1P	3340		SPARE	
SPARE		3340	20A/1P	19	*			20	20A/1P	3340		SPARE	
SPARE		3340	20A/1P	21		*		22	20A/1P	3340		SPARE	
SPARE		3340	20A/1P	23			*	24	20A/1P	3340		SPARE	
		0	20A/1P	25	*			26	20A/1P	0			
		0	20A/1P	27		*		28	20A/1P	0			
		0	20A/1P	29			*	30	20A/1P	0			
		0	20A/1P	31	*			32	20A/1P	0			
		0	20A/1P	33		*		34	20A/1P	0			
		0	20A/1P	35			*	36	20A/1P	0			
		0	20A/1P	37	*			38	20A/1P	0			
		0	20A/1P	39		*		40	20A/1P	0			
		0	20A/1P	41			*	42	20A/1P	0			
CONNECTED LOAD (KW) - A		16.78								TOTAL DESIGN LOAD (KW)		61.71	
CONNECTED LOAD (KW) - B		16.91								POWER FACTOR		0.99	
CONNECTED LOAD (KW) - C		17.73								TOTAL DESIGN LOAD (AMPS)		75	

Table 19 Redesigned Panel HLP4S2

In this panel, I included 10 spare circuits (based on existing panel) and loaded them to 60% (or 12A). I multiplied by 277V and then applied a .95 PF. After totaling the design load to 75 Amps, I then applied a scaling factor of 1.25 for future space. In the end I was able to reduce the panel's main breaker size from 225A to 100A. The associated wire sizes are below.

WIRE SIZE

PANEL	CCT	MAX AMPACITY	TYPE	# AND BRANCH CCT SIZE	# AND GROUND SIZE	CONDUIT SIZE
HLP4S2	5	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP4S2	6	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT

FEEDER SIZE

PANEL	CB RATING (AMPS)	TYPE	# AND SIZE OF CCC	# AND GROUND SIZE	CONDUIT SIZE
HLP4S2	100	THWN	(4) #3 AWG	(1) # 6 AWG	1-1/4" EMT

Table 20 Wire and Feeder sizing for HLP4S2

Electrical Depth | Student Gathering

Spatial Description:

This space provides the main distribution outlet in Gateway. It runs North to South and extends from the first level up to the fourth with and bridges cutting though the main central space. A walkway borders on the East side of the atrium on every floor. Openings extend from stairs and large landings up to the ceiling above, which seemingly hovers in the air, as light streams in from East and West clerestories which extend the length of the space. Over George St. (which splits the North and South Towers) a walkway joins portions of the Student Gathering space. This space is a continuous climb in through the middle of the building and ends when you reach the top of the Reading Lounge; it's Roof Garden.

List of Activities:

Transition through the space (mostly walking) is the main activity through this space. Others could potentially include reading (books and vertically posted materials), face-to-face interactions, or computer use.

Dimensions:

Length (North Tower): 92'-8"
Length (walkway): 76'-5"
Length (South Tower): 261'

Width (NT): 19'-6"
Width (walkway): 27'
Width (start/end ST): 24'-10" / 38'-7"
Area (approx. total): 15867 SF

In the Student Gathering Atrium, three panels serve the electric lighting loads. Two of these panels (HLP4S1 and HLP4S2) are located in the south tower of GCC. Panel HLP4SN is located in the north tower. The re-designed loads can be seen below for my current lighting design.

Lighting Power Density Calculation

	Total
Corridor Area:	6055
Allowable Corridor LPD (by Ashrae 90.1):	0.5

	Total
Atrium Area:	8018.5
Allowable Atrium (1-3) LPD (by Ashrae 90.1):	1.3
Allowable Atrium (+3) LPD (by Ashrae 90.1):	1.3

Total Allowable Watts (by Ashrae 90.1):	20423.19

Designed Wattage Consumption

Luminaire Type	Quantity	Ballast Watts	Total Watts	
S1	22	283	6226.00	
S2	115	32.1	3691.5	
S3	50	35.1	2106	
S4 (70 WMH)	4	95	380	
S5 (175 MH)	4	198	792	
S6 (250 MH)	12	284	3408	
S7	54	14.3	772.2	
S8			0	
S9			0	
S10			0	
			17375.70	**PASS**
			Watts to consume	7047.72

20 A cct (12.8A allowable) @ 277 volt		Volts	Amps	Total VA
KVA	S1	277	0.6	3656.4
3.5456	S2	277	0.12	3822.6
(= 20 * .8 * .8 * 277)	S3	277	0.042	581.7
	S4	277	0.7	775.6
	S5	277	0.76	842.08
	S6	277	1.03	3423.72
	S7			772.2
			Total kVA	13.8743
			Needed CCTs	4

Table 21 Re-designed loads and Circuit Analysis

The branch wire and feeder sizes are as follows:

PANEL ID:	HLP4S1	MAIN:	100A–3P	VOLTAGE:	480Y/277V,3ø,4W
SECTION:	1 OF 1	BUS RATING	225A	LOAD (KVA):	
POLES:	30	AISC RATING	14,000	MOUNTING:	SURFACE
NOTES:					

CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		LTG–ATRIUM	3.01	1.67	LTG–ATRIUM		20	1	2
3	1	20		LTG–SKILLS LAB #D402.3	2.37	1.54	LTG–SKILLS LAB #D402.7		20	1	4
5	1	20		LTG–CORRIDOR #D400.1	.50		–		20	1	6
7	1	20							20	1	8
9	1	20							20	1	10
11	1	20							20	1	12
13	1	20		SPARE			SPARE		20	1	14
15	1	20		SPARE			SPARE		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	22
23	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	24
25	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	26
27	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	28
29	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	30

REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION

Table 22 As-designed panel HLP4S1

PANEL ID:	HLP4S2	MAIN:	100A–3P	VOLTAGE:	480Y/277V,3ø,4W
SECTION:	1 OF 1	BUS RATING	225A	LOAD (KVA):	
POLES:	42	AISC RATING	14,000	MOUNTING:	SURFACE
NOTES:					

CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		EXIT SIGNS	1.00	2.38	LTG – RM A403		20	1	2
3	1	20		LTG ATRIUM	2.60	1.67	LTG – ATRIUM		20	1	4
5	1	20							20	1	6
7	1	20							20	1	8
9	1	20							20	1	10
11	1	20		SPARE			SPARE		20	1	12
13	1	20		SPARE			SPARE		20	1	14
15	1	20		SPARE			SPARE		20	1	16
17	1	20		SPARE			SPARE		20	1	18
19	1	20		SPARE			SPARE		20	1	20
21	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	22
23	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	24
25	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	26
27	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	28
29	1	–		SPACE & PROVISIONS			SPACE & PROVISIONS		–	1	30

REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION

Table 23 As-designed Panel HLP4S2

PANEL ID:	HLP4N				MAIN:	100A–3P		VOLTAGE:	480Y/277V,3ø,4W		
SECTION:	1 OF 1				BUS RATING	225A		LOAD (KVA):	36.8KVA		
POLES:	30				AISC RATING	14,000		MOUNTING:	SURFACE		
NOTES:											
CKT/BKR				LOAD DESCRIPTION	LOAD KVA	LOAD KVA	LOAD DESCRIPTION	CKT/BKR			
#	POLE	TRIP AMPS	NOTES					NOTES	TRIP AMPS	POLE	#
1	1	20		LTG–SCIENCE LABS #G416&418	2.87	2.95	LTG–SCIENCE LABS #G421&419		20	1	2
3	1	20		LTG–SCIENCE LABS #G422&424	2.95	1.52	LTG–OFFICES & TOILETS		20	1	4
5	1	20		LTG–CORRIDOR #G400.1	1.60	1.80	LTG–SCIENCE LAB #G404		20	1	6
7	1	20		LTG–CORRIDOR #G400.1	1.60	1.50	LTG–CLASSRM 1 #C401&402		20	1	8
9	1	20		LTG–SCIENCE LABS #E401&405	3.10	1.90	LTG–SCIENCE LAB #E406		20	1	10
11	1	20		LTG–SCIENCE LAB #F406	2.95	1.00	LTG–CORRIDOR #E400.1		20	1	12
13	1	20		LTG–ROOF	2.0	2.0	LTG–ATRIUM		20	1	14
15	1	20		LTG–ATRIUM	3.0	1.0	EXIT SIGNS		20	1	16
17	1	20		LTG–UNDER CABINET	1.0	1.0	LTG–UNDER CABINET		20	1	18
19	1	20		LTG–UNDER CABINET	1.0	1.0	LTG–UNDER CABINET		20	1	20
21											22
23	1	20		SPARE			SPARE		20	1	24
25	1	20		SPARE			SPARE		20	1	26
27	1	20		SPARE			SPARE		20	1	28
29	1	20		SPARE			SPARE		20	1	30
REFER TO NEW PANELBOARD, GENERAL AND SCHEDULE NOTES FOR ADDITIONAL INFORMATION					–	–					

Table 24 As-designed Panel HLP4N

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 100A
SIZE/TYPE MAIN: 100A/3P C/B

PANEL TAG: HLP4S1
PANEL LOCATION: South Tower
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG ATRIUM		2850	20A/1P	1	*			2	20A/1P	3420		LTG ATRIUM
LTG SKILLS LAB		2232	20A/1P	3				4	20A/1P	1463		LTG SKILLS LAB
LTG CORRIDOR		475	20A/1P	5			*	6	20A/1P	0		0
0		0	20A/1P	7	*			8	20A/1P	0		0
0	0	0	20A/1P	9		*		10	20A/1P	0		0
0		0	20A/1P	11			*	12	20A/1P	0		0
SPARE		3340	20A/1P	13	*			14	20A/1P	3340		SPARE
SPARE		3340	20A/1P	15		*		16	20A/1P	3340		SPARE
SPARE		3340	20A/1P	17			*	18	20A/1P	3340		SPARE
SPARE		3340	20A/1P	19	*			20	20A/1P	3340		SPARE
SPARE		3340	20A/1P	21		*		22	20A/1P	3340		SPARE
0		0	20A/1P	23			*	24	20A/1P	0		0
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		
CONNECTED LOAD (KW) - A		19.63								TOTAL DESIGN LOAD (KW)		52.63
CONNECTED LOAD (KW) - B		17.07								POWER FACTOR		0.99
CONNECTED LOAD (KW) - C		7.16								TOTAL DESIGN LOAD (AMPS)		64

Table 25 Re-designed panel HLP4S1

PANELBOARD SCHEDULE												
VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: 100A/3P C/B			PANEL TAG: HLP4S2 PANEL LOCATION: South Tower PANEL MOUNTING: SURFACE						MIN. C/B AIC: 10K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG ATRIUM		2470	20A/1P	1	*			2	20A/1P	1330		LTG ATRIUM
LTG SKILLS LAB		2252	20A/1P	3		*		4	20A/1P	1458		LTG SKILLS LAB
LTG CORRIDOR		475	20A/1P	5			*	6	20A/1P	0		0
0		0	20A/1P	7	*			8	20A/1P	0		0
0	0	0	20A/1P	9		*		10	20A/1P	0		0
0		0	20A/1P	11			*	12	20A/1P	0		0
SPARE		3340	20A/1P	13	*			14	20A/1P	3340		SPARE
SPARE		3340	20A/1P	15		*		16	20A/1P	3340		SPARE
SPARE		3340	20A/1P	17			*	18	20A/1P	3340		SPARE
SPARE		3340	20A/1P	19	*			20	20A/1P	3340		SPARE
SPARE		3340	20A/1P	21		*		22	20A/1P	3340		SPARE
0		0	20A/1P	23			*	24	20A/1P	0		0
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		
CONNECTED LOAD (KW) - A		17.16								TOTAL DESIGN LOAD (KW)		49.67
CONNECTED LOAD (KW) - B		17.07								POWER FACTOR		0.99
CONNECTED LOAD (KW) - C		7.16								TOTAL DESIGN LOAD (AMPS)		60

Table 26 Re-designed panel HLP4S2

PANELBOARD SCHEDULE												
VOLTAGE: 208Y/120V,3PH,4W SIZE/TYPE BUS: 225A SIZE/TYPE MAIN: 125A/3P C/B			PANEL TAG: HLP4SN PANEL LOCATION: South Tower PANEL MOUNTING: SURFACE						MIN. C/B AIC: 10K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG SCIENCE LABS		2727	20A/1P	1	*			2	20A/1P	2803		LTG SCIENCE LABS
LTG SCIENCE LABS		2803	20A/1P	3		*		4	20A/1P	1444		OFFICES AND TOILI
LTG CORRIDOR		1520	20A/1P	5			*	6	20A/1P	1710		LTG SCIENCE LABS
LTG CORRIDOR		1520	20A/1P	7	*			8	20A/1P	1425		LTG CLASSROOM
LTG SCIENCE LABS	0	2945	20A/1P	9		*		10	20A/1P	1805		LTG SCIENCE LABS
LTG SCIENCE LABS		2803	20A/1P	11			*	12	20A/1P	950		LTG CORRIDOR
LTG ROOF		1895	20A/1P	13	*			14	20A/1P	0		LTG ATRIUM
LTG ATRIUM		2850	20A/1P	15		*		16	20A/1P	950		EXIT SIGNS
LTG UNDER CAB		950	20A/1P	17			*	18	20A/1P	950		LTG UNDER CAB
LTG UNDER CAB		950	20A/1P	19	*			20	20A/1P	950		LTG UNDER CAB
SPARE		3340	20A/1P	21		*		22	20A/1P	3340		SPARE
SPARE		3340	20A/1P	23			*	24	20A/1P	3340		SPARE
SPARE		3340	20A/1P	25	*			26	20A/1P	3340		SPARE
SPARE		3340	20A/1P	27		*		28	20A/1P	3340		SPARE
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		
CONNECTED LOAD (KW) - A		18.95								TOTAL DESIGN LOAD (KW)		72.81
CONNECTED LOAD (KW) - B		26.16								POWER FACTOR		0.97
CONNECTED LOAD (KW) - C		15.56								TOTAL DESIGN LOAD (AMPS)		90

Table 27 Re-designed panel HLP4SN

Sizes for the Feeders serving these panels and the branch circuits serving lighting loads can be found below in Table 29.

WIRE SIZE

PANEL	CCT	MAX AMPACITY	TYPE	# AND BRANCH CCT SIZE	# AND GROUND SIZE	CONDUIT SIZE
HLP4S1	1	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP4S1	2	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP4S2	3	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP4S2	4	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT
HLP4SN	15	20	THWN	(2) # 12 AWG	(1) # 8 AWG	3/4" EMT

FEEDER SIZE

PANEL	CB RATING (AMPS)	TYPE	# AND SIZE OF CCC	# AND GROUND SIZE	CONDUIT SIZE
HLP4S1	100	THWN	(4) #3 AWG	(1) # 6 AWG	1-1/4" EMT
HLP4S2	100	THWN	(4) #3 AWG	(1) # 6 AWG	1-1/4" EMT
HLP4SN	125	THWN	(4) #1 AWG	(1) # 4 AWG	1-1/4" EMT

Table 28 Feeder and Branch Circuit Sizing for SG Panels

310.15 Article 310 • Conductors for General Wiring

Table 310.16 Allowable Ampacities of Insulated Conductors Rated 0 Through 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.13(A).]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	—	—	14	—	—	—	—
16	—	—	18	—	—	—	—
14*	20	20	25	—	—	—	—
12*	25	25	30	20	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000

CORRECTION FACTORS

Ambient Temp. (°C)	For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by the appropriate factor shown below.						Ambient Temp. (°F)
21–25	1.08	1.05	1.04	1.08	1.05	1.04	70–7
26–30	1.00	1.00	1.00	1.00	1.00	1.00	78–8
31–35	0.91	0.94	0.96	0.91	0.94	0.96	87–9
36–40	0.82	0.88	0.91	0.82	0.88	0.91	96–1
41–45	0.71	0.82	0.87	0.71	0.82	0.87	105–1
46–50	0.58	0.75	0.82	0.58	0.75	0.82	114–1
51–55	0.41	0.67	0.76	0.41	0.67	0.76	123–1
56–60	—	0.58	0.71	—	0.58	0.71	132–1
61–70	—	0.33	0.58	—	0.33	0.58	141–1
71–80	—	—	0.41	—	—	0.41	159–1

* See 240.4(D).

314 *2008 National Electrical Code Ha*

Table 30 NEC Wire Sizing Chart

22 Minimum Size Equipment Grounding for Grounding Raceway and Equipment

Setting of Automatic ent Device in Circuit Equipment, Conduit, Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

Table 29 NEC Ground Sizing Chart

NOTE: *Feeder, branch, and ground sizes are from Article 310 and 322 of NEC 2008.*

Efficient Transformer Analysis

As an added aim at saving energy, I researched the savings that could be produced by replacing the current transformers used with energy efficient transformers by Powersmiths. To analyze this change I used the supplied The Powersmiths Energy Savings Payback Calculator (see Table 31).

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ESP for LEED Calculator™
Energy Savings Payback Calculator

Project Description	Gateway Community College, New Haven CT
Date	19-Mar-09

Data Entry

Transformers on Project

QTY	kVA
4	15
2	30
	45
19	75
1	112.5
	150
	225
	300
	500
	750
	1000
	1500
	2000
	7.5

Available Full Load kW	**1657.5**		
Average kVA (calc)	64		
equipment operating hrs/ day	24		
equipment operating days/yr	250	Calc Load kW	Calc Annual kWh
Load during normal operating hours	35%	580	3,480,750
Load outside operating hours	0%	0	-
		Total Annual Load kWh:	**3,480,750**

Annual Cost to Operate Load Only			
kWh rate	$ 0.201	Annual Consumption:	$ 699,039
demand rate ($/kW/mo) ex. $10.00	$11.00	Annual Demand:	$ 76,577
		Total Cost to run load	**$ 775,616**

Note #1

Note #2

Table 31 Powersmiths Calculation

Note #1:
Because GCC is a Community College I am assuming that it is under operation 250 days out of the year. Additionally, 24hrs of operation per day and 35% of load under these normal conditions is based off of an article from MGM Transformer Company (5701 SMITHWAY STREET CITY OF COMMERCE, CALIF. 90040) which states "Studies sponsored by the Environmental Protection Agency (EPA) show that the typical loading of low voltage (600V and below) drytype distribution transformers averages around 35% of the transformers full load rating over a 24 hour period."

Note #2:

The utility rate of .201 $/kWh is based off the GST Rate supplied by The United Illuminating Company. Below in Table 13, one will notice the two summer and two winter rates at the bottom. An average of these rates follows:

$$\frac{¢}{kWh} = \frac{23.6778 + 17.4085 + 21.8372 + 17.4085}{4} = 20.083$$

$$\frac{\$}{kWh} = \frac{20.083}{100} = .201$$

Gatway Community College - Electrical Rate				
Based on GST Rate from The United Illuminating Company				
July-December	On Peak c/KWhr	6pm-10am Off peak c/KWhr	$	
1. Standard Service Generation	14.2994	12.2994		
2. Delivery Charges				
System benefits	0.1973	0.1973		
Conservation Charge	0.3	0.3		
Renewable Energy Charge	0.1	0.1		
Non Bypassable FMCC	0.4678	0.4678		
3.Competetive Transition Assesment(CTA)				
Demand Rate Charge	1.5222	1.5222		
4. Transmission Charge	2.0474	2.0474		
Sub-total 1-4	18.9341	16.9341		
5. Where Demand Is Billed				
Basic Service Charge			60.42	
Summer:June-September				
Demand Charge				
On Peak Hours			**3.35**	per KW
Off Peak Hours Of Excess KW			**1.67**	per KW
Charge per KWhr				
On Peak Hours	4.7437			
Off Peak Hours		0.759		
Winter: October -May				
Demand Charge				
On Peak Hours			**1.84**	per KW
Off Peak Hours Of Excess KW			**1.66**	per KW
Charge per KWhr				
On Peak Hours	2.9031			
Off Peak Hours		0.4744		
Summer	**23.6778**	**17.4085**		
Winter	**21.8372**	**17.4085**		

Table 32 Utility Rates for GCC

Annual Cost of Status Quo Transformer Losses & Associated Air Conditioning (A/C) burden

Nameplate Linear efficiency (normal op hrs)	97.8%		% electronics or current THD	30.0%
Calculated operating efficiency	97.2%			
Transformer kW Losses (Normal Operation)	17.0	kW		
Status quo Efficiency (Outside op. hrs)	97.8%			
Transformer kW Losses (Outside op. hrs)	0.0	kW		
Annual addititional kWh from transformers	101,743	kWh		
Annual Cost of Transformer Losses	$ 22,671			
A/C System Performance (kW/ton)	0.76			
Additional Tons of Cooling (on peak)	4.82	tons		
Annual addititional kWh from A/C	21,924	kWh		
Annual Cost of Associated A/C	$ 4,885			
Summary with Status Quo Transformer				
Annual Cost of feeding Building Load	$ 775,616			
Annual Cost of Transformer Losses	$ 22,671			
Annual Cost of Associated A/C	$ 4,885			
Electrical Bill (Status Quo Transformer)	**$ 803,172**			

Note #3

Note #4

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Table 33 Powersmiths Calculation Cont.

Note #3:
The Nameplate Efficiency (normal and outside normal hours of operation) was found by once again averaging the efficiencies of assumed transformers. Since the actual efficiencies are not available to me right now, I checked the specification for the original transformer types and they are as follows:

The specification (Section 16461) calls out the following:

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA Standard TP-1-1996, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

Figure 78 Transformer Specification

Knowing that the transformers must comply with the NEMA Standard TP-1 I found the following chart (again from MGM transformer Company):

The following table lists the NEMA TP- 1 minimum efficiency levels for low voltage dry type distribution transformers:

Single-Phase Efficiency	
Rated Capacity (kVA)	Minimum Efficiency (%)
15	97.7
25	98.0
37.5	98.2
50	98.3
75	98.5
100	98.6
167	98.7

Three-Phase Efficiency	
Rated Capacity (kVA)	Minimum Efficiency (%)
15	97.0
30	97.5
45	97.7
75	98.0
112.5	98.2
150	98.3
225	98.5
300	98.6
500	98.7
750	98.8

Figure 79 NEMA TP-1 Minimum Efficiency Dry Type

Size kVA	Number of Transformers	Minimum Efficiency
15	4	97
30	2	97.5
75	19	98
112.5	1	98.2
	Avg Efficiency	**97.8**

Table 34 Average NEMA TP-1 Efficiency

Note #4:
To assess the Air Conditioning system performance (kW/ton) I looked at the HVAC schedules supplied to me by BVH Engineering.

CENTRIFUGAL WATER CHILLER SCHEDULE

TAG	WATER COOLED CONDENSER							FULL LOAD (KW/TON)	DESIGN NPLV (KW/TON)	OPERATING WEIGHT (LBS)
	EWT (°F)	LWT (°F)	GPM	MAX WPD (FT)	PASSES	FOULING FACTOR	WATER WORKING PRESSURE (PSIG)			
CH-1	85	95	900	7.8	2	.00025		0.659	0.592	21065
CH-2	85	95	900	7.8	2	.00025		0.659	0.592	21065

TAG	WATER COOLED CONDENSER							FULL LOAD (KW/TON)	DESIGN NPLV (KW/TON)
	EWT (°F)	LWT (°F)	GPM	MAX WPD (FT)	PASSES	FOULING FACTOR	WATER WORKING PRESSURE (PSIG)		
CH-1	80.00	86.70	900	7.9	2	.00025		0.858	0.924
CH-2	80.00	86.70	900	7.9	2	.00025		0.858	0.924

Table 35 Chiller Schedule

By averaging the full load kW/ton for the Centrifugal Water Chiller I found the value that I would use in the calculation:

$$\frac{kW}{ton} = \frac{.659 + .858}{2} = .76$$

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Using Powersmiths instead of status quo transformers

Powersmiths Efficiency (Normal Operation)	98.7%	
Powersmiths kW Losses (Normal Operation)	7.7	kW
Powersmiths Efficiency (Outside op. hrs)	98.4%	
Transformer kW Losses (Outside op. hrs)	0.0	kW
Annual addititional kWh from transformers	45,983	kWh
Annual Cost of Powersmiths Losses	$ 10,246	
Additional Tons of Cooling (on peak)	2.18	tons
Annual addititional kWh from A/C	9,909	kWh
Annual Cost of Associated A/C	$ 2,208	

Note #5

Comparing Status Quo & Powersmiths

	Status Quo	Powersmiths	Reduction
Annual Cost of feeding Building Load	$ 775,616	$ 775,616	
Annual Cost of Transformer Losses	$ 22,671	$ 10,246	
Annual Cost of Associated A/C	$ 4,885	$ 2,208	
Annual estimated Electrical Bill	$ 803,172	$ 788,070	**2%**

Peak kW reduction (normal op hours)	**11.3**	**kW**
Annual kWh reduction	**67,775**	**kWh**
Reduction in Air Conditioning Load (on peak)	**2.64**	**tons**

Cost Analysis (calc)

Energy Cost Escalation (above inflation)	4.0%
Annual Power Quality Benefit	$ -

	Annual Operating Cost	Life Cycle Operating Cost & Savings 20 years	32 years
Status Quo Transformers	$27,557	$1,207,600	$3,093,450
Powersmiths Transformers	$12,454	$545,781	$1,398,100
Savings with Powersmiths	**$15,102**	**$661,819**	**$1,695,349**

Cost	**Cost**
Powersmiths Transformers	$112,281
Status Quo Transformers	$89,825

Note #6

Payback on total cost	1.49	years	current kWh rate:
Cost of Energy Savings	$ 0.010	**/kWh**	**$0.201**
Cost - Benefit Ratio	19.4	**times less to save a kWh than to buy a kWh**	

Leasing Option	60 Month Term	48 Month Term	36 Month Term
Total Annual Leasing Payments	**$28,389**	**$34,628**	**$44,059**
Net Annual Cost with savings	$13,287	$19,525	$28,957

Table 36 Powersmiths Calculation Cont.

Note #5:
The Nameplate Efficiency (normal and outside normal hours of operation) of the Energy Efficient Transformers was found by once again averaging the efficiencies. Since the actual efficiencies of Powersmiths Transformers are not available to me right now, I used Cooper Energy Efficient Transformers to find the average efficiency:

Reference Condition	Temperature	% of Nameplate Load
Load Loss	55°C	50%
No-Load Loss	20°C	50%
kVA	Single-Phase Efficiency	
10	98.4	
15	98.6	
25	98.7	
37.5	98.8	
50	98.9	
kVA	Three-Phase Efficiency	
45	98.6	
75	98.7	
112.5	98.8	
150	98.9	
225	99.0	
300	99.0	
500	99.1	
750	99.2	
1000	99.2	
1500	99.3	
2000	99.4	
2500	99.4	

COOPER Power Systems

1045 Hickory Street
Pewaukee, WI 53072 USA
www.cooperpower.com

Note #5 Cont.:
Using the highlighted efficiencies I found the average:

Table 37 NEMA Class 1 Efficiency Levels for Liquid-filled Distribution

Size kVA	Number of Transformers	Minimum Efficiency
15	4	98.6
30	2	98.7 (assumed)
75	19	98.7
112.5	1	98.8
	Avg Efficiency	**98.7**

Besides the energy saving effects of these transformers, Cooper also claims that they "have high fire point fluid, providing fire safety benefits and a projected life well beyond that of a traditional mineral oil transformer. Envirotran EF transformers are available to meet the nationally recognized NEMA TP 1 efficiency standard, which provides a highly efficient, cost-effective option."

Note #6:
Equipment prices for standard transformers were assessed using RS Means 2009 version. Information follows:

Transformer Type	Price ($)
(4) 15 kVA (Ventilated)	1,825
(2) 30 kVA (Ventilated)	2,125
(19) 75 kVA (Ventilated)	3,850
(112.5) 112.5 kVA (Ventilated)	5,125
Total	**$ 89,825**

Note #6 Cont.:
Equipment prices for energy efficient transformers were assessed by adding 25% to the price of the standard transformers.

In closing, the following benefits were found:

Cost Analysis (calc)			
Energy Cost Escalation (above inflation)	4.0%		
Annual Power Quality Benefit	$ -		
	Annual Operating Cost	**Life Cycle Operating Cost & Savings**	
		20 years	**32 years**
Status Quo Transformers	$27,557	$1,207,600	$3,093,450
Powersmiths Transformers	$12,454	$545,781	$1,398,100
Savings with Powersmiths	**$15,102**	**$661,819**	**$1,695,349**

Cost	**Cost**
Powersmiths Transformers	$112,281
Status Quo Transformers	$89,825

Payback on total cost	1.49 years		current kWh rate:
Cost of Energy Savings	$ 0.010	/kWh	$0.201
Cost - Benefit Ratio	19.4	times less to save a kWh than to buy a kWh	

Leasing Option	60 Month Term	48 Month Term	36 Month Term
Total Annual Leasing Payments	**$28,389**	**$34,628**	**$44,059**
Net Annual Cost with savings	$13,287	$19,525	$28,957

Summary of Environmental Benefits

Annual Reduction in Greenhouse Gases (per EPA)	Equivalence
50 tons of CO2	9 Acres trees planted
162 tons of Coal	7 Car Emissions
392 kgs of SO2	7 homes heated
169 kgs of NOx	

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Table 38 Total Savings by Switching to Energy Efficient Transformers

Total annual cost savings totaled $15,102 and the payback period was only 1.5 years. Additional environmental savings can be seen above in Table 19. Taking these saving into account, I would strongly recommend that Gateway Community College switch to Cooper Liquid-filled Envirotran EF Transformers.

Photovoltaic Analysis

For my Depth investigation I will be analyzing the current Photovoltaic array used in GCC as well as incorporating a redesign (and analysis) into my ongoing daylight analysis and study. The current array totals 448 PV units which are located above the 5th story on the roof. Please see the following Drawings (Figures 3 and 4) for the current layout, and the Spec sheet (Figure 5) for the Sanyo HIT Double 190 product data.

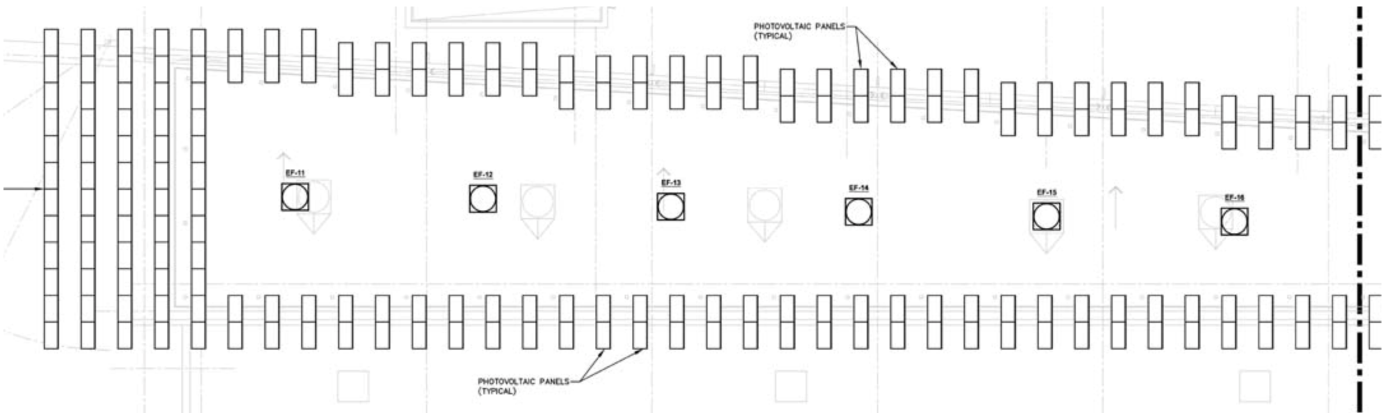


Figure 80 PV Layout A

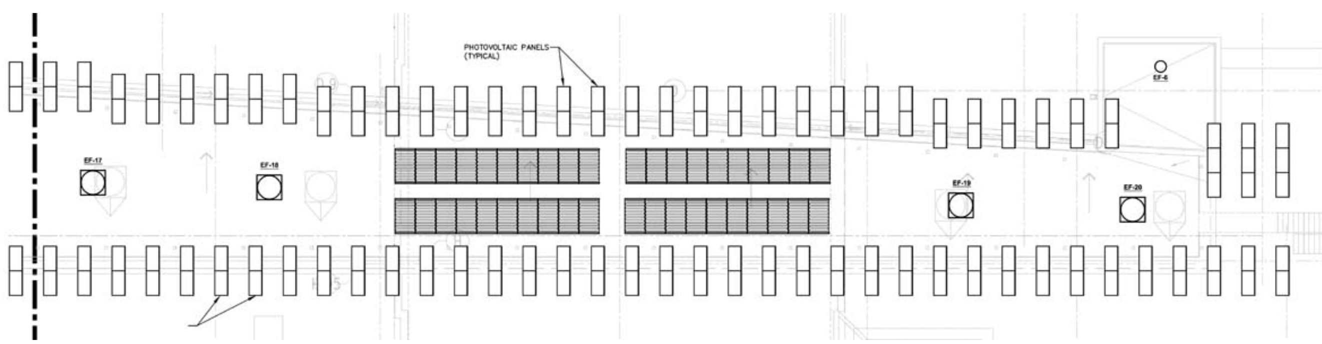


Figure 81 PV Layout A

As a LEED GOLD rated building, it was not a surprise that GCC already was interested in incorporating photovoltaic panels into the new college campus. The current system is mounted by steel channel to the top of the Atrium roof. The array totals 448 panels of which the specification is listed later in this section (see pg. ___).

To analyze the current system, I used a two methods. To start, I used AGI to test whether the PV array was receiving direct sunlight consistently throughout the three test dates (March 21st, June 21st, and December 21st—all at 8am, noon, and 4pm).

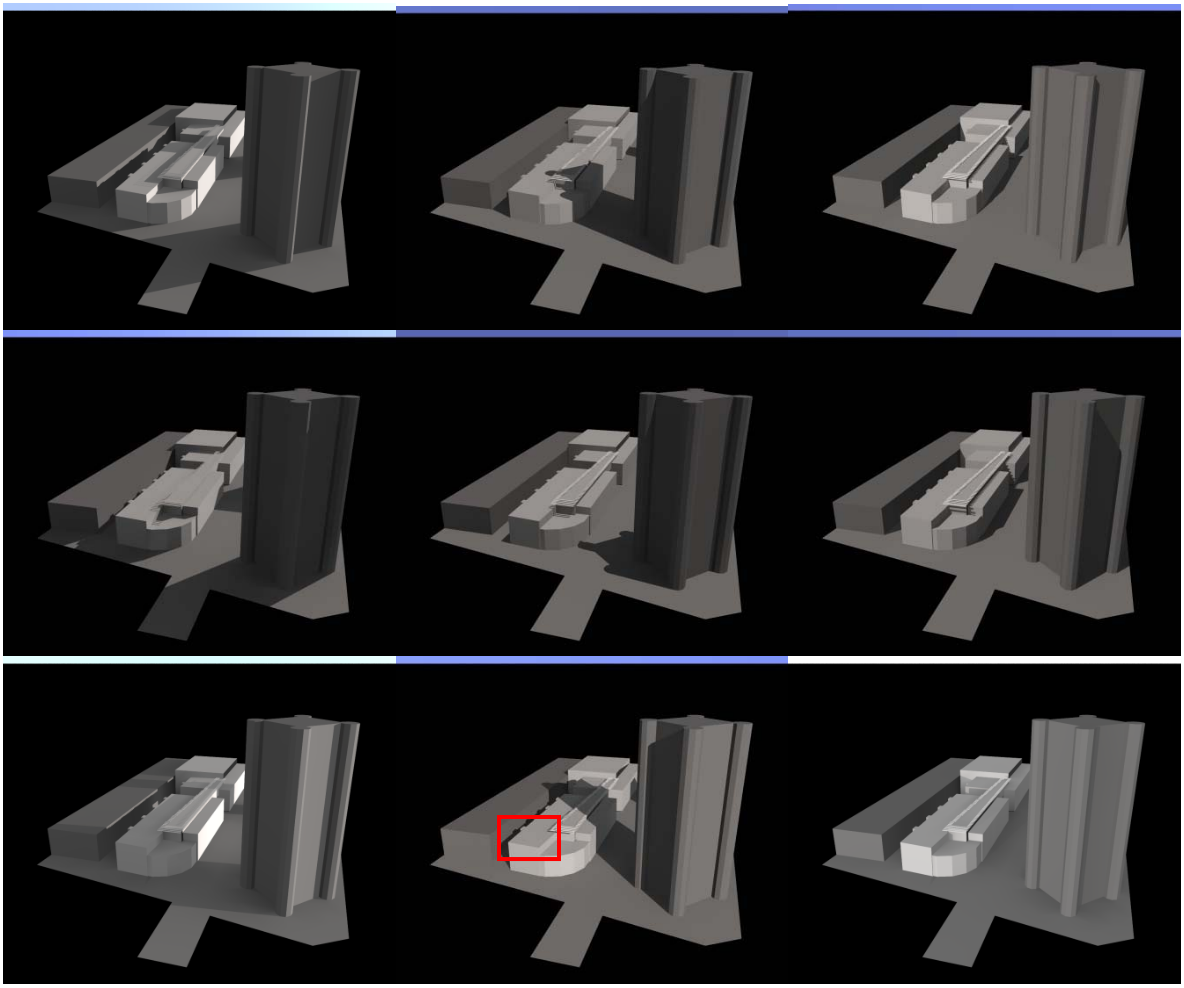
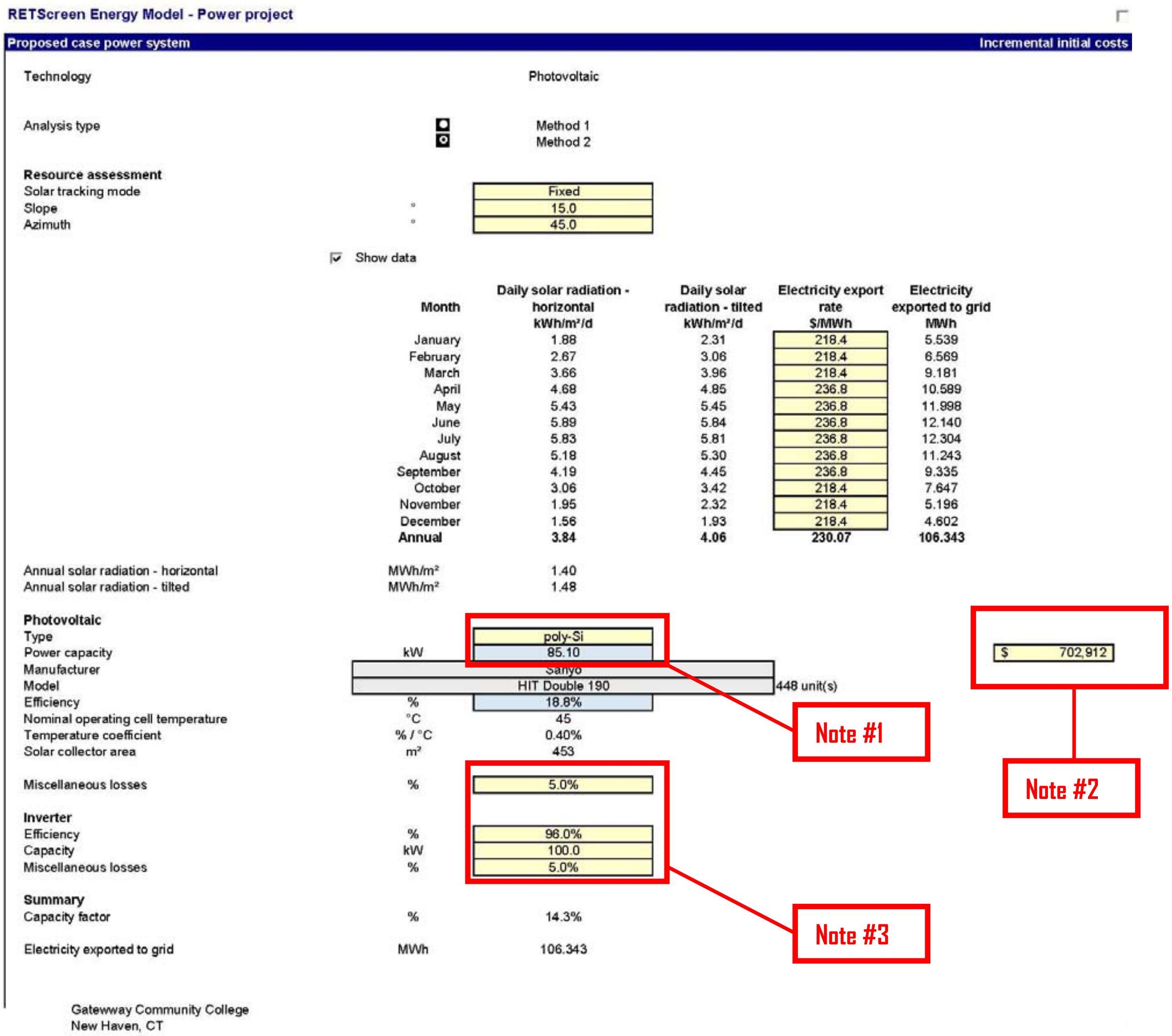


Figure 82 Daylight Exposure Study of GCC

From this model I concluded that the amount of shadow created from the neighboring buildings would reduce the existing panel efficiency throughout the year (and especially during the winter months when the sun is at a lower profile angle and shadows are larger). An area (as marked with red box) would be beneficial to place a new array, due to the longer exposure to sun light especially in hours soon after noon.

I then used RET Screen to analyze the current system's payback period. On the next page, I have noted the inputs I used to run the as-designed analysis.



RETScreen Energy Model - Power project

Proposed case power system | Incremental initial costs

Technology: Photovoltaic

Analysis type: Method 1 / Method 2

Resource assessment
Solar tracking mode: Fixed
Slope (°): 15.0
Azimuth (°): 45.0

Show data

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity export rate $/MWh	Electricity exported to grid MWh
January	1.88	2.31	218.4	5.539
February	2.67	3.06	218.4	6.569
March	3.66	3.96	218.4	9.181
April	4.68	4.85	236.8	10.589
May	5.43	5.45	236.8	11.998
June	5.89	5.84	236.8	12.140
July	5.83	5.81	236.8	12.304
August	5.18	5.30	236.8	11.243
September	4.19	4.45	236.8	9.335
October	3.06	3.42	218.4	7.647
November	1.95	2.32	218.4	5.196
December	1.56	1.93	218.4	4.602
Annual	**3.84**	**4.06**	**230.07**	**106.343**

Annual solar radiation - horizontal	MWh/m²	1.40
Annual solar radiation - tilted	MWh/m²	1.48
Photovoltaic		
Type		poly-Si
Power capacity	kW	85.10
Manufacturer		Sanyo
Model		HIT Double 190 (448 unit(s))
Efficiency	%	18.8%
Nominal operating cell temperature	°C	45
Temperature coefficient	% / °C	0.40%
Solar collector area	m²	453
Miscellaneous losses	%	5.0%
Inverter		
Efficiency	%	96.0%
Capacity	kW	100.0
Miscellaneous losses	%	5.0%
Summary		
Capacity factor	%	14.3%
Electricity exported to grid	MWh	106.343

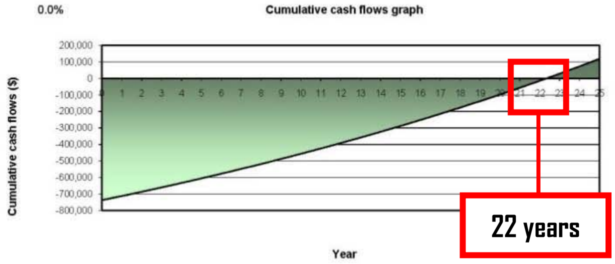
Incremental initial costs: $ 702,912

Figure 83 Input Into RET Screen

Note #1: 85.1 kW production capacity is calculated by multiplying 190W (production) by 448 (number of units).
Note #2: $702,912 initial cost is based on a suggested list price of $ 1,569 supplied by Mona Rotkopf, Dealer Sales Manager for *SunWize Technologies*
Note #3: Other Properties assumed

Financial Analysis

Financial parameters			
Inflation rate	%	2.5%	
Project life	yr	25	
Debt ratio	%		
Initial costs			
Power system	$	702,912	95.2%
Other	$	35,146	4.8%
Total initial costs	$	738,058	100.0%
Incentives and grants	$	0	0.0%
Annual costs and debt payments			
O&M (savings) costs	$		
Fuel cost - proposed case	$	0	
	$		
Total annual costs	$	0	
Annual savings and income			
Fuel cost - base case	$	0	
Electricity export income	$	24,467	
	$		
Total annual savings and income	$	24,467	
Financial viability			
Pre-tax IRR - assets	%	1.1%	
Simple payback	yr	30.2	
Equity payback	yr	22.3	



In the output above (given by RET Screen) the simple payback period is approximately 25 years. While this time frame is somewhat acceptable for an education facility that has potential to be in operation for a long period of time, it was my intention to decrease the payback period as much as possible while also achieving the following:

- Reducing the installation time and cost by removing the PV system from the highest roof and integrating new panels into the lower roofs
- Reducing the amount of materials needed to support the system; therefore reducing the structure of the Atrium roof
- Increasing the accessibility of the modules for maintenance
- Increasing the exposure to sun by removing from the high roof which is exposed to longer periods of shade

To achieve these criteria I utilized a photovoltaic system that could be incorporated as a roofing membrane. By using this product I was not only replacing with a system that was more accessible, but one that could replace building material and serve as multiple features of the building. Applied Solar is the manufacturer and the product name is Roofing Membrane. The Membrane requires no special structure to support and doubles as the roofing membrane itself (hence the name). The data sheet also totes the high efficiency of the crystalline silicon PV cells and includes a 20 year warranty. This warranty is the same as the original Sanyo HIT Double 190. It was an additional guideline to reduce payback to within this time frame of 20 years and have the replacement system last the full warranty without the original system surpassing it in energy production and/or savings.

The input for the new module is on the next page.

Proposed case power system | **Incremental initial co:**

Technology		Photovoltaic	
Analysis type		Method 1 / Method 2	
Resource assessment			
Solar tracking mode		Fixed	
Slope	°	0.0	
Azimuth	°	45.0	

Show data

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity export rate $/MWh	Electricity exported to grid MWh
January	1.88	1.88	218.4	3.534
February	2.67	2.67	218.4	4.480
March	3.66	3.66	218.4	6.621
April	4.68	4.68	236.8	7.958
May	5.43	5.43	236.8	9.278
June	5.89	5.89	236.8	9.500
July	5.83	5.83	236.8	9.579
August	5.18	5.18	236.8	8.553
September	4.19	4.19	236.8	6.856
October	3.06	3.06	218.4	5.354
November	1.95	1.95	218.4	3.420
December	1.56	1.56	218.4	2.911
Annual	**3.84**	**3.84**	**230.57**	**78.045**

Annual solar radiation - horizontal	MWh/m²	1.40	
Annual solar radiation - tilted	MWh/m²	1.40	
Photovoltaic			
Type		mono-Si	
Power capacity	kW	69.44	$ 303,800
Manufacturer		Applied solar	
Model		Roofing Membrane	448 unit(s)
Efficiency	%	10.0%	
Nominal operating cell temperature	°C	45	
Temperature coefficient	% / °C	0.40%	
Solar collector area	m²	694	
Miscellaneous losses	%	10.0%	
Inverter			
Efficiency	%	96.0%	
Capacity	kW	100.0	
Miscellaneous losses	%	5.0%	
Summary			
Capacity factor	%	12.8%	
Electricity exported to grid	MWh	78.045	

Note #1

Note #2

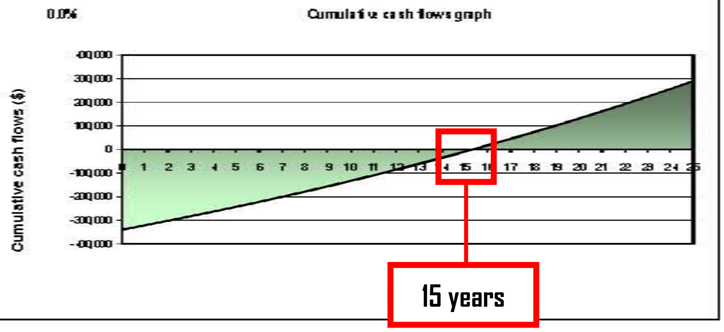
Note #3

Note #1: 69.44 kW production capacity is calculated by multiplying 10W/ft^2 (installed production) by 217 (number of units).
Note #2: $303,800 initial cost is based on a suggested list price of $4/W installed supplied by Len May a representative of Sun Tech Power
Note #3: Other Properties assumed

The results of this analysis are on the next page.

Financial Analysis

Financial parameters			
Inflation rate	%	2.5%	
Project life	yr	25	
Debt ratio	%		
Initial costs			
Power system	$	303800	89.6%
Other	$	35116	10.4%
Total initial costs	$	338916	100.0%
Incentives and grants	$	0	0.0%
Annual costs and debt payments			
O&M (savings) costs	$		
Fuel cost - proposed case	$	0	
	$		
Total annual costs	$	0	
Annual savings and income			
Fuel cost - base case	$	0	
Electricity export income	$	11995	
	$		
Total annual savings and income	$	11995	
Financial viability			
Pre-tax IRR - assets	%	1.9%	
Simple payback	yr	18.8	
Equity payback	yr	15.3	



The Membrane module had a significantly less payback period, reducing the original by seven years. Also, by the 25 year range, the Membrane system had already produced $300,000 while the Sanyo system only produced $100,000. The time to payback the difference of $200,000, assuming each system continually produces the same output was found by applying this equation; where x is the number of years it would take to payback.

$$\$200{,}000 + \$17{,}995(X) = \$24{,}467(X)$$

$$X = 200{,}000/(24{,}467 - 17{,}995)$$

$$\underline{X = 30.9 \text{ or } 31 \text{ years}}$$

So, the total payback period from installation to when Sanyo fully replaces the Membrane system, assuming that neither array fails nor needs extensive maintenance, is 25 + 31 years or 56 years. Knowing this, I would strongly recommend that the owner incorporate the Membrane system that I have researched. *It is assumed that the type and price of inverters is constant when comparing the two PV systems.*

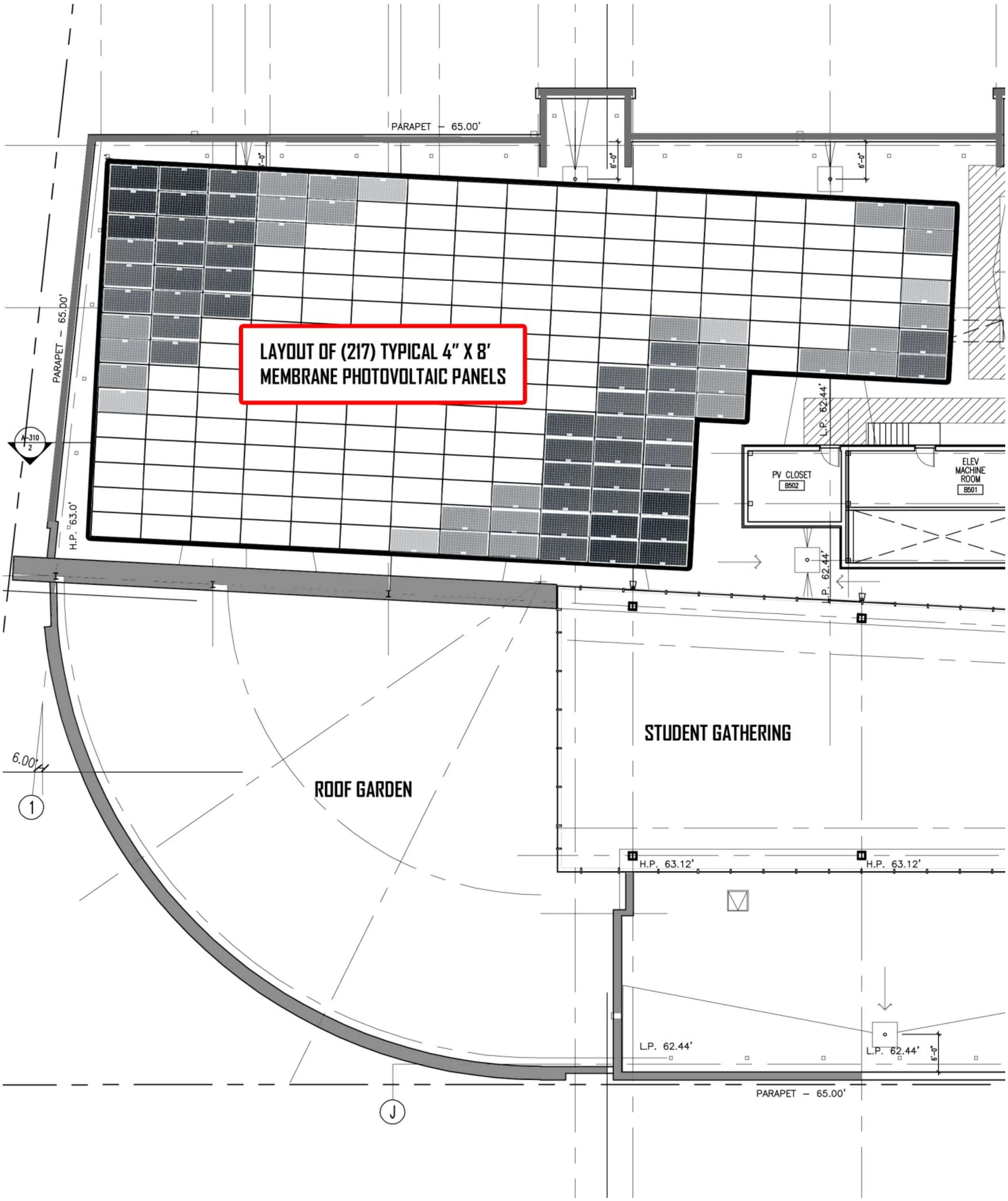


Figure 84 Membrane Layout on 5th floor roof

Coordination Study

A protective device study helped me analyze a single path in GCC; this path was from switchboards MSBS1 through HDP1S1 through HLP1S1. The protective devices incorporated into this equipment are Molded Case Circuit Breakers and range from Cord type style CC @ 400A (switchboard feeder), type F Style F6 @ 100A (distribution panel feeder), and type JD style CJ @ 20A (lighting panel branch circuit). Please see the single line drawing E-1 below for more information.

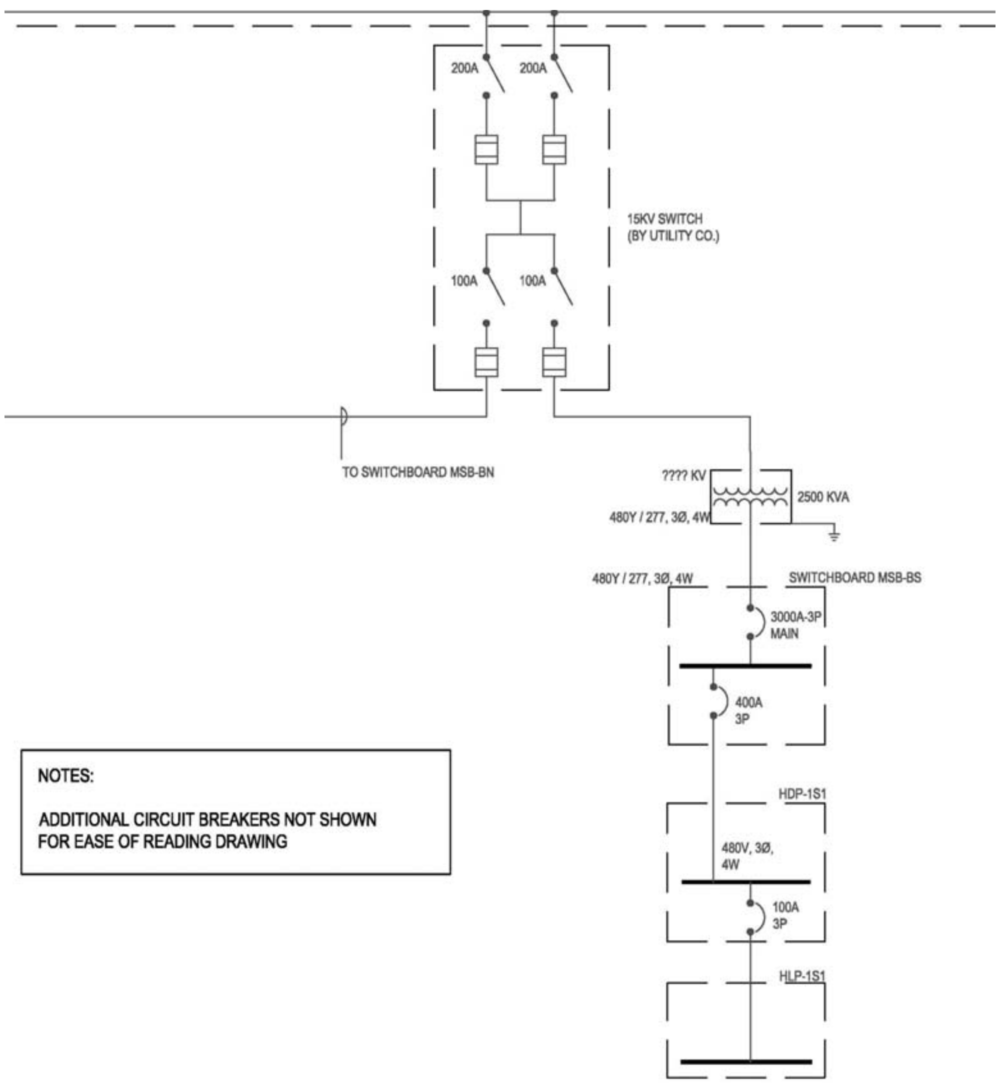


Figure 85 Drawing E-1 Coordination Study Path

On the next page, please refer to the diagram showing the trip current curves for the aforementioned circuit breaker types and styles.

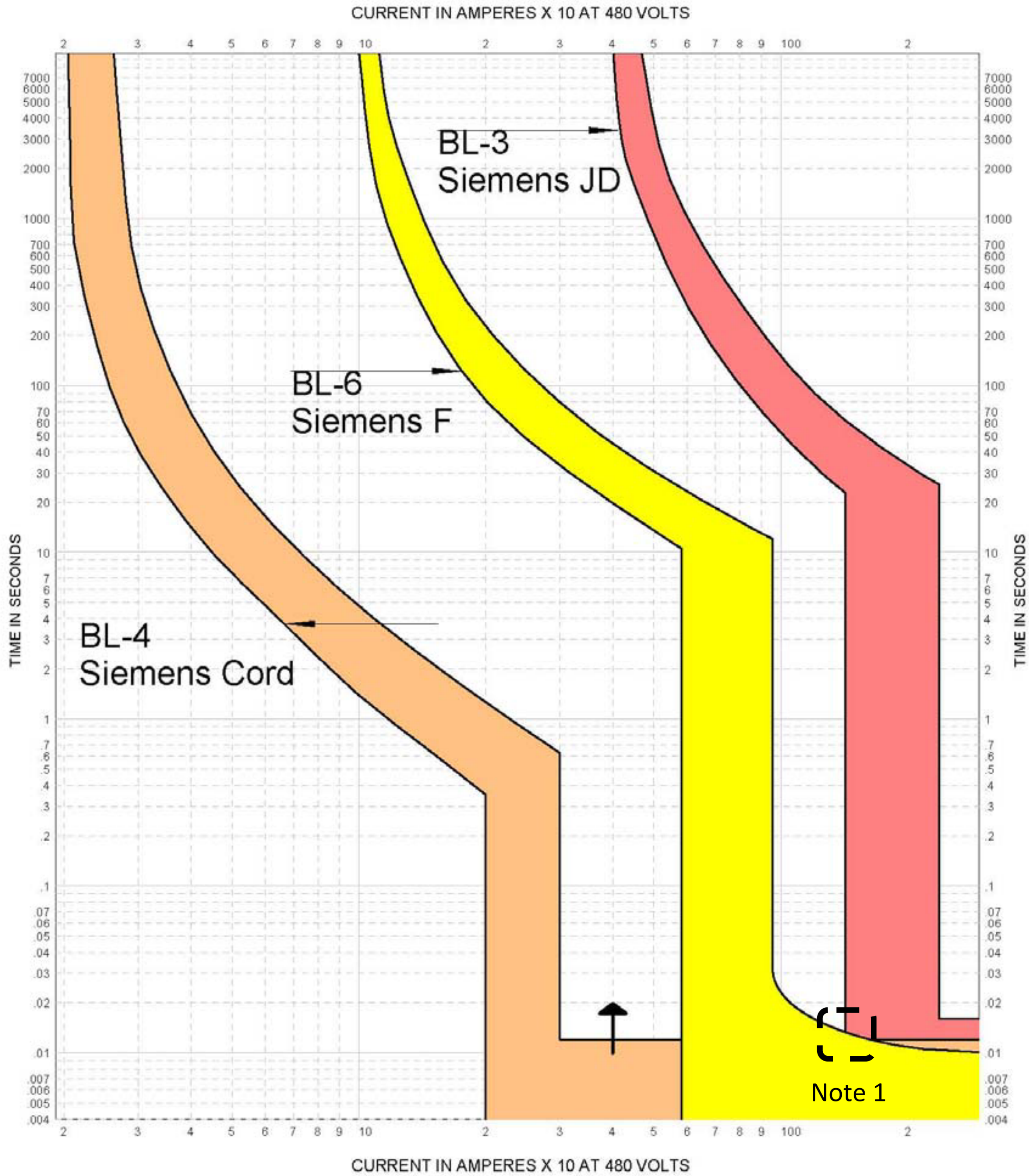
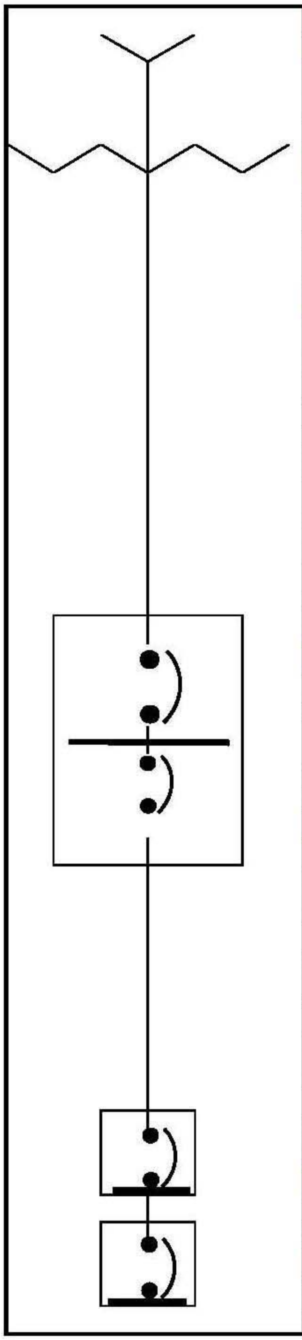


Figure 86 Siemens TCC diagram for Trip Current

In this diagram, there are little to no overlaps. In the area designated by Note 1, the 400A CB may have a slight potential to trip before the 100A. The lower limit of the type JD CB trips at a lower amperage rating than that of the higher limit of the type F CB. This break in the normal trip order (20>100>400) occurs around 1500A and .0125 seconds. The protective devices appear to operate and trip in normal order other than this overlap.

Short Circuit Analysis

For my short circuit analysis I explored the path previously shown.



			X (p.u.)	R (p.u.)	Z (p.u.) sum	I sc rms sys
UTILITY XFMR PRIMARY			0.1			
BASE KVA	10000					
UTILITY KVA	100000					
VOLTAGE	480					
UTILITY XFMR SECONDARY 2500 KVA			0.219240067	0.018270006	0.319762433	75231.66813
Z	5.5					
X/R	12					
X%	5.481002					
R%	0.45675					
FEEDER TO MSB-BS						
8 Sets of (3) 4"			0.023883464	0.151513672		
H (ft)	0					
L	87					
Total	87					
X	0.0506	TABLE 7				
R	0.321	TABLE 7				
(2) 500 MCM			0.017605794	0.013027344		
H (ft)	0					
L	87					
Total	87					
X	0.0373					
R	0.0276					
MSB-BS					0.404412367	59484.48454
3000A CB MSB-BS			1.77778E-06			
X	0.00004	DISCON CHART				
400A CB			3.55556E-06			
X	0.00008	DISCON CHART				
FEEDER TO HDP1S1						
1 Set of (3) 4"			0.323387587	2.051529948		
H (ft)	18.25					
L	129					
Total	147.25					
X	0.0506	TABLE 7				
R	0.321	TABLE 7				
1 Set (3) 500 MCM			0.238386502	0.176393229		
H (ft)	18.25					
L	129					
Total	147.25					
X	0.0373	TABLE 7				
R	0.0276	TABLE 7				
HDP1S1			0.004340278		2.582767603	9314.140844
100A CB						
X	0.0001	DISCON CHART				
HLP1S1			0.004340278		2.410738105	159.6607191
20A CB						
X	0.0001	DISCON CHART				

Table 39 Short Circuit Spreadsheet

	FAULT CURRENT (CALCULATED)	STD BKR RATING
UTILITY XFMR SECONDARY	75232	65000
MSB-BS	59484	50000
HDP1S1	9314	25000
HLP1S1	160	14000

In the table shown above, it is clear to see that my calculated fault current would trip the CB protecting the utility transformer and Switchgear MSB-BS. This could mean either of two things one, my calculation is incorrect and the fault current is O.K., or two, that the protective devices on the two pieces of equipment need to be sized up.