1A. MAIN LOBBY and LIBERTY AVENUE FACADE
[with SECOND LEVEL LOBBY, GIFT SHOP, BOX OFFICE, GRAND STAIRCASE]

Existing Design

The existing electrical design for the main lobby utilizes three separate lighting panels (1N1, 1E1, ALDR5). These panels are in various locations and control is split between dimming and switching. The other spaces that will be combined with the main lobby for the redesigned control system also use the three previously mentioned panels, as well as 2N1 and 2E1.

Redesigned System

The new electrical system for the lower and upper lobbies as well as connected spaces will combine many lighting loads onto a single dimming system. More dimming control was a desire for the redesigned lighting system and therefore it was a logical choice to combine these loads into a complete system, rather than using a collection of panels to supply power.

A new dimming rack has been specified that is large enough to handle all the aforementioned loads. It also eliminates the need for separation of loads onto normal and emergency circuits due to an automatic emergency transfer switch located in the dimmer rack assembly. The panel specified for these spaces has seven modules with four control circuits per module with a maximum of 20A connected load per circuit. The panel is main lugs only and is protected at the distribution panel.

The new system utilizes 23 circuits with a total of 24.89 KW of connected load and has six circuits of spare capacity. A total demand load of 86.43 A was used to size the feeder and protection. The feeder has been sized at (4) #3. The breaker protected the feeder on distribution panel 1NDP1 is still sized at 100 A.

The 23 circuits are divided into 16 control zones. Since these loads comprise all the public spaces of the building, they will be controlled by a single head unit located in the box office.

Dimmer rack/panelboard layouts for both the existing and new system are provided below. See Appendix F and G for full size worksheets and schedules. Electrical plans are available in Appendix H. Product Information for the dimmer racks is available in Appendix K.

Redesign Analysis

The redesigned system offers incredible flexibility and greatly simplifies the existing system. Utilizing a main point of control will provide management with the ability to set and alter various scenes on the fly, creating a dynamic environment. Electrically, the system is convenient and centralized. The lighting loads are grouped together and are separated from the auditorium dimmer racks.

he studio i company
rchitectural lighting

AWC
DR-201
01 October 2007

Area	Control Channel #	Circuit / Dimmer #	Description	Fixt. Type	Approx. # Fixt.	Watts / Fixture	Approx. Total Connected Load (Watts)	Load Type	E Circuit
Lobby	1	1	1st Floor Drum Lower	SAX	17	50	1063	ELV	
		2	1st Floor Drum Lower	SAX	17	50	1063	ELV	
	2	3	1st Floor Drum Upper		70	15	1313	NEON	
		4	1st Floor Drum Upper		70	15	1313	NEON	
	3	5	Art Lights Lobby	SBC	10	65	813	ELV	
	4	6	2nd Floor Drum	SAF	6	225	1350	INC	
		7	2nd Floor Drum	SAF	6	225	1350	INC	
		8	2nd Floor Drum	SAF	6	225	1350	INC	
		9	2nd Floor Drum	SAZ	6	225	1350	INC	
		10	Spare				0		
		11	Spare				0		
		12	Spare				0		

TOTAL:	10.96	k W

NOTE: Contractor must pull separate neutrals for each circuit.
A factor of 1.25 has been added to all LV, FL, & HID loads.

Figure 5.1A.1 | Existing Dimmer Rack DR-201

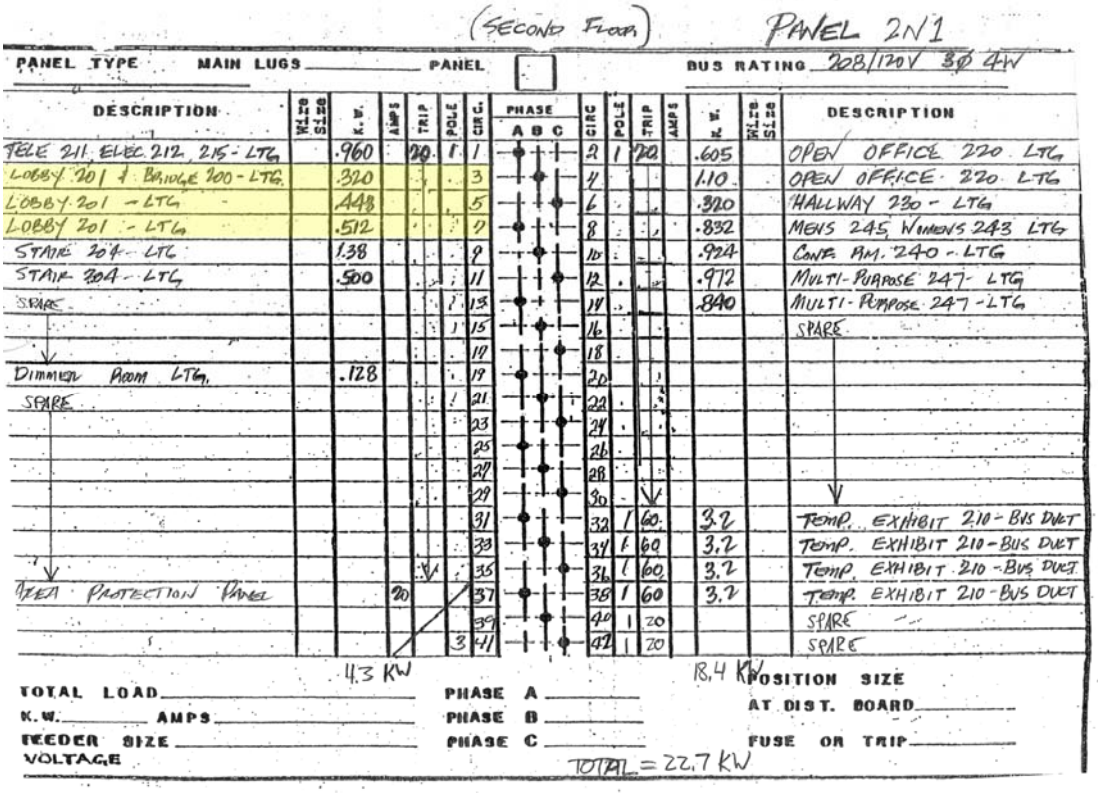

Figure 5.1A.2 | Existing Panel 2N1

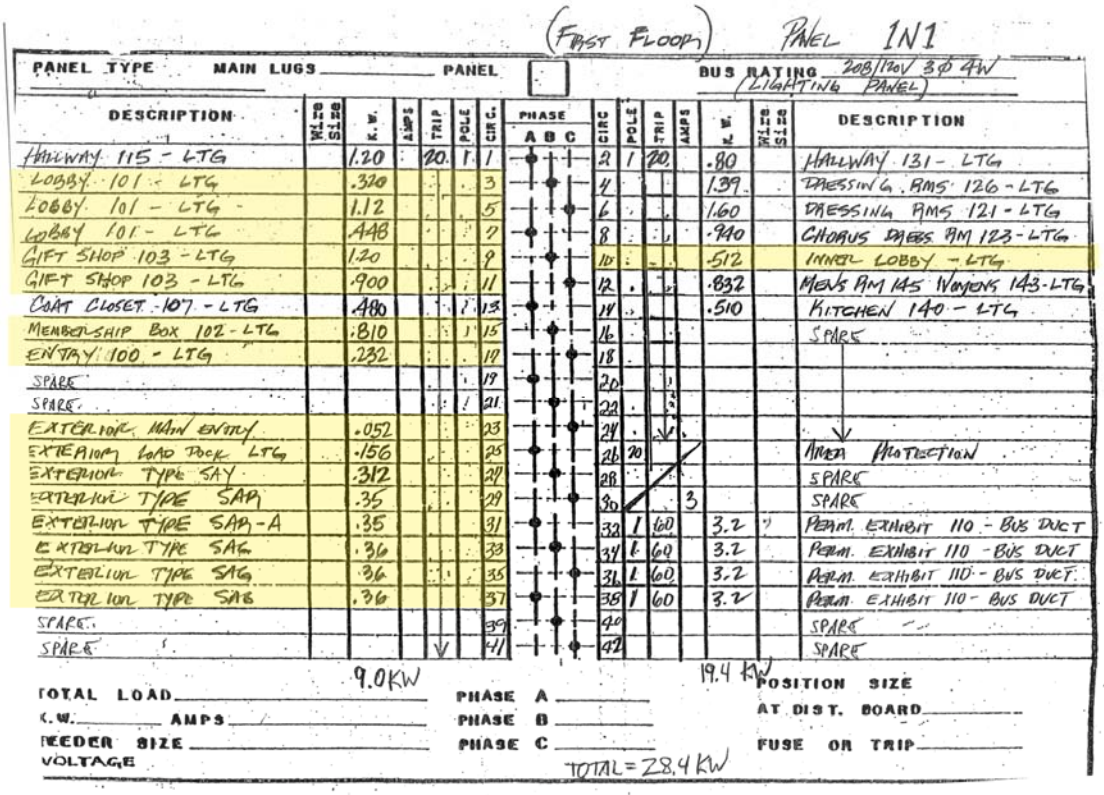

Figure 5.1A.3 | Existing Panel 1N1

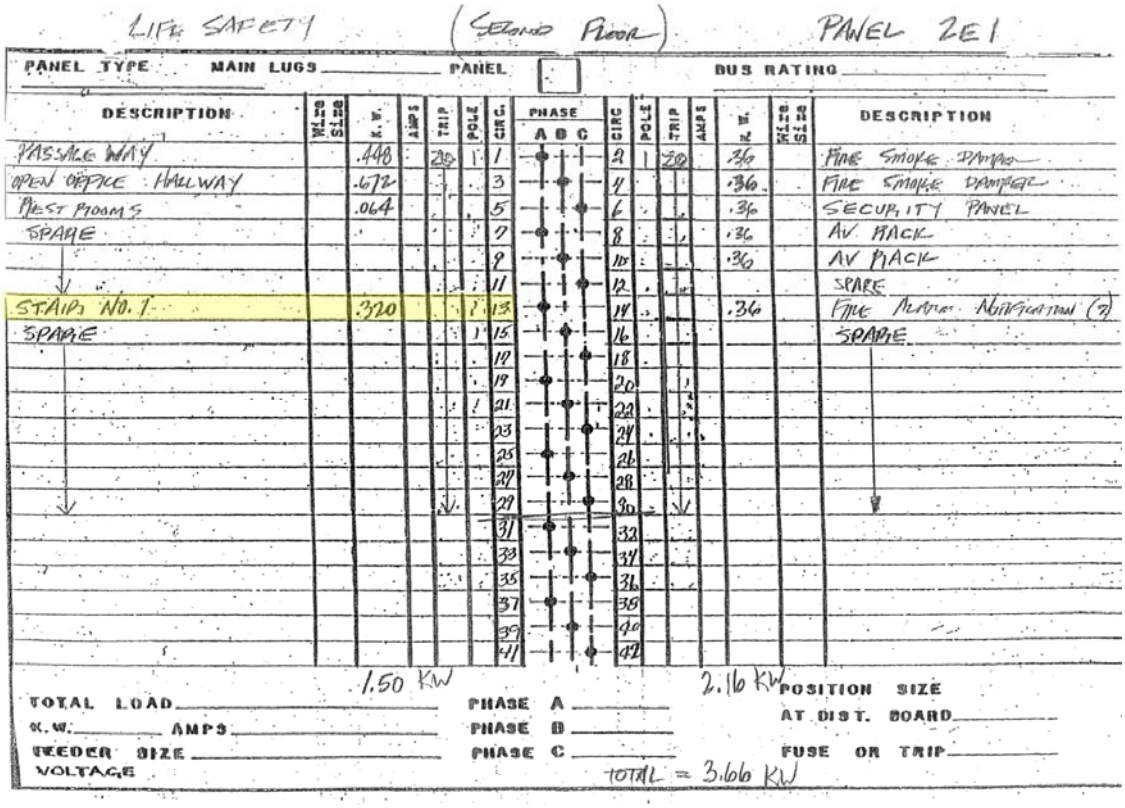

Figure 5.1A.4 | Existing Panel 2E1

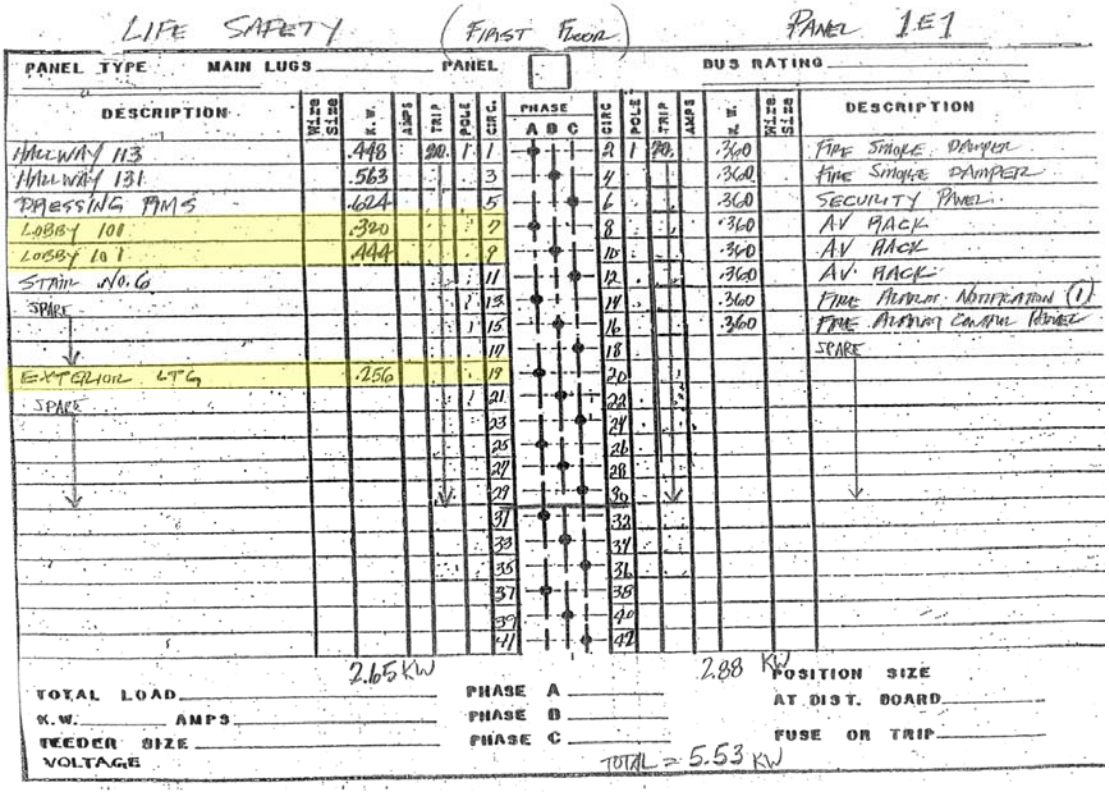

Figure 5.1A.5 | Existing Panel 1E1

DIMMER RACK LAYOUT: DR101/201										
AREA	CONTROL CHANNEL	CIRCUIT / DIMMER	DESCRIPTION	FIXT. TAG	NO. OF FIXT.	WATTS/ FIXTURE	MULT.	TOTAL WATTS	PHOTO CELL?	EMER. CRCT?
LOWER LOBBY	1	1	Theater Drum Upper	D	25	50	1.0	1250		
	2	2	Theater Drum Lower	D	25	50	1.0	1250		
	3	3	Downlights - Linear	A	17	63	1.25	1338.75	■	■
	4	4	Downlights - Round	E	15	49	1.25	918.75		■
UPPER LOBBY	5	5	Theater Drum	C	5	300	1.0	1500		
		6	Theater Drum	C	5	300	1.0	1500		
		7	Theater Drum	C	5	300	1.0	1500		
		8	Theater Drum	C	6	300	1.0	1800		
UPPER LOBBY	5	9	Theater Drum	C	6	300	1.0	1800		
	6	10	Downlights - Linear	A	20	63	1.25	1575	■	■
		11	Downlights - Linear	A	20	63	1.25	1575	■	■
	7	12	Downlights - Round	E	13	49	1.25	796.25		■
CABINETS	8	13	Downlights	G/F	7/4	50/49	1.25	682.5		
STAIRCASE	9	14	Wallwash	C	4	300	1.0	1200		
		15	Wallwash	C	4	300	1.0	1200		
	10	16	Downlights	B	10	64	1.25	800		■
VESTIBULE	11	17	Downlights - Interior	H	8	38	1.25	380		■
	12	18	Downlights - Exterior	L	15	22	1.25	412.5		
GIFT SHOP	13	19	Downlights	G	20	50	1.25	1250		
		20	Downlights	G	17	50	1.25	1062.5		■
EXTERIOR	14	21	Inside	O	1	500	1.25	625		
	15	22	Sail LED	Q	1	300	1.25	375		
	16	23	LED Buttons	P	8	10	1.25	100		
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
Panel Type: Lutron LP7/16-1204ML-20							LOAD =	24.89 kW		
Distribution Panel: 1NDP1						(125% GROWTH FACTOR)	DEMAND LOAD =	86.43 A		
Emergency Panel: BE1							FEEDER SIZE =	(4) #3		
Location: Auditorium Dimmer Room							PROTECTION =	100 A		

Figure 5.1A.6 | New Dimmer Rack DR101/201

1B. EDUCATION AND LECTURE ROOM and MEETING ROOM

Existing Design

The current design for the education and lecture room uses a dimmer rack (DR202) connected to a distribution panel (1N1). DR202 serves only the education and lecture room and the meeting room. In total between the two rooms, 5 circuits are used. The total connected load was 5.13 KW, which was protected by a 100A three pole circuit breaker on panel 1NDP1. This system was controlled by a main control panel in room 202 with two satellite control panels, one in each space. An emergency dimmer transfer rack is used to provide emergency power to the rack.

Redesigned System

The new system for the education and lecture room will utilize the same organization as the previous system. The lighting design is not extremely different and the load is nearly identical. There are new fixtures and different zones, but the total load is still very small. A new dimming rack system has been specified that eliminates the need for a second emergency transfer panel. The panel specified for these spaces has four modules with four control circuits per module with a maximum of 20A connected load per circuit. The panel is main lugs only and is protected at the distribution panel.

The new system utilizes 8 circuits with a total of 5.04 KW of connected load and has eight circuits of spare capacity. A total demand load of 27A was used to size the feeder and protection. The feeder has been sized at (4) #10. The breaker protected the feeder on distribution panel 1NDP1 is still sized at 30A.

The system will be controlled by two main wall panels, one in the Meeting Room and one in the Education Room. The education will also feature a secondary wall dimmer switch. These panels will control both the lights and the window shades that are present in both rooms. Photosensors will be added to the Education Room to dim the exterior zones because daylight analysis shows that ample daylight is available in the space.

Dimmer rack/panelboard layouts for both the existing and new system are provided below. See Appendix F and G for full size worksheets and schedules. Electrical plans are available in Appendix H. Product Information for the dimmer racks is available in Appendix K.

Redesign Analysis

The new system does not differ dramatically from the existing system, but the system is simplified slightly by eliminating an external emergency power transfer rack. The streamlined control system will allow for control of both lighting and shading devices. Extra room is left should the need to expand the system arise.

Area	Control Channel #	Circuit / Dimmer #	Description	Fixt. Type	Approx. # Fixt.	Watts / Fixture	Approx. Total Connected Load (Watts)	Load Type	E Circuit
Educ. Class	1	1	Linear Fluorescent	SK	3	324	1215	FL	
		2	Linear Fluorescent	SK	4	324	1620	FL	
	2	3	Low Voltage Downlight	SK-a	21	50	1313	MLV	
Conf. Room	3	4	Linear Fluorescent	SD1	8	54	540	FL	
	4	5	Linear Fluorescent	SD1	8	54	540	FL	
		6	Spare				0		
		7	Spare				0		
		8	Spare				0		
		9	Empty				0		
		10	Empty				0		
		11	Empty				0		
		12	Empty				0		
						TOTAL:	5.23	kW	

NOTE: Contractor must pull separate neutrals for each circuit.
A factor of 1.25 has been added to all LV, FL, & HID loads.

Figure 5.1B.1 | Existing Dimmer Rack DR-202/207

DIMMER RACK LAYOUT: DR202/207										
AREA	CONTROL CHANNEL	CIRCUIT / DIMMER	DESCRIPTION	FIXT. TAG	NO. OF FIXT.	WATTS/ FIXTURE	MULT.	TOTAL WATTS	PHOTO CELL?	EMER. CRCT?
EDUCATION	1	1	Northwest Downlights	A	5	125	1.25	781.25	■	
	2	2	Northeast Downlights	A	5	125	1.25	781.25	■	
	3	3	Southwest Downlights	A	5	125	1.25	781.25		■
	4	4	Southeast Downlights	A	5	125	1.25	781.25		■
MEETING	5	5	Pendants	K	3	116	1.25	435		
	6	6	Downlights	F	8	49	1.25	490		■
	7	7	Accent - Wood/Sail	I	13	50	1.25	812.5		
	8	8	Linear Wallwasher	J	4	35	1.25	175		
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
Panel Type: Lutron LP4/16-1204ML-20							LOAD =	5.04 kW		
Distribution Panel: 1NDP1						(200% GROWTH FACTOR)	DEMAND LOAD =	27.99 A		
Emergency Panel: BE1							FEEDER SIZE =	(3) #10		
Location: 202 Closet							PROTECTION =	30 A		

Figure 5.1B.2 | New Dimmer Rack DR-202/207

2. PHOTOVOLTAIC ARRAY ANALYSIS

With the growth of the LEED movement, photovoltaic (PV) systems are surging as a popular 'green' choice for owners who want an energy conscious design. With numerous governmental incentives available, the cost-effectiveness of implementing such a system can become complex. As a building seeking LEED certification, a PV system is something that should at least be considered by the designer.

This analysis was conducted utilizing RETScreen , an analysis tool for energy design. Since enough area is not available to provide power for the entire building, the system needs to be an on-grid system. The designed system would not use a battery supply and excess energy would be transferred back to the grid. The following is a summary of the analysis:

Roof Area available for PV array: Approximately 12,000 ft^2 (1115 m^2)

Product: BP Solar 5170S

Power Produced: 192KWh

Physical Size: 1.26 m^2

Efficiency: 13.5%

Total System Efficiency: 3%

Unit Cost: $5,750

Maintenance Costs: $10,000/10 Years

Design Costs: $15,000

Other Equipment Costs: $100,000

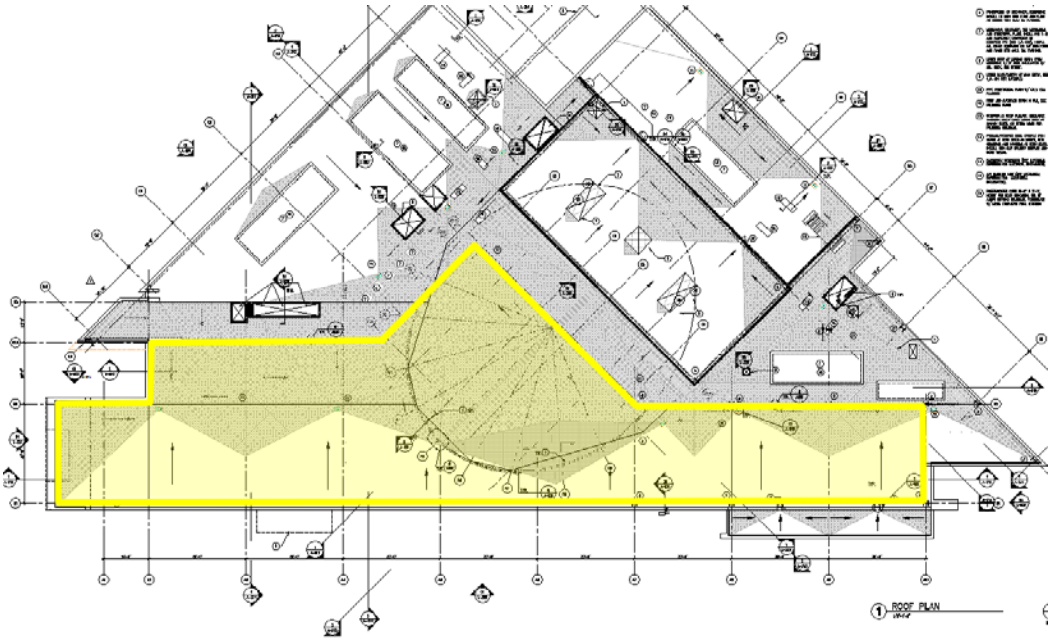

Figure 5.2.1 | Available Area for PV Array

Annual Energy Available (Pittsburgh): 1.53MWh/m^2

Energy Rate: .1236 cents/KWh

Energy Savings/Year/Panel: $28

Financial Incentives:

- *Federal tax incentives* do not apply since the August Wilson Center is a non-profit organization.
- The *Pennsylvania Energy Harvest Grant,* or any other state incentive, is no longer available.
- *Duquesne Light* does not currently offer any incentives for implementation of renewable energy.

Payback Period: This installation will never provide a return on the investment.

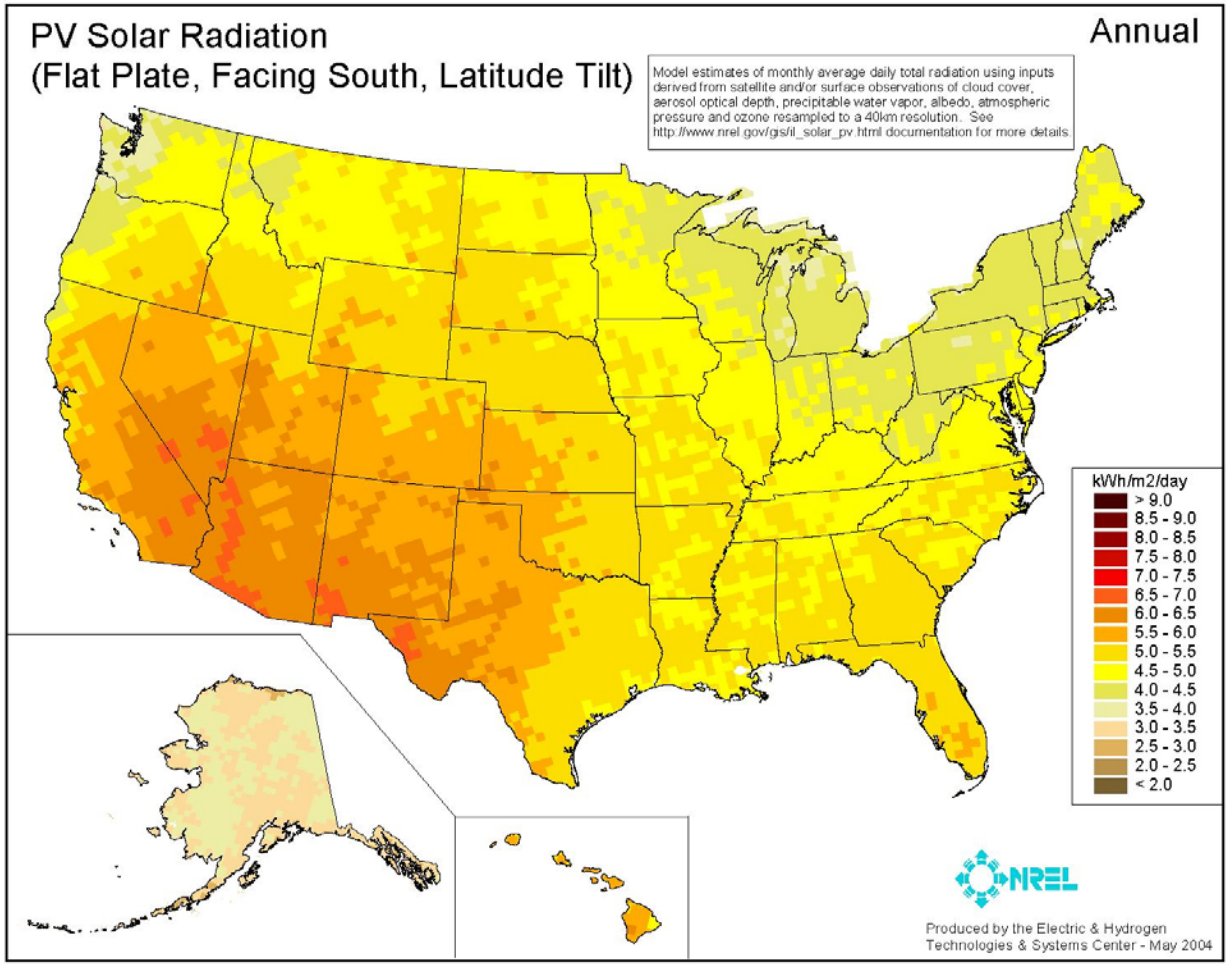

Figure 5.2.2 | PV Solar Radiation Map

Photovoltaic Array Feasibility Conclusion:

Based on the calculations, it is certainly not feasible to use a photovoltaic array for this project. Figure 5.2.2 shows that Pittsburgh does not receive a substantial amount of solar energy. Another factor affecting the feasibility is the low utility rate that this property receives. Based on the buildings location in the urban center of Pittsburgh and the shadowing provided by adjacent buildings, the actual energy savings would likely be less that the model predicts. Finally, since the August Wilson Center is a non-profit organization, it cannot receive federal and state tax incentives for solar energy. This places the full cost of the initial installation on the owner, significantly affecting the payback of the system.

3. SYSTEM TYPE CONVERSION STUDY

The existing design for the August Wilson Center utilizes two parallel service entrances, providing redundancy should one fail through a collector bus which connects to two main switchboards. One of the switchboards (MSB1) feeds primarily mechanical loads and the emergency power system while the second switchboard (MSB2) feeds predominantly lighting and receptacle loads. Both switchboards are currently designed at 280Y/120V.

Studying the single line diagram revealed that MSB1 could be switched to a 480/277V system with minimal disruption to the system. One drawback to this change is the elimination of the point of redundancy, however. In order to make a justifiable decision on the advantage of the system conversion, a comparative cost analysis was conducted.

The Existing System:

The portion of the existing system being studied includes the following equipment:

Table 5.3.1: Existing Design Equipment Schedule

TYPE	TAG	LOCATION	DESCRIPTION
Transformer	*NA*	Transformer Vault	Duquesne Light Transformer
Main Switchboard	MSB1	Basement (013)	208Y/120, 3000A MCB
Distribution Panel	BNDP1	Basement (013)	208Y/120, 1200A MLO
Distribution Panel	BNDP2	Basement (013)	208Y/120, 400A MLO
Branch Circuit Panel	2P1	Electrical Room (212)	208Y/120, 225A MLO
Branch Circuit Panel	1KN1	Kitchen (140)	208Y/120, 400A MLO
Branch Circuit Panel	1KN2	Kitchen (140)	208Y/120, 225A MLO

A portion of the existing single line diagram as well as the panelboards that will change are shown on the following pages. Full size images are available in Appendices F-J.

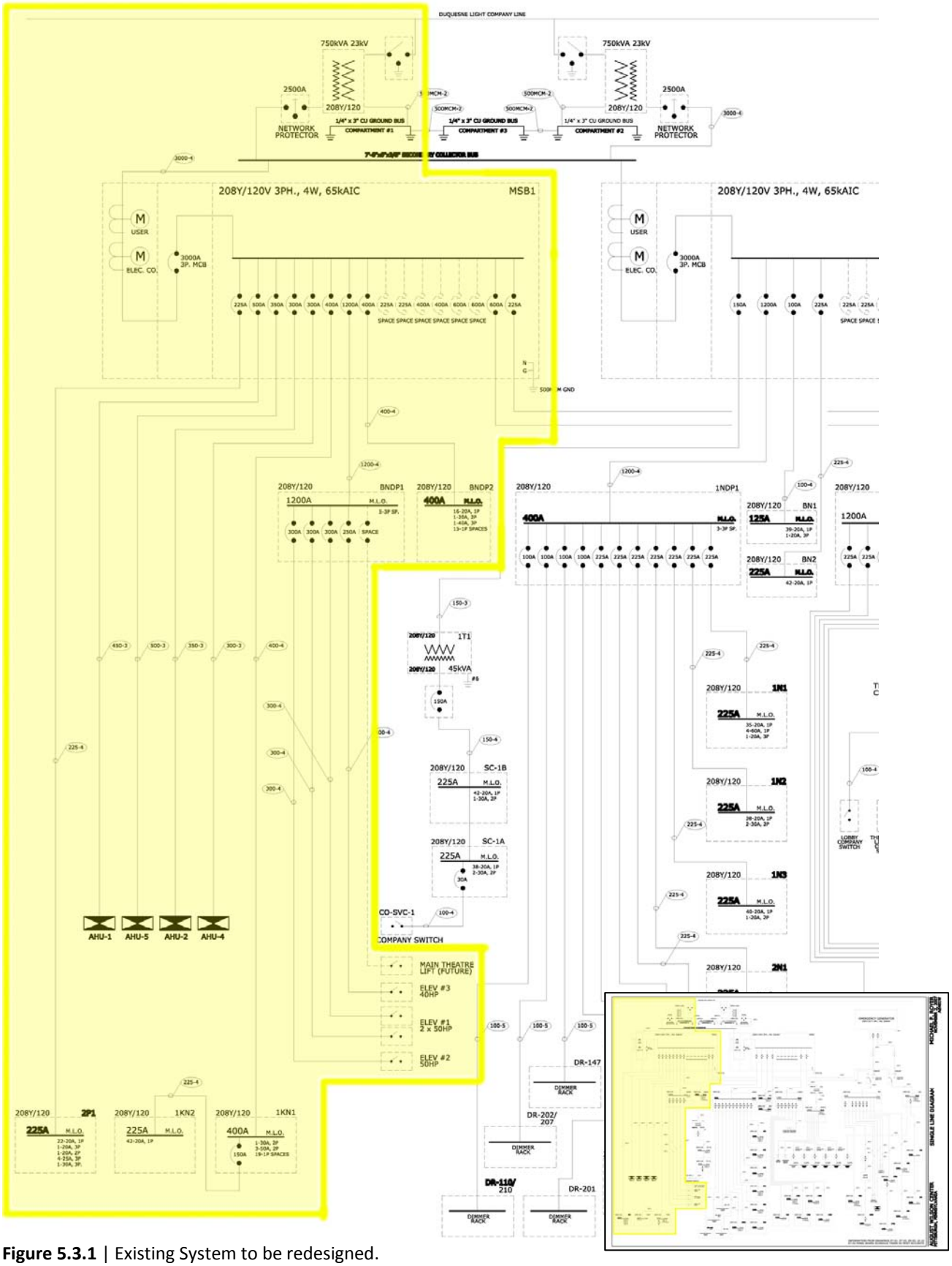

Figure 5.3.1 | Existing System to be redesigned.

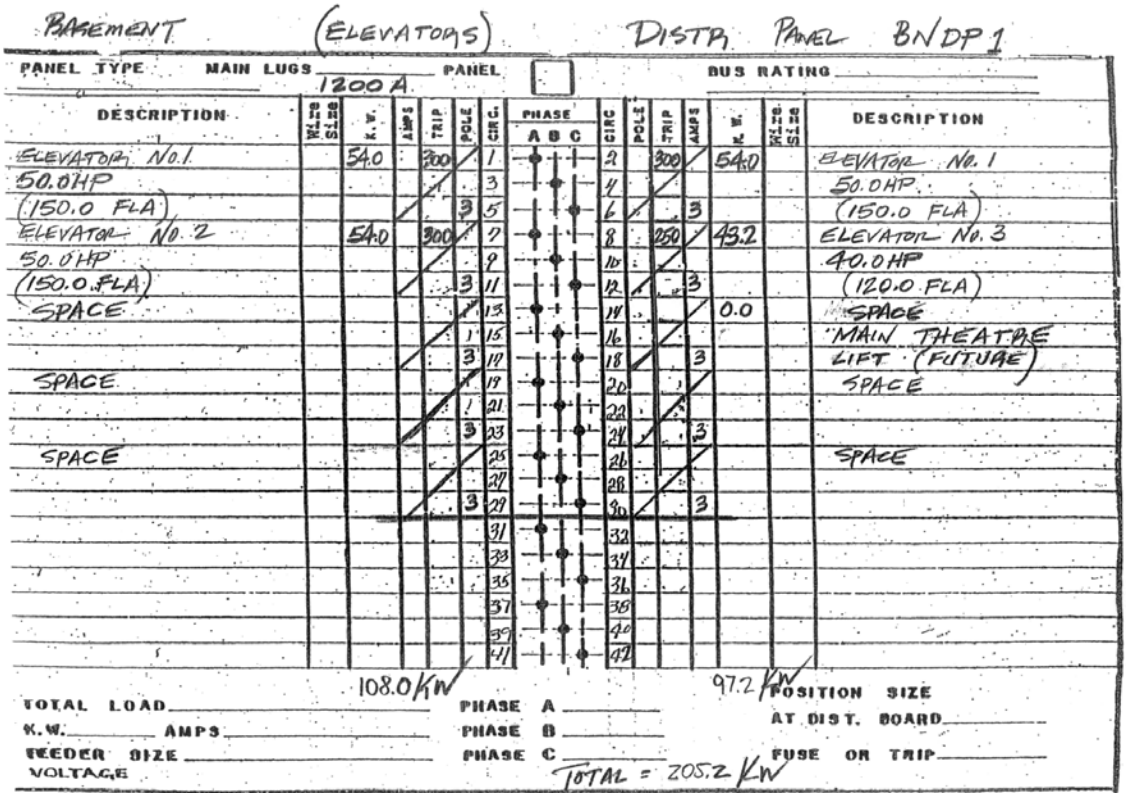

Figure 5.3.2 | BNDP1

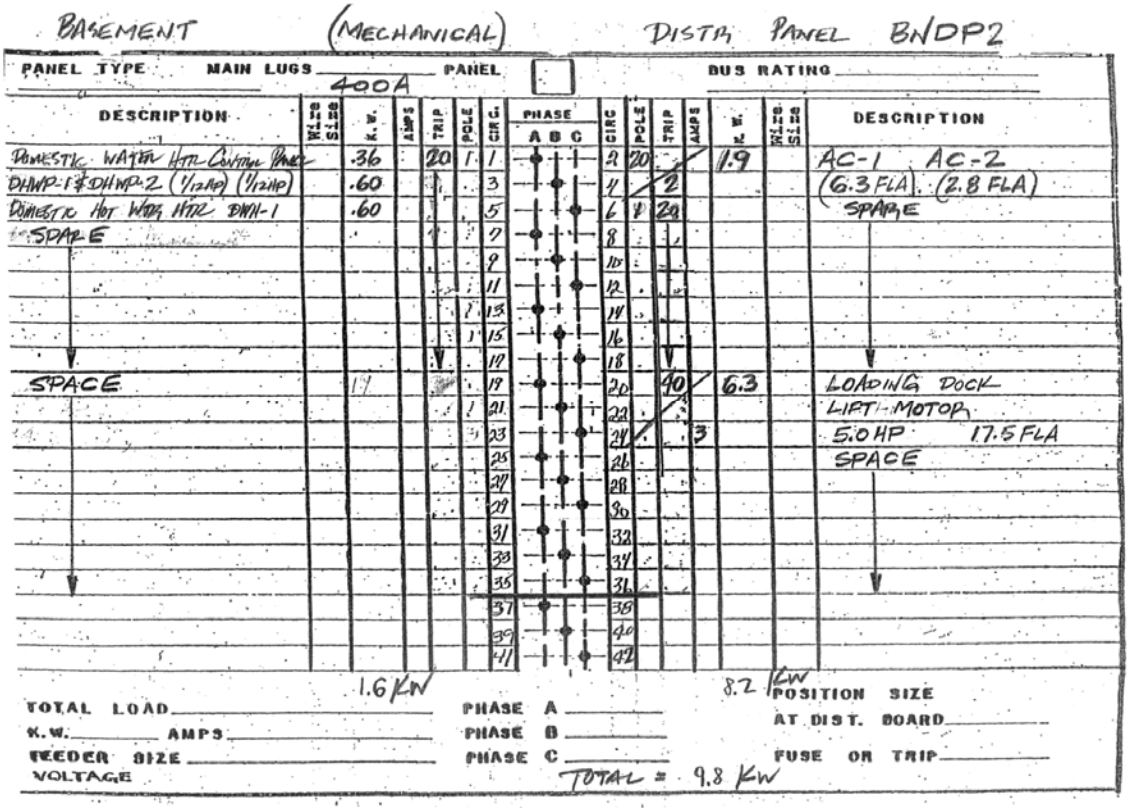

Figure 5.3.3 | BNDP2

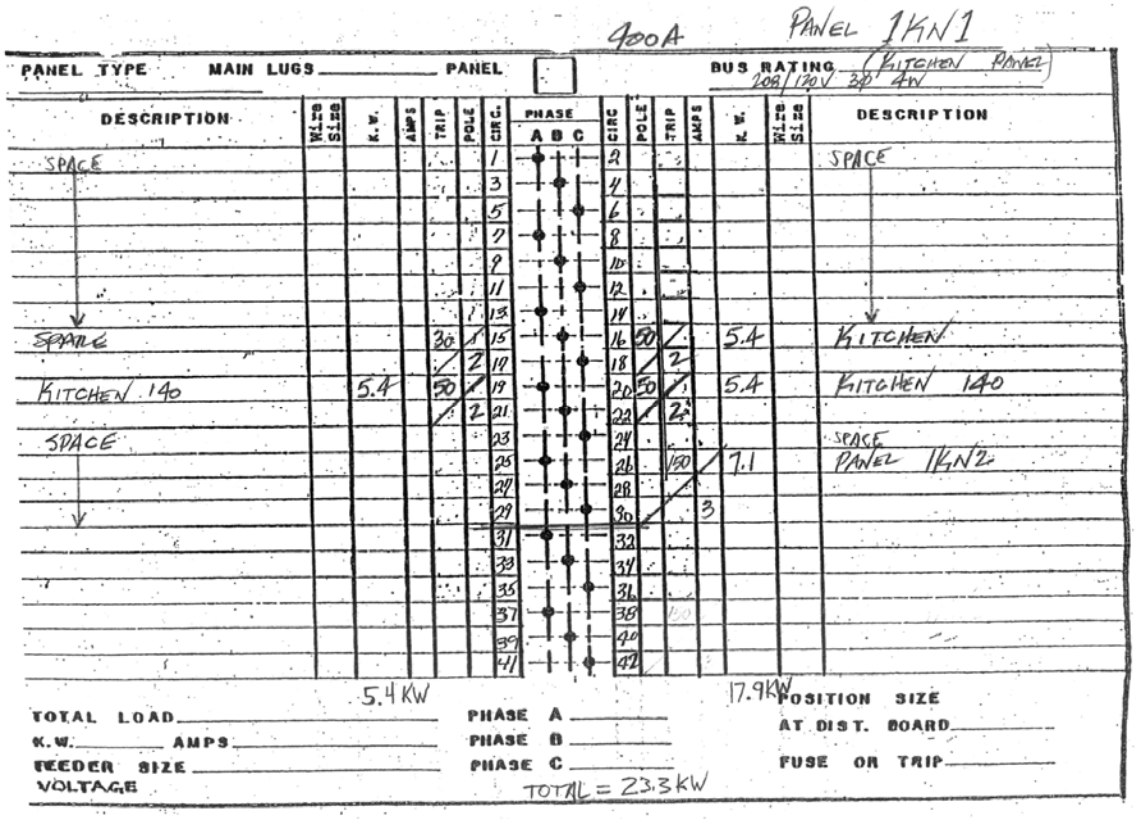

Figure 5.3.4 | 1KN1

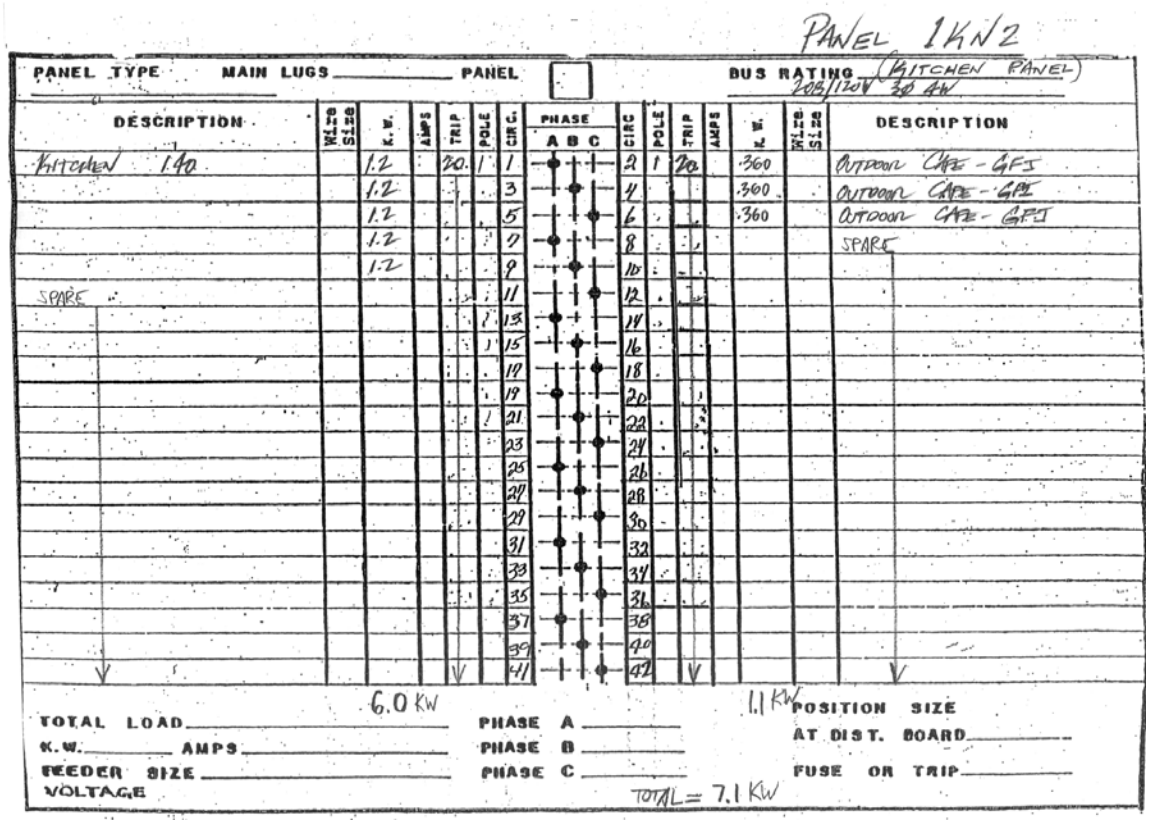

Figure 5.3.5 | 1KN2

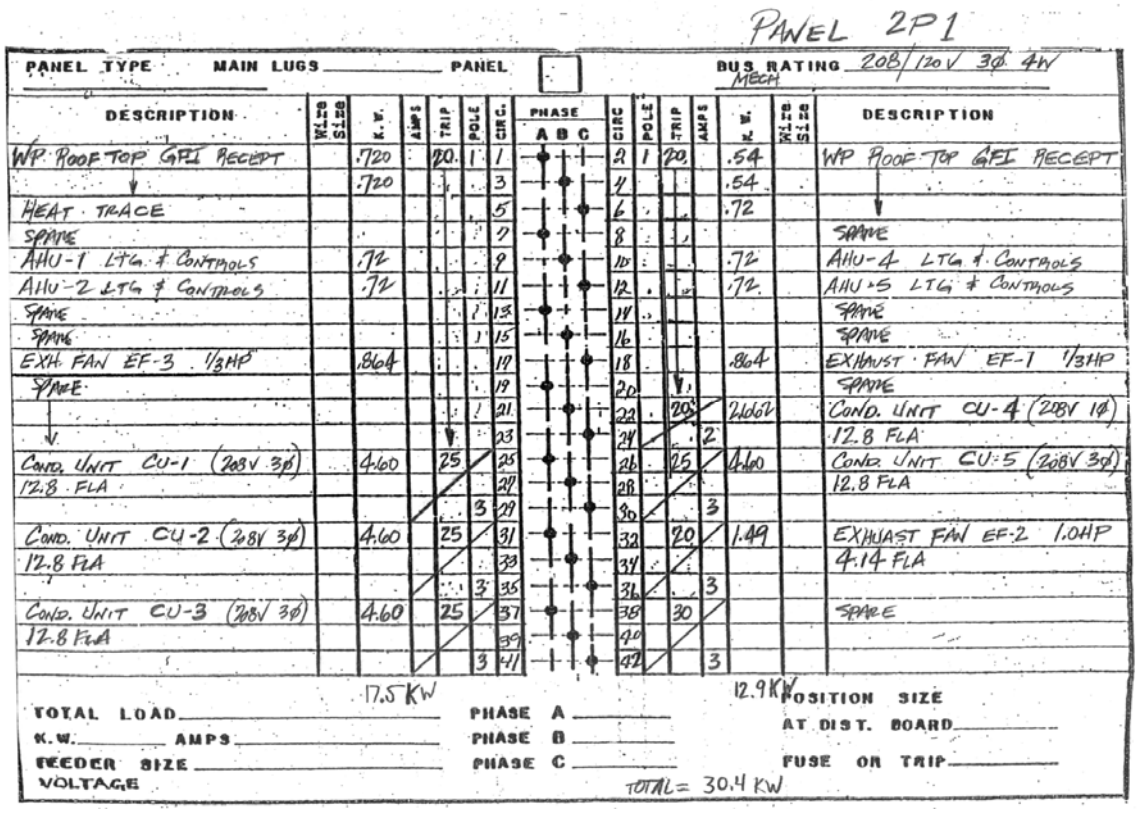

Figure 5.3.6 | 2P1

The Redesigned System:

Redesigning the system involved recalculating the loading on each panelboard in order to resize the bus and the feeder. Also, the addition of two transformers is necessary to accommodate loads that must run at 120V. Below is the new equipment schedule and panelboard schedules. A new single line diagram and full size images of the panelboard schedules are available in Appendices F-J.

Table 5.3.2: Redesign Equipment Schedule

TYPE	TAG	LOCATION	DESCRIPTION
Transformer	*NA*	*Trans. Vault*	*Duquesne Light Transformer (Unch)*
Transformer	2T1	Electrical Room (212)	9 KVA, 480V to 108Y/120V
Transformer	1T3	Kitchen (140)	30 KVA, 480V to 108Y/120V
Main Switchboard	MSB1	Basement (013)	480/277, 1600A MCB
Distribution Panel	BNDP1	Basement (013)	480/277, 400A MLO
Distribution Panel	BNDP2	Basement (013)	480/277, 100A MLO
Branch Circuit Panel	2P1	Electrical Room (212)	480/277, 100A MLO
Branch Circuit Panel	2P1A	Electrical Room (212)	480/277, 60A MLO
Branch Circuit Panel	1KN1	Kitchen (140)	208Y/120, 400A MCB
Branch Circuit Panel	*1KN2*	*Kitchen (140)*	*208Y/120, 225A MLO (Unchanged)*

PANEL BOARD SCHEDULE

VOLTAGE: 480/277V,3PH,4W
SIZE/TYPE BUS: 400A
SIZE/TYPE MAIN: M.L.O

PANEL TAG: BNDP1
PANEL LOCATION: BASEMENT B013
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 25K
OPTIONS:

DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (W)	DESCRIPTION
ELEVATOR NO. 1 (50 HP)	18000	150A/3P	1	*			2	150A/3P	18000	ELEVATOR NO. 1 (50 HP)
[65 FLA]	18000		3		*		4		18000	[65 FLA]
	18000		5			*	6		18000	
ELEVATOR NO. 2 (50 HP)	18000	150A/3P	7	*			8	100A/3P	14400	ELEVATOR NO. 3 (40HP)
[65 FLA]	18000		9		*		10		14400	[52 FLA]
	18000		11			*	12		14400	
SPARE		150A/3P	13	*			14	150A/3P		*FUTURE LIFT*
			15		*		16			
			17			*	18			
SPARE		150A/3P	19	*			20	150A/3P		SPARE
			21		*		22			
			23			*	24			
SPARE		100A/3P	25	*			26	100A/3P		SPARE
			27		*		28			
			29			*	30			

CONNECTED LOAD (KW) - A	68.40	TOTAL DESIGN LOAD (KW)	205.20
CONNECTED LOAD (KW) - B	68.40	SPACE (GROWTH) FACTOR	1.35
CONNECTED LOAD (KW) - C	68.40	TOTAL DESIGN LOAD (A)	333

Figure 5.3.7 | New Panel BNDP1

PANEL BOARD SCHEDULE

VOLTAGE: 480/277V,3PH,4W
SIZE/TYPE BUS: 100A
SIZE/TYPE MAIN: M.L.O.

PANEL TAG: BNDP2
PANEL LOCATION: BASEMENT B013
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 25K
OPTIONS:

DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (W)	DESCRIPTION
DOMESTIC WATER HTR CONTL	360	20A/1P	1	*			2	20A/2P	950	AC-1 & AC-2
DHWP-1 & DHWP-2 (1/12 HP EA)	600	20A/1P	3		*		4		950	[2.73 + 1.21 FLA]
DOMESTIC HOT WATER HTR DHW-1	600	20A/1P	5			*	6	20A/1P		SPARE
SPARE		20A/1P	7	*			8	20A/1P		SPARE
SPARE		20A/1P	9		*		10	20A/1P		SPARE
SPARE		20A/1P	11			*	12	20A/1P		SPARE
SPARE		20A/1P	13	*			14	20A/1P		SPARE
SPARE		20A/1P	15		*		16	20A/1P		SPARE
SPARE		20A/1P	17			*	18	20A/1P		SPARE
SPACE			19	*			20	20A/3P	2100	LOADING DOCK LIFT MOTOR (5 HP)
SPACE			21		*		22		2100	[7.58 FLA]
SPACE			23			*	24		2100	
SPACE			25	*			26			SPACE
SPACE			27		*		28			SPACE
SPACE			29			*	30			SPACE
SPACE			31	*			32			SPACE
SPACE			33		*		34			SPACE
SPACE			35			*	36			SPACE

CONNECTED LOAD (KW) - A	3.41	TOTAL DESIGN LOAD (KW)	9.76
CONNECTED LOAD (KW) - B	3.65	SPACE (GROWTH) FACTOR	1.50
CONNECTED LOAD (KW) - C	2.70	TOTAL DESIGN LOAD (A)	20

Figure 5.3.8 | New Panel BNDP2

PANEL BOARD SCHEDULE

VOLTAGE: 480/277V,3PH,4W	PANEL TAG: 2P1	MIN. C/B AIC: 22K
SIZE/TYPE BUS: 100A	PANEL LOCATION: ELECTRICAL ROOM 212	OPTIONS:
SIZE/TYPE MAIN: M.L.O.	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (W)	DESCRIPTION
EXH FAN EF-3 (1/3 HP)	864	20A/1P	1	*			2	20A/1P	864	EXH FAN EF-1 (1/3 HP)
SPARE		20A/1P	3		*		4	20A/1P		SPARE
SPARE		20A/1P	5			*	6	20A/2P	1331	COND UNIT CU-4
SPARE		20A/1P	7	*			8		1331	[5.54 FLA]
COND UNIT CU-1	1533	20A/3P	9		*		10	20A/3P	1533	COND UNIT CU-5
[5.54 FLA]	1533		11			*	12		1533	[5.54 FLA]
	1533		13	*			14		1533	
COND UNIT CU-2	1533	20A/3P	15		*		16	20A/3P	497	EXH FAN EF-2 (1.0 HP)
[5.54 FLA]	1533		17			*	18		497	[1.79 FLA]
	1533		19	*			20		497	
COND UNIT CU-3	1533	20A/3P	21		*		22	20A/3P	2500	PANEL 2P1A
[5.54 FLA]	1533		23			*	24		2500	
	1533		25	*			26		2500	
SPACE			27		*		28			SPACE
SPACE			29			*	30			SPACE
SPACE			31	*			32			SPACE

CONNECTED LOAD (KW) - A	12.19	TOTAL DESIGN LOAD (KW)	31.78
CONNECTED LOAD (KW) - B	9.13	SPACE (GROWTH) FACTOR	1.25
CONNECTED LOAD (KW) - C	10.46	TOTAL DESIGN LOAD (A)	51

Figure 5.3.9 | New Panel 2P1

PANEL BOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: 2P1A	MIN. C/B AIC: 22K
SIZE/TYPE BUS: 60A	PANEL LOCATION: ELECTRICAL ROOM 212	OPTIONS:
SIZE/TYPE MAIN: M.L.O.	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (W)	DESCRIPTION
WP ROOF TOP GFI RCPT	720	20A/1P	1	*			2	20A/1P	540	WP ROOF TOP GFI RCPT
WP ROOF TOP GFI RCPT	720	20A/1P	3		*		4	20A/1P	540	WP ROOF TOP GFI RCPT
HEAT TRACE	0	20A/1P	5			*	6	20A/1P	720	WP ROOF TOP GFI RCPT
SPARE	0	20A/1P	7	*			8	20A/1P	0	SPARE
AHU-1 LTG & CONTROLS	720	20A/1P	9		*		10	20A/1P	720	AHU-4 LTG & CONTROLS
AHU-2 LTG & CONTROLS	720	20A/1P	11			*	12	20A/1P	720	AHU-5 LTG & CONTROLS
SPARE	0	20A/1P	13	*			14	20A/1P	0	SPARE
SPARE	0	20A/1P	15		*		16	20A/1P	0	SPARE
SPARE	0	20A/1P	17			*	18	20A/1P	0	SPARE
SPACE			19	*			20			SPACE
SPACE			21		*		22			SPACE
SPACE			23			*	24			SPACE

CONNECTED LOAD (KW) - A	1.26	TOTAL DESIGN LOAD (KW)	7.50
CONNECTED LOAD (KW) - B	2.70	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	2.16	TOTAL DESIGN LOAD (AMPS)	21

Figure 5.3.10 | New Panel 2P1A

Sample Calculations for New Sizing:

Brach Circuit Breaker for Motor (Sample for Elevator No. 2):

MCA (NEC 2005 430.250) = 65A * 1.25 (First Motor) = 81.25A

MOPD (NEC 2005 430.52) = 250% (Inverse Time Breaker)

2.5 * 65A = 162.5A

BREAKER SIZE: 150A

WIRE SIZE: (3) #4 Conductors

Transformer (Sample for Panel 1KN1):

Calculated Design Load = 23.3 KW

Transformer = 30 kVA

Secondary Protection = 110A (125A)

Primary Protection = 30.1A (50A)

Cost Analysis:

The cost comparison between the new and existing systems was completed using *R.S. Means 2008 Electrical Cost Data*. The existing system from the most current recent set of drawings is designed and sized for the original contract, which was a guaranteed maximum price (GMP). Because of this, all equipment and feeders were grossly oversized. Feeders were sized to match bus size. In order for the cost estimate to provide comparable results, this same method was utilized. The bus sizes have all been resized based on the new panel demand loads, however, greatly reducing the feeder sizes. The cost comparison is broken down in the following table:

Table 5.3.3: Electrical System Redesign - 208/120V to 480/277V - Cost Analysis

PANELS

Label	Load (KW)	Ex. Size (A)	Ex. Cost	New Size (A)	New Cost
MSB1	-	3000	$40,600.00	1600	$26,100.00
MSB2	NO CHANGE IN SIZE				
BNDP1	205.2	400	$1,750.00	100	$900.00
BNDP2	9.8	1200	$5,275.00	400	$1,750.00
1KN1	23.2	400	$3,125.00	100	$1,300.00
1KN2	NO CHANGE IN SIZE				
2P1	30.4	225	$1,175.00	100	$900.00
2P1A	NA	NA	NA	60	$700.00
		Subtotal =	**$48,800.00**	**Subtotal =**	**$30,350.00**

FEEDERS **Per 100'** **(All feeders 75 C type THWN)**

Label	Length (ft)	No. Wires	Ex. Size	Ex. Cost/Unit	Ex. Cost	New Size	New Cost/Unit	New Cost
A	30	4	(4) 500	$1,550.00	$7,440.00	(4) 500	$1,550.00	$7,440.00
B	35	4	4/0	$755.00	$1,063.04	3	$244.00	$343.55
C	129	4	(2) 4/0	$755.00	$7,773.48	2/0	$505.00	$2,599.74
D	248	4	(2) 250	$870.00	$17,226.00	3/0	$620.00	$6,138.00
E	76	4	500	$1,550.00	$4,705.80	1	$350.00	$1,062.60
F	190	4	350	$1,150.00	$8,753.80	2	$291.00	$2,215.09
G	242	4	(2) 3/0	$620.00	$12,003.20	2	$291.00	$2,816.88
H	15	4	(4) 350	$1,150.00	$2,760.00	(2) 3/0	$620.00	$744.00
I	15	4	(2) 3/0	$620.00	$744.00	3	$244.00	$146.40
J	35	4	350	$1,150.00	$1,610.00	4	$209.00	$292.60
K	35	4	350	$1,150.00	$1,610.00	4	$209.00	$292.60
L	35	4	350	$1,150.00	$1,610.00	4	$209.00	$292.60
M	35	4	350	$1,150.00	$1,610.00	6	$152.00	$212.80
				Subtotal =	**$68,909.32**		**Subtotal =**	**$24,596.86**

OTHER

Item	Existing	Existing Cost	New Size	New Cost
1TKN1	NA	NA	30 kVA	$3,425.00
2TP1A	NA	NA	9 kVA	$2,200.00
			Subtotal =	**$5,625.00**

Existing System Total = $117,709.32

New System Total = $60,571.86

COST DIFFERENCE = $57,137.46

System Conversion Conclusion:

As shown in Table 5.3.3, converting MSB1 and its connected loads to a 480/277V system saves a significant amount of money. For a project that is trying to reduce the bottom line, this change seems to be a viable option. The tabulated data does not include further cost savings that would result from a reduction of individual breakers for branch circuits.

The second factor that must be considered in the conversion of this system is the loss of redundancy provided by the collector bus. Since the system includes a substantial emergency generator and the system does not include critical loads, it is my opinion that using a 480/277V system for switchboard MSB1 is an appropriate choice for this project.

4. PROTECTIVE DEVICE COORDINATION STUDY and FAULT CURRENT ANALYSIS

As a sample calculation, a protective device coordination study and a fault current analysis was performed for a selected path through the system. The calculations that follow summarize these two procedures. That path is as follows:

Utility Transformer > Main Switchboard (MSB1) > Distribution Panel (1NDP1) > End-Use Panel (1N1)

The results show that the currently designed system uses has equipment specified which is, in one cases, is less than that required by the calculations. Branch circuit panelboard 1TN1 requires 25000 AIC but the specified equipment is rated at 22,000 AIC.

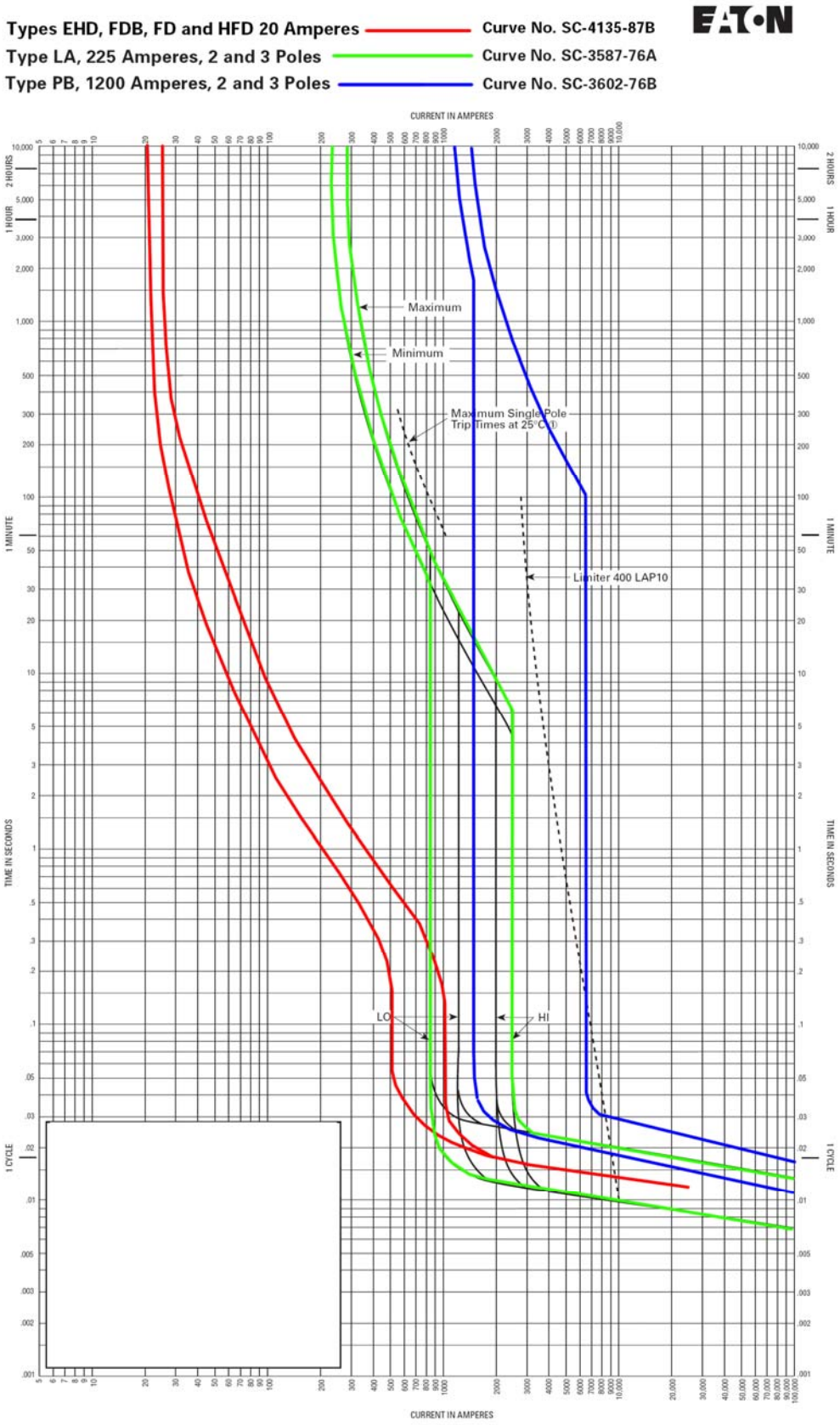

Figure 5.4.1 | Protective Device Coordination

Table 5.4.1: Summary Results of Fault Analysis			
Point	Location	Available Fault (A)	Standard Breaker Rating (A)
A	Utility Company Secondary	41630	50000
B	Switchboard (MSB2)	40197	50000
C	Distribution Panel (1NDP1)	34195	35000
D	End Use Panel (1N1)	24599	25000

Table 5.4.2: Fault Current Analysis (Per Unit Method)					
	System Voltage = 208				
	Base KVA = 10000				
	Utility Company Available Fault = 100000000	ΣX	ΣR	ΣZ	I_{sc} (A)
Utility Primary					
	$X_{(p.u.)} = KVA_{base}$ / Utility S.C. KVA = 0.0001	0.000	0.000	0.000	**277572245**
	$R_{(p.u.)}$ = 0.0000				
Transformer Secondary					
%Z = 5.00	$X_{(p.u.)} = \%X * KVA_{base} / 100 * KVA_{xfrmr}$ = 0.5951	0.595	0.301	0.667	**41630**
X/R = 1.98	$R_{(p.u.)} = \%R * KVA_{base} / 100 * KVA_{xfrmr}$ = 0.3005				
%X = 4.46					
%R = 2.25					
kVA = 750					
Switchboard MSB1					
Wire = 500	$X = (L/1000) * X_L * (1/Sets)$, $X_{(p.u.)}$ = 0.0202	0.615	0.313	0.691	**40197**
Length = 15	$R = (L/1000) * R * (1/Sets)$, $R_{(p.u.)}$ = 0.0127				
Sets = 8					
X = 0.047					
R = 0.029					
Panel Board 1NDP1					
Wire = 400	$X = (L/1000) * X_L * (1/Sets))$, $X_{(p.u.)}$ = 0.0991	0.714	0.385	0.812	**34195**
Length = 35	$R = (L/1000) * R * (1/Sets)$, $R_{(p.u.)}$ = 0.0720				
Sets = 4					
X = 0.049					
R = 0.036					
Panel Board 1N1					
Wire = 4/0	$X = (L/1000) * X_L * (1/Sets))$, $X_{(p.u.)}$ = 0.2068	0.921	0.652	1.128	**24599**
Length = 18	$R = (L/1000) * R * (1/Sets)$, $R_{(p.u.)}$ = 0.2663				
Sets = 1					
X = 0.050					
R = 0.064					