## **SECTION FIVE |** Electrical

# 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.



**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	1st Floor Drum Lower	SAX	17	50	1063	ELV	
	1	2	1st Floor Drum Lower	SAX	17	50	1063	ELV	
	2	3	1st Floor Drum Upper		70	15	1313	NEON	
	2	4	1st Floor Drum Upper		70	15	1313	NEON	
	3	5	Art Lights Lobby	SBC	10	65	813	ELV	
		6	2nd Floor Drum	SAF	6	225	1350	INC	
	4	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
101111	10170	

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

PANEL TYPE MAIN LUG	3		P	AN	EL.	N				BUS	I TA n	NG 208/1201 30 4W
DESCRIPTION	Wire Sire	, W.	TRIP S	POLE	CIR C.	PHASE A B C	0 80	POLE	TRIP	ji	Wire Size	DESCRIPTION
ELE 211 ELEC 212, 215- LTG		.960	20	1.	1.	-++	-2	1	20	.605		OPEN OFFICE 220 LTG
-0684 201 & BRIDGE 200 - LTG.		.320	1.3		3	-+++	- 4		1	1.10		OPEN OFFICE 220 LTG
OBBY-201 - LTG -		,448		,	5	-+++	-6	5		.320	100	HALLWAY 230 - LTG
088/ 201 - LTG	0	.512		7	2	-4+4	-18	1	:,	.832		MENS 245, WOMENS 243 LTG
STATE 204-LTG:		1.38			9		10	7		.924		CONF. AM. 240 - LTG
STAIR 204- LTG		.500	1.1	1	11	110	- 12			.972		MULTI-PURPOSE 247- LTG
SMAC			1.1	17	15	-++	-11	.,		840		MULTI- PUMPOSE 247-LTG
				1.	15		-16	:	$\Box$	•		SPARE.
					19	+++	- 18					
DIMMER ROOM LTG.		.128		٦.	19	-++	- 21		15			
SPIRE				!	21	<del>- -</del>  +- -	22		1.5			
				3.1	23	-++	24	1				4
					25	<b> -++</b>	- 2	<u>.</u>	Ш			
				L	27	1-1-1	28			· .	-	
	_			L	29		- 30	1	W		1	<u> </u>
	_			1	31	<b> -++</b>	- 3	2 /	60:	3.2	1	TEMP. EXHIBIT 210-BIS DUC
	_			1/2	33	1-1-4-1	-3	11	60	3.2		TEMP. EXHIBIT 210-BUS DUE
, <u> </u>		· .	_:V	1	35	1-++	- 3	1	60,	3.2		TEMP, EXHIBIT 210 - BUS DUC
AKEA PROTECTION PANEL		100	20	1	137	- <del> </del> - - -	-32	9 1	60	3.2	'	TEMP. EXHIBIT 210-BUS DUC
the state of the s				1	30		-4	0	ZO			SPARE
			$\mathcal{A}$	3	41	1-1-1-4	-4	2	70			SPARE
	ή,	43	KM		, :		1.	-		18,4	Klos	IITION SIZE
TOTAL LOAD	<del></del>		-	PH	BA	E A	÷	÷	- :			DIST. BOARD
K.WAMPS		7	<del></del>	PH	AS	E B	÷	+	_		4	
VOLTAGE		-		P	AS	E C_		-		2.7 KI	FUS	DE ON TRIP

Figure 5.1A.2 | Existing Panel 2N1

PANEL TYPE MAIN LUG	3			_ P	AN	EL							BUS	274	NG 208/120/ 3\$ 4W TING PANEL)
DESCRIPTION	Wire Sire	b.	AMPS	TRIP	POLE	CIR C.	PHA	SE C	0130	POLE	TRIP	AMPS	Z.	Wire	DESCRIPTION
MINNAY 115 - LTG		1.20	: '	20.	T.	1.	- 6-	1-1-	-2	1	20,		-80	-	HALWAY 131- LTG.
LOBBY 101 - LTG	-: 1	.320				3	-+-	1	- 4		T		1.39.	- 1	TAESSING . BMS 126-LTG
08BY 101 - LTG -		1.12		, ,		5	+	10	-6	٠,	T.		1.60	* **	DRESSING AMS 121 - LTG
obby 101- LTG		448				2	-4-	++	-18		:,		.940	15.	CHORUS DAESS AM 123-LTG
IFT SHOP 103 - LTG		1.20				9		+	10	:			-512		INNEL LOBBY - LTG
IFT SHOP 103 - LTG		.900		. ,	i	11	+	1	-12		1		.832		Men's AM 145 Wayers 143-L
COAT CLOSET - 107 - LTG		480		1.	17	13		++	-14	.,	П		.510		KITCHEN 140 - LTG.
TEMBERISHIP BOX 102-LTG		:810		. 1	1.	15	-4-	<b>-</b>  -	-16		$\prod$				SPARE
NTRY 100 - LTG		,232		: ].		17	+	† 🕈	-18		П				
SPARE					٦.	19		++	- 20		1				
SPARE.				1	1	21.		<del>ا</del> ⊦۴	22						
EXTERIOR MAIN ENTRY		-052			2.5	23	<b>-</b> †·	╁┿	24		$\downarrow$				· •
XTEPION LOAD TOCK LIG	4.3	-156		, -		25	-	t†	- 21	20		$\mathbb{Z}$		1	AREA PROTECTION.
XTEPHOR TYPE SAY.		.312		1		27	1-1-	<b>†</b> †	28		Z				5 PARC
ateria Type SAP		.35	L	1	Ľ.	29	1-1-	1-0	- 30	1		3	100		SPARE
EXTERIOR TYPE SAR-A	_	.35		$\perp$	L	31	<b> </b>	† †	- 32	1	60		3.2	7	PEAM EXHIBIT 110 - BUS DUC
EXTERIOR TYPE SAG		.36		1	2.	33	-+	ቀተ	- 32	1	60	L	3.2	4.7	PERM. EXHIBIT 110 - BUS DUC
EXTERLION TYPE SAG		36		: 1	1	35	1-1	╁┿	- 31	1	60		3.2		PERM. EXHIBIT 110 - BUS DUC
ERTALION TYPE SAB		.36				37	- <del> </del>	++	-38	1	60		3.2	1	PERM. EXHIBIT 110 - BUS DUCT
SPARE.			L	Ш		30	1-1	<b>†</b> †	-4	9					SPARE
SPARE	1.			$\forall$	L	41	1-1	1.0	-42	4					SPARE
TOTAL LOAD		9.01	<w< td=""><td>-</td><td>PH</td><td>: As</td><td>E A</td><td></td><td></td><td>1</td><td></td><td>•</td><td>19.4 K</td><td>Fos</td><td>ITION SIZE</td></w<>	-	PH	: As	E A			1		•	19.4 K	Fos	ITION SIZE
K.W. AMPS	20.0				PH	AS	E 8	_	ξ.	1.				AT	DIST. BOARD

Figure 5.1A.3 | Existing Panel 1N1

DESCRIPTION	9 9	-		a.	4	ų l	PHA	SE	U	4	. 1	40		60 49	Pol	ESCRIPTION
DESCRIPTION :	対な	Jii .	A P	7819	0	CIRC.	A	BC	0180	ğ	8	AK	Bri nd	5.44	U	ESCRIPTION
PASSALE WAY.		.448	:	20	1	1.	-0	17	2	1	ŹQ		36		Fine	Smoke PAMPER.
PEN OPPICE HALLWAY		.672				3	-+-	+1-	4		1		.36.		FIRE	SMAKE DAMPER
PLEST PROBMS		.064		, "		5	+	14-	6		1.		,36	1 4.		UP, ITY PANEL
SPAGE				1:	2	2	-4	++	8		: ,		136		AV.	RACK-
HI PIPC						9		++	115	:			.36	_	AV	MACK
1				12	1	11	1	1 -	12		10				SPAR	€
STAIPS NO. 1.		320	1		17	13	-	++	14	.,	1		.36			MARIA NORGERTANI (
SPAPIE	-		L	4	1.	15.	1-1	<b>†</b> -!	16	1	1	_		_	501	BE
	-	-	-	14	-	12	17	14	18	Ŀ	1	L				
	1		1	14	-	19	-	+:-	20	_	4	_		-		
4	-		1	1	1	21	1	7	122	1	14	_				
	1		1	Ш	L	133		19	21	1 <u>·</u>	14	1	<u> </u>	_	·-	
	-	<u> </u>	1-	4	1	25	1-1	11	21	÷	₩	1_		-	-	
	1	-	- <del> </del> -	1	1	27	1	71	- 28	1	1	F	-	-	-	
	-	<del> </del>		W.	-	127			- 30	4-	W.	-	-	-	-	L
	-	ļ		<u> </u>	-	12/	17	TT	3	2	-	-		-	-	
7	-	-		-	1	130		TT	3	4	-	-	-	127	-	
	-	-	-	-	1	32			-13	6	┢┷	4	-			
	-	-	-	-	-	P	17	T	- 32	1_	-	-			-	
		-		-	-	130	4	TI	7	1	-	- -	-	+-		1 200
	- <u>l</u> -	1	٠,	1-		14	1-1	1.4	- 4	4	Ļ	Ť	11 \		-	
	À	1.50	) <sub>:</sub>	W		. ,						2	16 K	POS	ITION	SIZE
C.WAMPS			-	-	PE	[A]	E	A	-	-	nia '			AT	DIST.	DOARD

Figure 5.1A.4 | Existing Panel 2E1

PANEL TYPE MAIN LUG			_	_			_1		-		_	-	-	1	
DESCRIPTION	Wire Size	ъ.	Aires	1819	POLE	CIRC.	- 0	B C	- 12	300	4 36	AMPS	bi nd	14 14 14 14 15 14 16 18	DESCRIPTION
MIWAY H3	-	.448		20.	1	1.	-	++	-2	1	20,	1	17/00		: The smoke: Designer.
HELWAY 131		.563	-	I		3		++	-4	1	1		1360		fine Smoke PAMPER.
DAESSING PMS -		.624	-		1	5	-	14	-16	1		1	360	1.57	SECURITY PAWELI.
1.0884 108		.320	Г	1	17	2	-	++	-18	1	1.		1360		AV PACK
10884 107	-	.444		17		9		++	- 11	1	J		.360		AV AACK
STAIN NO.6	1		Г	I	1;	11	-	1-10	-1/		11		1360		AV. MACK
SPARE -				11	17	13	1-	1+	-17	/ .,	П		.360		FIRE ALMEN NOTIFICATION
	1			1	1	15	1-	1-4-1	-1	,	П		.360		FIRE Arman Contra liting
1				1:1		112	-	+++	-1	8 .	Ц	1	_		ZEVEE
EXTALION LTG		.256			1	19	1-	<b>+</b> +-!	- 2	0	1.1	4	-	1	
ZPARE					!	21	1-	1-4-1	$\dot{\tau}_{a}$	2		1	1	_	
					Ŀ	123	-	++4	1	4.	1.1	1	1		
			L	14	L	2	1-	411		<i>1</i> 6	11	1		1	
		1		11	1	27	4-	1.0		8	-	-			
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	_	1	1	-1-	_	. 3	4-	1	-	32	-	4.			
The second secon	_	1	1	_ _	-	13	3 -	-1-9	$\Box$	3/	4	4	-		
	1	1	1	_	1	13	5	111	9-1	36	1	4-	-		
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And the second of the second	-			_		10	9:	11	П	90	_	_ -			
f			_	_		- 4	<u>//</u> -	1-4	4-1	42	L	_		1	
	5	2.65	K	W		٠,		٠.,		٠.		.,	2.88	No:	SITION SIZE
TOTAL LOAD	<u>;</u> -		-		P	HA	3E	A	-	-	-				DIST. BOARD

Figure 5.1A.5 | Existing Panel 1E1

		DI	MMER RACK	LAY	OUT:	DR101/	201			
	CONTROL	CIRCUIT /		FIXT.	NO. OF	WATTS/		TOTAL	РНОТО	EMER.
AREA	CHANNEL	DIMMER	DESCRIPTION	TAG	FIXT.	FIXTURE	MULT.	WATTS	CELL?	CRCT?
	1	1	Theater Drum Upper	D	25	50	1.0	1250		
LOWER	2	2	Theater Drum Lower	D	25	50	1.0	1250		
LOBBY	3	3	Downlights - Linear	Α	17	63	1.25	1338.75		•
	4	4	Downlights - Round	E	15	49	1.25	918.75		•
		5	Theater Drum	С	5	300	1.0	1500		
UPPER	5	6	Theater Drum	С	5	300	1.0	1500		
LOBBY	3	7	Theater Drum	С	5	300	1.0	1500		
		8	Theater Drum	С	6	300	1.0	1800		
	5	9	Theater Drum	С	6	300	1.0	1800		
UPPER	6	10	Downlights - Linear	Α	20	63	1.25	1575	•	•
LOBBY	0	11	Downlights - Linear	Α	20	63	1.25	1575	•	•
	7	12	Downlights - Round	Е	13	49	1.25	796.25		•
CABINETS	8	13	Downlights	G/F	7/4	50/49	1.25	682.5		
	9	14	Wallwash	С	4	300	1.0	1200		
STAIRCASE	9	15	Wallwash	С	4	300	1.0	1200		
	10	16	Downlights	В	10	64	1.25	800		•
VESTIBULE	11	17	Downlights - Interior	Н	8	38	1.25	380		•
VESTIBULE	12	18	Downlights - Exterior	L	15	22	1.25	412.5		
CIETCHOD	13	19	Downlights	G	20	50	1.25	1250		
GIFT SHOP	13	20	Downlights	G	17	50	1.25	1062.5		•
	14	21	Inside	0	1	500	1.25	625		
EXTERIOR	15	22	Sail LED	Q	1	300	1.25	375		
	16	23	LED Buttons	Р	8	10	1.25	100		
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
Panel Type: Lut	tron LP7/16-1	204ML-20					LOAD =	24.89	kW	

Panel Type: Lutron LP7/16-1204ML-20 LOAD = 24.89 kV

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.	1	1	Linear Fluorescent	SK	3	324	1215	FL	
Class	1	2	Linear Fluorescent	SK	4	324	1620	FIL	
	2	3	Low Voltage Downlight	SK-a	21	50	1313	MLV	*
Conf.	3	4	Linear Fluorescent	SD1	8	54	540	FL	
Room	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

			MAMED DACK	. A V	AUT.	DD202/	207			
			MMER RACK				207			
	CONTROL	CIRCUIT /		FIXT.	NO. OF	WATTS/		TOTAL	рното	EMER.
AREA	CHANNEL	DIMMER	DESCRIPTION	TAG	FIXT.	FIXTURE	MULT.	WATTS	CELL?	CRCT?
EDUCATION	1	1	Northwest Downlights	Α	5	125	1.25	781.25	•	
	2	2	Northeast Downlights	Α	5	125	1.25	781.25	•	
	3	3	Southwest Downlights	А	5	125	1.25	781.25		
	4	4	Southeast Downlights	А	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	1	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: Lut	tron LP4/16-1	204ML-20					LOAD =	5.04	kW	
Distribution Pa	anel: 1NDP1		(200	% GROW	TH FACTO	R) DEMANI	D LOAD =	27.99	Α	
Emergency Par	nel: BE1					FEED	ER SIZE =	(3) #10		

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

Location: 202 Closet

30 A

PROTECTION =

## 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<sup>2</sup> (1115 m<sup>2</sup>)

Product: BP Solar 5170S

Power Produced: 192KWh

**Physical Size:** 1.26 m<sup>2</sup>

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

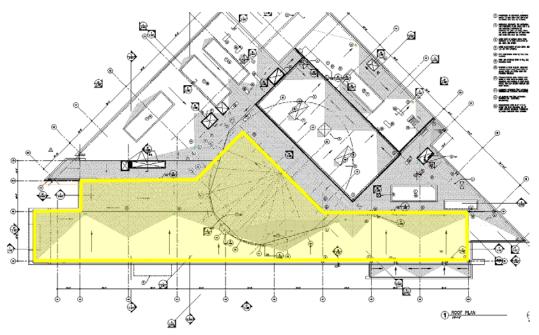


Figure 5.2.1 | Available Area for PV Array

Annual Energy Available (Pittsburgh): 1.53MWh/m<sup>2</sup>

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.

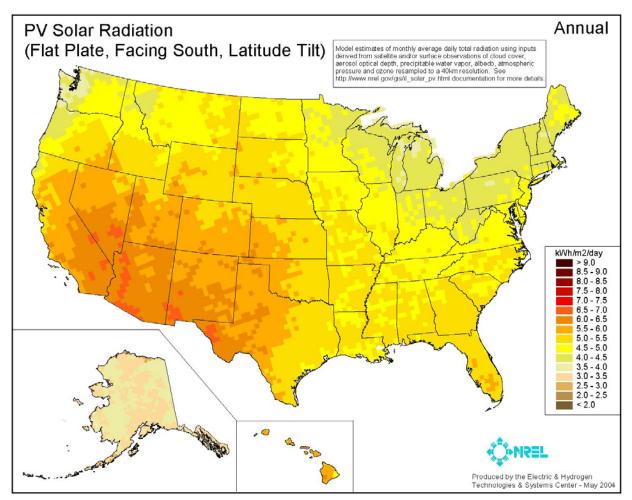


Figure 5.2.2 | PV Solar Radiation Map

## **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.

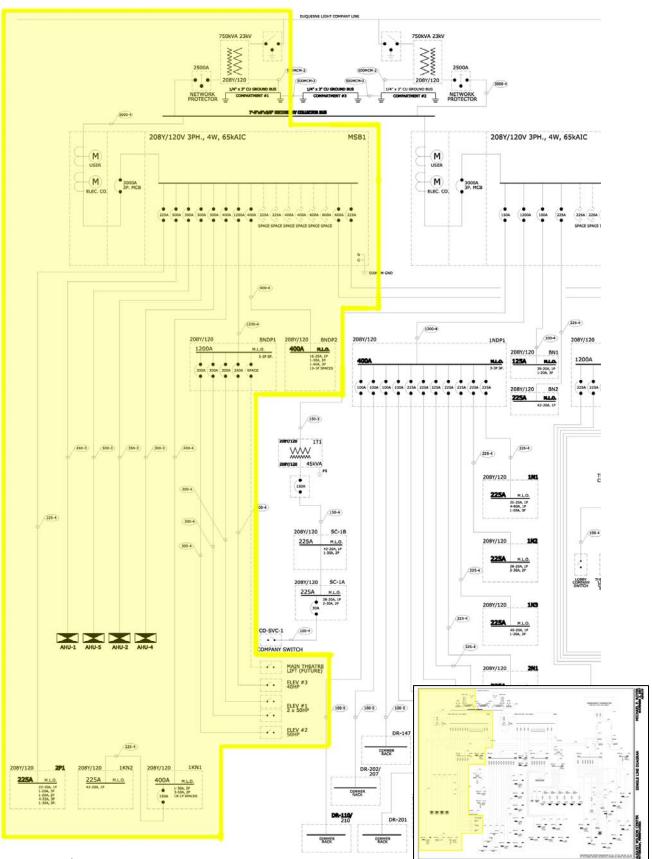
Studying the single line diagram revealed that MSB1 could be switched to a 480/277V system with minimal disruption to the system. One drawback to this change is the elimination of the point of redundancy, however. In order to make a justifiable decision on the advantage of the system conversion, a comparative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

PANEL TYPE MAIN LUG		200		_ P	ANI	EL	-		]			. 4				RL BNDP1
DESCRIPTION	25 25 25 25 25 25 25 25 25 25 25 25 25 2		A bee S	7818	POLE	CIRC.	-	B	_	CIRC	POLE	a. IK	AKPS	Bri ad	Wire.	DESCRIPTION
SLEVATORY NO.1.		54.0	:	?ioo	N	7.		+	+	2		300		540		BEVATOR NO. 1
50.0HP				1		3		ф	1	4		7				50.0HP
(150.0 FLA)				, -	3	5	-	- 1	<b>\$</b> -	6	1		3		7 %	(150.0 FLA)
ELEVATOR NO. 2		54.0	П	300		2	-4	+	+	8	7	250	1	43.2	7	ELEVATOR NO. 3
50.0HP				1		9		·-ф	+	10	Ė	Z			-	40.0HP
(150.0.FLA)			/	1.7	13	11		- 4	<b>-</b>	12	1		3			(120.0 FLA)
SPACE					1	13	-	+	+	14				0.0		SPACE
				Z	1	15.		- •	-!	16	·	Z		C		MAIN THEATRE
			1		3	17	-	١Ť	<b>†</b> -	18	1		3			LIFT (FUTURE)
SPACE	1-		1_		K	19	-	ŀŀ		20	_	1	$\mathbb{Z}$			SPACE
	-		L	V	1	21	-	1-19	Ť	22	_	Z				
	1		K		3	23	-	1+	•	24	1	_	3		1 .	
SPACE	1			<u></u>	K	25	1-	71	+	26	Ŀ	L	K		_	SPACE
	-		-	1	-	27	1-	1	1	28	L	Z	Ŀ		ļ	
	-		14	1	13	29	_	-:	-	30	K	<u> </u>	13	_	-	
	-		1	-	1	3/	-	۲1	1	32	-	-	_		-	
	-	1	1	<u>_</u>	-	33	-	+9	†	37	1	-	L	_	1	
	1_	_	1		1	35	1-	† !	1	- 31	L	1-	_		1	
	-		1	-	-	137	1	۲-۱	- †-	- 36	1_	1	ļ.,	ļ	<del> </del>	
	-		1	-	1	130	1	: 1	1	- 44	1_	<u> </u>	1_	-	1	2.
	بنا	1	_	_	ķ.	41	1	1-1	9	-47	1	Ŀ	1_			4
	<b>1</b> .	. 108	.0/	KW	<i>-</i>						1	1	. 1	97.2	Fos	ITION SIZE
TOTAL LOAD				-	9° 94	AS	E	<u>A</u> .		÷	Ť	4			AT.	DIST. BOARD
W.W. AMPS AMPS TEEDER SIZE		1		7. ,	PH	EAI	E	8.	<u> </u>	+	-	-			. "	E OR TRIP

**Figure 5.3.2** | BNDP1

ANEL TYPE MAIN LUG		100	A	_ P	ANE	EL.							003	RATI	NG
DESCRIPTION	Wire	)0	N. P.	781P	POLE	CIN C.	PHA A I	SE'	0180	POLE	a. 100	AKPS	bi n!	NY N	DESCRIPTION
MESTIC WATER HOR COVINGE PARK		.36		20	7	7	-	H	2	20		Ż	1.9	12.00	AC-1 AC-2
WP-1 \$ DHWP-2 (1/12AP) (1/12HP)		.60				3	-1.	<b> </b>	4	Z	2				(6.3 FLA). (2.8 FLA)
MESTIC HOT WARE HITE DWH-1		.60	П	1		5	-+ -	14-	6	4	20			7.5	SPARE
SPAPE !!			П	1	7	2	- <b>\$</b> -	$\vdash$	8		1,				
				T		9		<b>+</b>	10	Ė	T			-	
						11	+	i +-	12						1 2 2
La transfer of the second					1	13		+	14		I		. 1		
				23	1	15	-4-	<b>-!-</b>	16		L				
<b>Y</b>				V.		12	+	† <del>†</del>	18	_	V.				<b>V</b>
SPACE		17:		M	4.	19		+-!	20		10	K	6.3		LOADING DOCK
4 A 2 3 4 1 1				1.1	1	21.	-	<b>†</b> - -	- 22			L			LIFT MOTOP
to the second of the second					3	23	1	┼┿╌	24	$\boldsymbol{\mathbb{Z}}$		13			5.0 HP 17.5 FLA
			L			25	-	11	21	Ŀ					SPACE
	-	ļ	-		-	27	1-1	1	28	L	<u> </u>	Ŀ	_	1_	
	-	<u> </u>	1		1	29	17	++	30	-	<u>.</u>	_		1	
	<u> </u>	1	1	_	Ŀ	31	1-9	1:	- 32	4	1	1_		-	
	-		1	<u>_</u>	-	33	1-	91	- 33	4	-	1	_	12:	
	1_	1	1		1	35		+ 0	- 31	4	-	4_		_	<u> </u>
	-		1	I		37	1	+:	- 38	1_	_	_	ļ	-	
	1		- -	_	-	30	1	7	14	9	<u></u>	_	-	<u> </u>	the state of the s
	1		Ļ	ļ_	1	41	1-1	1.4	-4	4	Ŀ	_	l	1	
	١.	. 1.6	KN	-		٠,.				1			8.2	POS	ITION SIZE
TOTAL LOAD	-	<del></del>	-	-		IAS	-, -,		<del>-</del>	÷	-				DIST. BOARD
K.WAMP3		1	-	٠.,		IAS IAS		i	<u> </u>	-	-		5 .		E OR TRIP

**Figure 5.3.3** | BNDP2

te a transpersion of		2			: 1 - 1 :	. 4	loc	A	4	1	PA	NEL 1KN1
PANEL TYPE MAIN	LUGS			PANEL					В	U 3 R	AT 11 8/120	16 (KITCHEN PANE)
DESCRIPTION	6 s	K K	TRIPS	POLE	PHASE	C	POLE	TRIP	AKPS		W. 18	DESCRIPTION
SPACE			17.	17	-++	1-2	1	. 3				SPACE
			1	3	1-1+	1-14			$\neg$			
	-		1-1-	5	7-1-1	1-16	5		-		1.50	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
	11.	1.	1-15	17/3	7-4+	1-18	1	:,			77.	
	-		1-1-	1 9		1-1/1				-		
	7.			1, 1,	71-1-1-	b-12	1.	- ,	7			
<b>V</b>	1	-		17 1	<b>₹</b>  -•-	1-17	/					1
SPANCE			30	1	7-1-	i-17	. 50	7		5.4		KITCHEN
,	-			121	0-++	4-17	3/	12	П	7 7		
KITCHEN 140	7.77	5.4	7 12	1	7-4-	1-12	050	/	П	5.4		FITCHEN 140
TITTONEN				120	7	++2	2/	12	П			
SPACE	-	_	11		31-1-	<b>4-</b> 12	ų ·		1. 1		T	SPACE
37770					<b>v</b> − +	1-17	ь.	150	7	7.1	1.	PANEL 1KNZ
					刎→◆	1-12	g ·	1/	1		- 1	The second of the second of the second
		1.			29 -+ 1	4-6	0	Æ.	3			
				1	3/1-4-1	1-1	32	1:::				
					33		4					
7					35 -1-1		31.					/ /
	:			$\top$	37 - 4-1		18	150				7.11
	1.				39 -1		20		T			The second section
				-	71-1-1	4-1	12	1	3			
		5.	4 KW			1		1		17.94	W	ITION SIZE
TOTAL LOAD		· .		PH	SE A.			-				DIST. BOARD
K.WAMPS	• •	<u> </u>		PH/	SE B.	<del></del>		-				ora i. Boxino
REEDER SIZE				P01/	SE C.			<u> </u>	έ,		FUS	E OR TRIP.
VOLTAGE					TOTA	L=	23	3 K	W			

Figure 5.3.4 | 1KN1

- 61		N LUG						_	Ŀ		-						HE GITCHEN	
	DESCRIPTION		Sire	N.	4	181	POLE	CIN C	PH	B C	S S S S S S S S S S S S S S S S S S S	POLE	481	AKPS	19.5 10.2	77.78 S. 26	DESCRIPTIO	IN .
Kitchen	1 140			1.2		20.	1:	7.	-	++-	-2	t	20		-360	100	OUTDOOR CAPE -	GFI
1.5			5	1.2		T		3		+1-	- 4		I		360		OUTDOOR CAPE-	GPI
				1.2		7		5	1-	++-	-6		I.		.360	7.50	OFDOOR CARE-	
100	And the second		-	1.2		1	7	2	-4	++	-18	٠,	1,	•		177	SPARE	
				1.2				9		<b>♦</b> +	10	-	I.					
SPARE						1.	1	11	1-1	· 🛉 💠	1/2		1	1			1	
	to the plant of					1	17.	13	-+	++	-111	.,	J					
		100			T	I	1	15		<b>-!-</b>	16	Ŀ	$\prod$				, 1	1
		/" · · · ·				$\Box$	Ŀ	19	1-1	·+•	- 18							
			7			I	1	19	1-4	++	- 20							
1 1/1		, ···.					!	21	1-1	-+-	- 22	Ŀ	1					
					1	Ш	1	23	1-1	++	24	Ŀ	1	1_				
						<sub>e</sub> -	L	25	1-1	++	- 21		11	_		1		
·			-	<b> </b>	1	11	1	27		71	- 28	Ľ	11	1	<u> </u>	_		
			_	<u> </u>	1		1	29			- 30	Ŀ	14	1	_	-		
			-		1	14	Ŀ	31	1-1	1 †	- 32	4_	14	1_		1_		
			_	_	1	1.1	1	33	1-	-9-1	- 32		1	L	<u> </u>	1.		
			_		1	1	1	35	1-		- 31		4	4	1.	1		
	<u> </u>			-	1	11	1	13	7		-38		11	1	ļ	_		
1		٠,	1_	-	_	Ш	L	30	1	* * †	-9		1	1	1	1		
V			1.		1	V	L	141		-+•	-4	-	IV	1		_		314,1
			ī	6.0	KW					٠.,	١.,				1.18	Pos	ITION SIZE	
	LOAD		<del></del>	<del></del>	-	-	PI	EA1	E.	Α	<del>-</del> ; -	+	-				DIST. BOARD	
K.W	AMPS	· · ·	-		· ,			IÁS		C	<u> </u>		_			i	E OR TRIP	

**Figure 5.3.5** | 1KN2

PANEL TYPE MAIN LUG	<b>3</b>	-	-	_ p	ANI	EL)	1					E	MECH	ATI	NG 208/120 V 30 4W
DESCRIPTION	Wire Size	b.	A MP S	7818	POLE	CIN C.	_	ASE B C	0180	POLE	TRIP	AKPS	Ni N	Wire Size	DESCRIPTION
NP ROOF TOP GPI RECEPT		.720		20.	1	1.	-	++	2	1	20,		.54		WP PLOOF TOP GFI PECEPT
v sjille v	. 1	.720			1.0	3		• <del> </del>   -	- 4		1		.54 .		
HEAT TRACE		1				5	-	++-	-6	٠,	$\mathbf{L}$		.72	7 %	V
SPANE				7	7	2	-4	++	-18	1	Ţ				SAME
AHU-1 LTG & CONTMOLS	"	.72				9		++	10	·	T.		.72		AHU-4 LTG & CONTROLS
AHU-2 LTG & CONTROLS		.72		1.	17	11	-	- j 👆	-1/2				.72.		AHU +5 LTG + CONTROLS
SPANE					17	13	-4	++	-111	.,	I	-			SPANE
Span6		: :	Γ		1	15		<b></b>	-16		II.				SPANE
EXH FAN EF-3 1/3HP	1	,864	Г	II.		19	Н	-++	-18		IT.		.864		EXHAUST FAN EF-1 1/3HF
PARE	1		1	IT		19	-	1-1-	-20	1	٧,		7		SPANE
	1		T	П	1	21.	1-		- 22		20	P	21662		COND. UNIT CU-4 (208V 14
V	1	1	T	V		23	-	╁┼╈	- 24		1	2			12.8 FLA
COND. UNIT CU-1 (208 V 36)		4.60	1	25	/	25	1-	<b> </b>	- al		25	V	4.60		COND. UNIT CU:5 (208V 39
12.8 FLA			1	1	L	27	1-	<b>├-┿</b> -├	- 28		$\mathbb{Z}$	1			12.8 FLA
			V	1	3	29	-		- 30	1	1	3	174		- 1
COND. UNIT CU-2 (2081 30)		4.60	Т	<b>Z</b> 5	V	131	1-	<b> </b>	- 32	3	20		1.49	1.	EXHUAST FAN EF-2 1.04P
12.8 FLA	1	-	T		1	33	1-		-39	1	/	7		,	4.14 FLA
			V	1	3	35	1-	+-1-4	-3		1	. 3		1	
COND. UNIT CU-3 (208V 30)		4.60		25	V	13	1-	<b> - - </b>	-32	7	30	V			SPARE
12.8 FLA	1	1	T	$\nabla$	7	30	1-	₽. <del>∳</del> ∮	-4	0	$\overline{V}$	7			The second section
· · · · · · · · · · · · · · · · · · ·			V	1	3	4	1-	1-1-4	-4	4	1	3			The state of the s
	,	. 17.5	K١	J			· .	. '."	, Ţ.	-	1		12.9	(Vos	ITION SIZE
TOTAL LOAD	7.			-			E	A	÷	+	_				DIST. BOARD
K.WAMPS		;		7			E	C		1				-	E OR TRIP

**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 S	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)

	i	PANE	EL B	0	Α	R	D S	HE	ULE				
VOLTAGE: 480/277 SIZE/TYPE BUS: 400A SIZE/TYPE MAIN: M.L.O	V,3PH,4W		PANEL T IEL LOCATI EL MOUNTI	ON:	BAS	SEM	IENT B013		MIN. C/B AIC: 25K OPTIONS:				
DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	Α	В	С	POS. NO.	C/B SIZE	LOAD (W)	DE	SCRIPTION		
ELEVATOR NO. 1 (50 HP)	18000	150A/3P	1	*			2	150A/3P	18000	ELEVATOR NO. 1	(50 HP)		
[65 FLA]	18000	1	3		*		4		18000	[65 FLA]	,		
	18000		5			*	6		18000	1			
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 21	*	*		20	150A/3P		SPARE			
				Н	•		22 24						
SPARE		100A/3P	23 25	*			26	100A/3P		SPARE			
SFARE		1007/37	27		*		28	1004/35		SPARE			
			29	Н		*	30						
				Н			- 00						
CONNECTED LOAD (KW) - A	68.40								TOTAL DESIG	N LOAD (KW)	205.20		
CONNECTED LOAD (KW) - B	68.40								SPACE (GROWTH) FACTOR		1.35		
CONNECTED LOAD (KW) - C								TOTAL DESIG	N LOAD (A)	333			

Figure 5.3.7 | New Panel BNDP1

	P A	NEL	ВО	Α	R	D	SCF	IEDU	JLE		
VOLTAGE: 480/277V,3P SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: M.L.O.	H,4W		PANEL T IEL LOCATI EL MOUNTI	ON:	BAS	SEM	ENT B013	MIN. C/B AIC: 25K OPTIONS:			
DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	Α	В	С	POS. NO.	C/B SIZE	LOAD (W)	DESC	CRIPTION
DOMESTIC WATER HTR CONTL DHWP-1 & DHWP-2 (1/12 HP EA)	360 600	20A/1P 20A/1P	1 3	*	*		2	20A/2P	950 950	AC-1 & AC-2 [2.73 + 1.21 FLA]	
DOMESTIC HOT WATER HTR DHW-1	600	20A/1P	5 7	*		*	6	20A/1P 20A/1P		SPARE SPARE	
SPARE		20A/1P	9		*	*	10	20A/1P		SPARE	
SPARE SPARE		20A/1P 20A/1P	11 13	*			12 14	20A/1P 20A/1P		SPARE SPARE	
SPARE SPARE		20A/1P 20A/1P	15 17		*	*	16 18	20A/1P 20A/1P		SPARE SPARE	
SPACE SPACE			19 21	*	*		20 22	20A/3P	2100 2100	LOADING DOCK I [7.58 FLA]	LIFT MOTOR (5 HP)
SPACE SPACE			23 25	*		*	24 26		2100	SPACE	
SPACE			27		*		28			SPACE	
SPACE SPACE			29 31	*		_	30 32			SPACE SPACE	
SPACE SPACE			33 35		*	*	34 36			SPACE SPACE	
											T
CONNECTED LOAD (KW) - A	3.41								TOTAL DESIG	` ,	9.76
CONNECTED LOAD (KW) - B CONNECTED LOAD (KW) - C	3.65 2.70								SPACE (GROV	NTH) FACTOR	1.50

Figure 5.3.8 | New Panel BNDP2

	ı	PANE	EL B	0	Α	R	D S	HE	ULE			
VOLTAGE: 480/277 SIZE/TYPE BUS: 100A SIZE/TYPE MAIN: M.L.O.	V,3PH,4W		PANEL T IEL LOCATI EL MOUNTI	ON:	ELE	СТ	RICAL ROO CE	MIN. C/B AIC: 22K OPTIONS:				
DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	Α	В	С	POS. NO.	C/B SIZE	LOAD (W)	DE	SCRIPTION	
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		
				H								
CONNECTED LOAD (KW) - A	12.19								TOTAL DESIG	N LOAD (KW)	31.78	
CONNECTED LOAD (KW) - B	9.13								SPACE (GROV	VTH) FACTOR	1.25	
CONNECTED LOAD (KW) - C	10.46								TOTAL DESIG	TOTAL DESIGN LOAD (A) 5		

Figure 5.3.9 | New Panel 2P1

PANEL BOARD SCHEDULE												
VOLTAGE: 208Y/1 SIZE/TYPE BUS: 60A SIZE/TYPE MAIN: M.L.O.		PAN	PANEL T IEL LOCATI EL MOUNTI	AG: ON:	2P1 ELE	A CTI	RICAL ROO	MIN. C/B AIC: 22K OPTIONS:				
DESCRIPTION	LOAD (W)	C/B SIZE	POS. NO.	Α	В	С	POS. NO.	C/B SIZE	LOAD (W)	DESC	RIPTION	
WP ROOF TOP GFI RCPT	720	20A/1P	1	*			2	20A/1P	540	WP ROOF TOP GF	TRCPT	
WP ROOF TOP GFI RCPT	720	20A/1P	3		*		4	20A/1P	540	WP ROOF TOP GF		
HEAT TRACE	0	20A/1P	5			*	6	20A/1P	720	WP ROOF TOP GF		
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 & CON	TROLS	
AHU-2 LTG & CONTROLS	720	20A/1P	11			*	12	20A/1P	720	AHU-5 LTG & CON		
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 DESIG	N LOAD (KW)	7.50	
CONNECTED LOAD (KW) - B	2.70								POWER FACT	OR	1.00	
CONNECTED LOAD (KW) - C 2.16									TOTAL DESIG	N LOAD (AMPS)	2	

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: Electrica	al System F	Redesign - 208	120V to 48	0/277V - C	ost 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 I	N 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			
		=						
FFFFF				D 400l				
FEEDERS		No. Wires	Ex. Size	Per 100' Ex. Cost/Unit	Ex. Cost	New Size	(All feeders 75 New Cost/Unit	New Cost
Label	Length (ft)			\$1,550.00				
A	30	4	(4) 500 4/0	, ,	\$7,440.00	(4) 500	\$1,550.00	\$7,440.00
В	35	4		\$755.00	\$1,063.04	3	\$244.00	\$343.55
С	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
	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
М	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	<b>Existing Cost</b>	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.

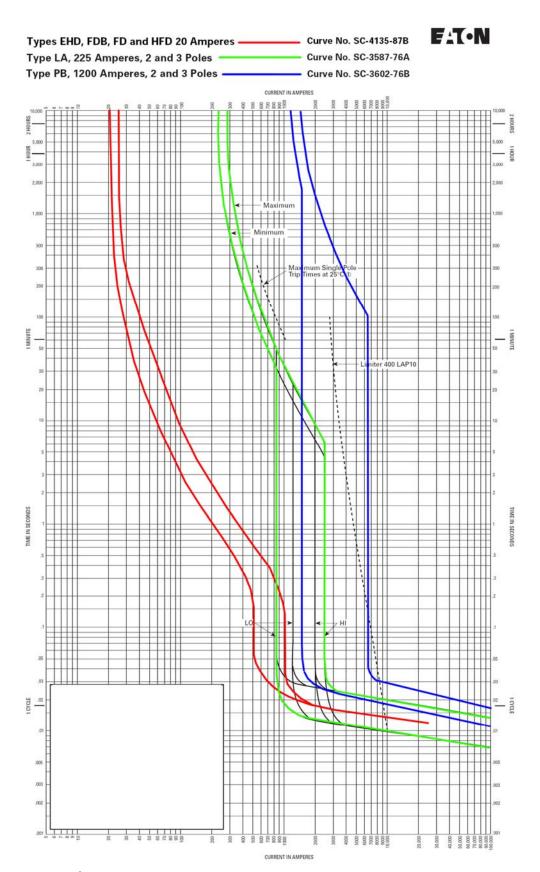


Figure 5.4.1 | Protective Device Coordination

	Table 5.4.1: Sumn	nary Results of Fault Ana	alysis
Point	Location	Available Fault (A)	Standard Breaker Rating (A)
Α	Utility Company Secondary	41630	50000
В	Switchboard (MSB2)	40197	50000
С	Distribution Panel (1NDP1)	34195	35000
D	End Use Panel (1N1)	24599	25000

	Table 5.4.2: Fault Current	Analysis (Per l	Jnit Me	thod)		
	System Voltage	= 208				
	Base KVA	= 10000				
	Utility Company Available Fault	= 100000000	ΣΧ	ΣR	ΣZ	I <sub>sc</sub> (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	0.000	0.000	0.000	277372243
Transformer Seconda	nry					
%Z = 5.00	$X_{(p.u.)} = %X * KVA_{base} / 100 * KVA_{xfrmr}$	= 0.5951	0.505	0.201	0.667	41630
X/R = 1.98	$R_{(p.u.)} = \%R * KVA_{base} / 100 * KVA_{xfrmr}$	= 0.3005	0.595	0.301	0.667	41630
%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 <sub>(p.u.)</sub>	= 0.0127	0.013	0.515	0.091	40137
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	24105
Length = 35	R = (L/1000) * R * (1/Sets), R <sub>(p.u.)</sub>	= 0.0720	0.714	0.385	0.812	34195
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 <sub>(p.u.)</sub>	= 0.2663	0.921	0.032	1.120	24333
Sets = 1						
X = 0.050						
R = 0.064						