

# **Fisk Corporate Headquarters**

## **Houston, Texas**



**Penn State AE Senior Capstone Project**  
**Stephen Blanchard – Construction Management Option**  
**Advisor: Dr. John Messner**



## Project Summary

### Analysis #1: Project Sequencing

- Sequencing Process
- Schedule Results
- Cost Implications

### Analysis #2: Electrical System Redesign

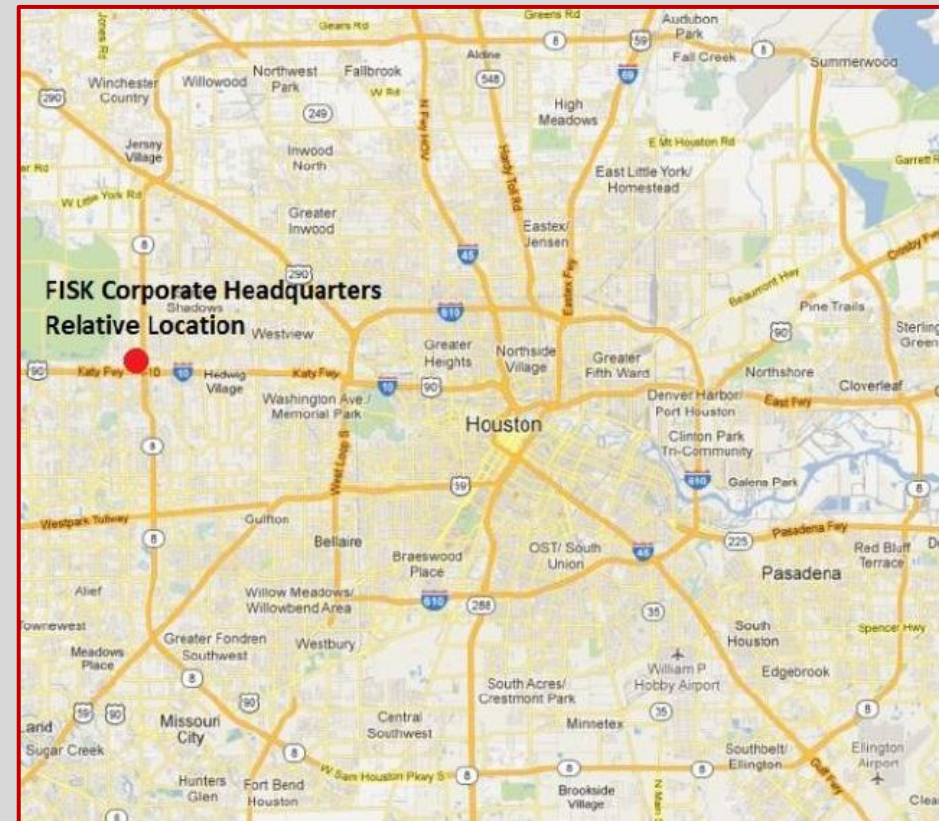
- Electrical Redesign
- Redesign Impacts

### Analysis #3: Implementation of LEED

- LEED Cost Analysis
- Architectural Breadth
- Energy Impacts
- BIM Research

### Final Recommendations

### Acknowledgments



## Project Location

Houston, Texas

## Building Information

Office Size: 37,780 Sq. Feet  
Pre-Fab Size: 16,380 Sq. Feet  
2 Stories Above Grade  
Structural Steel

## Construction Logistics

Cost: \$7,957,144  
Duration: 11/21/11 – 10/5/12  
Delivery: Design-Bid-Build  
Contract Type: Lump Sum

## Ownership Team Information

Fisk Electric Corp.  
Tutor Perini Corp.





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## Problem Identification

- 47 Week Construction Duration
- Scheduling Gaps
- Limited Activity Overlap (Finish to Start)

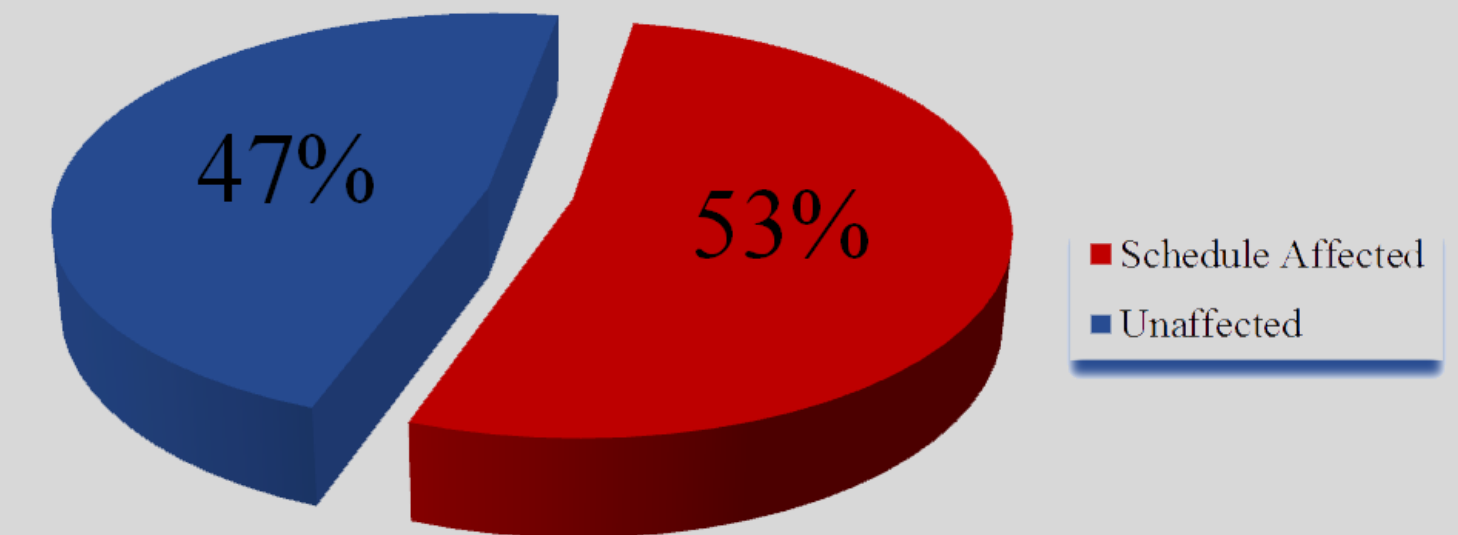
## Background

- Extensive General Conditions Implications
- Fisk Electric Carried General Conditions
- Includes Tutor Perini Staffing and Fees

## General Conditions Overview

- Total Cost: \$1,122,906
- 14% of Construction Costs

### Composition





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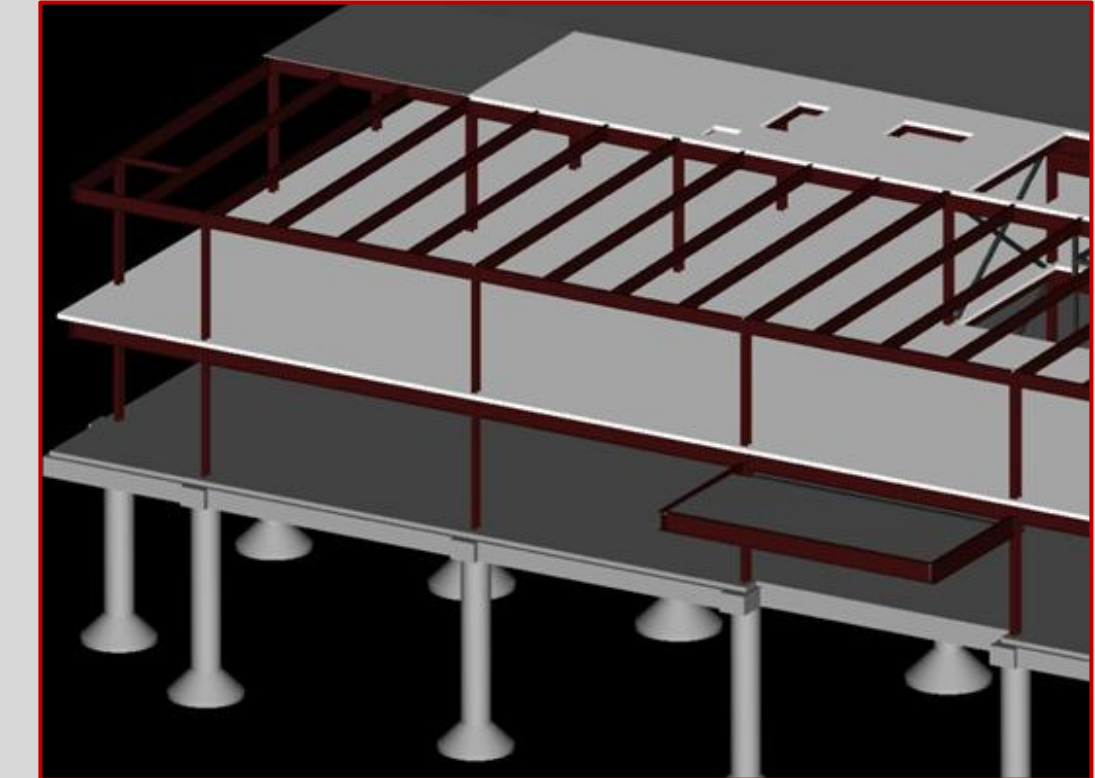
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Office Building Foundations and Structure	90 days	Mon 12/12/11	Fri 4/13/12
Drill & Pour Caissons	5 days	Wed 1/4/12	Tue 1/10/12
Rebar/Form & Pour Pile Caps/Grade Beams	6 days	Fri 1/13/12	Fri 1/20/12
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Original Structure Erection Schedule

Duration: 90 Days  
All Activities on Critical Path  
Relationships: Finish to Start (All Activities)  
Separated Pours





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**Re-Sequencing Process**

1. Remove All Schedule Gaps
2. Re-Sequence Activities
3. Identify Potential Overlap





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One Month

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**Sequencing Process**

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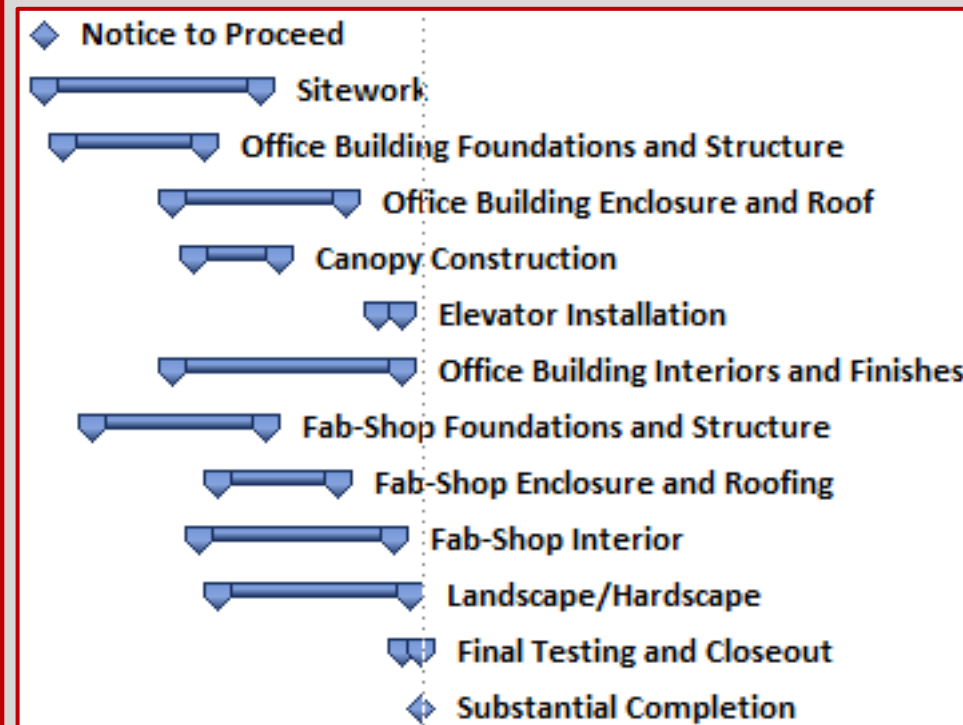
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**Duration Results**

**Overall Schedule Reduced by 4 Weeks**  
**No Activity Durations Were Altered**

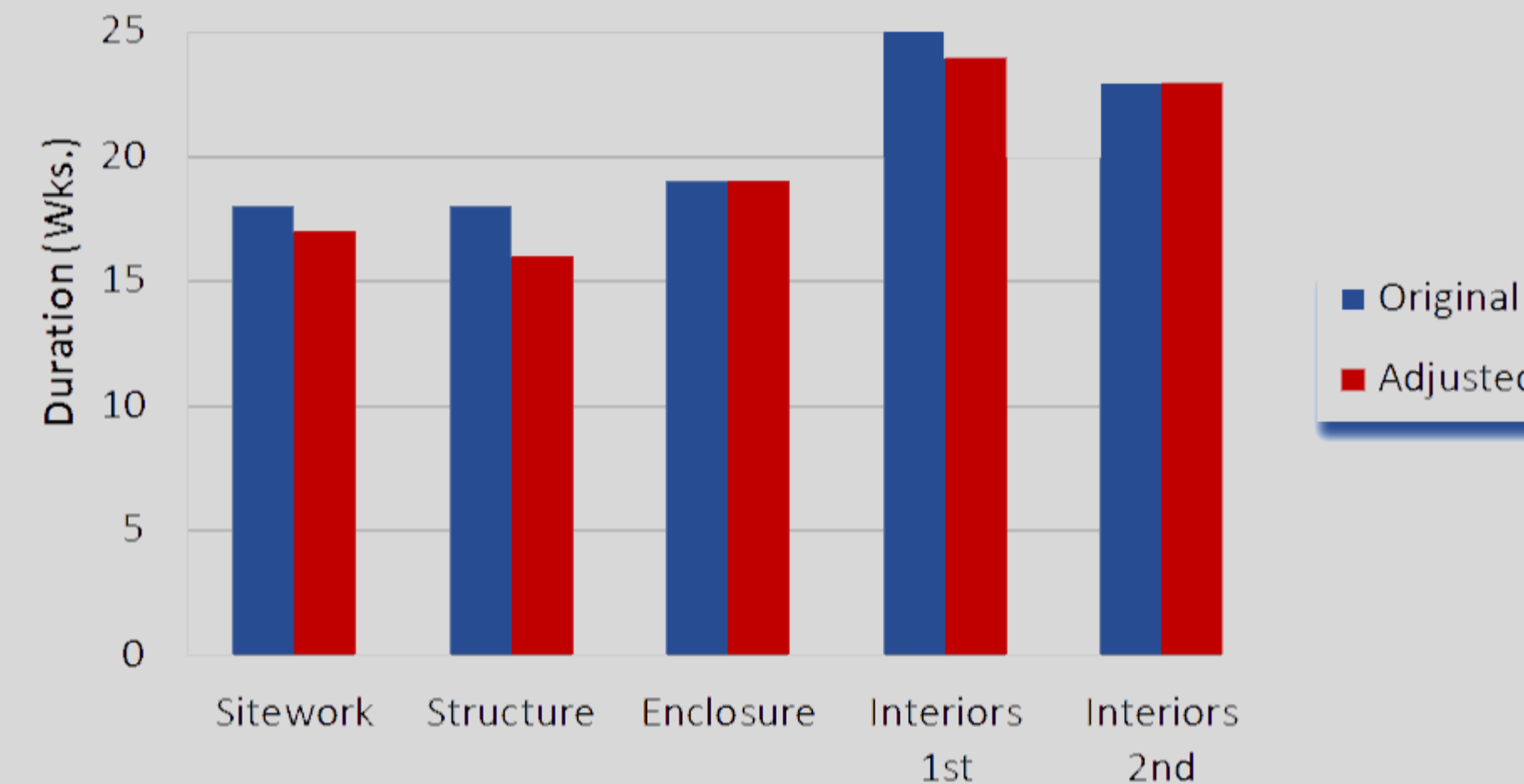
**Phase Reductions**

**Office Sitework: 1 Week**  
**Office Structure: 2 Weeks**  
**Office Interiors: 1 Week**

**Non-Critical Path Phase Reductions**

**Fab-Shop Enclosure: 7 Weeks**  
**Fab-Shop Interior: 2 Weeks**  
**Landscape/Hardscape: 2 Weeks**

**Phase Duration Comparison**





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**Cost Implications**

**\$50,698 Total GC Savings**

**Savings Type**

**\$45,780 in Weekly Savings**

**\$4,917 in Monthly Savings**

**Non-Quantifiable**

Activity Duration Reductions

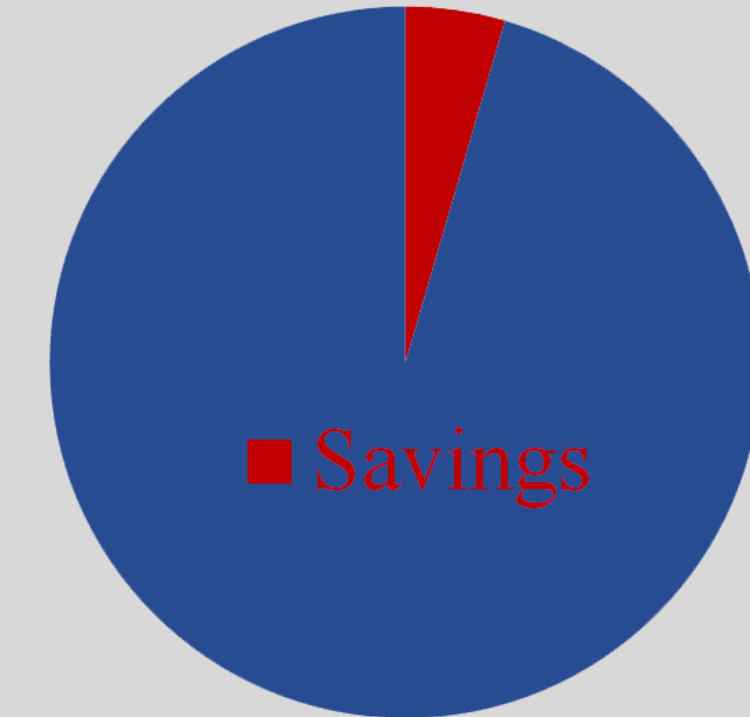
Crew Mobilizations

Crew Consistency

**General Conditions Savings Breakdown**

<b>Project Management</b>	<b>\$27,500</b>
<b>Project Supervision</b>	<b>\$14,500</b>
<b>Temporary Facilities</b>	<b>\$1,917</b>
<b>Temporary Utilities</b>	<b>\$3,000</b>
<b>Waste Management</b>	<b>\$3,780</b>

**General Conditions 5% Savings**





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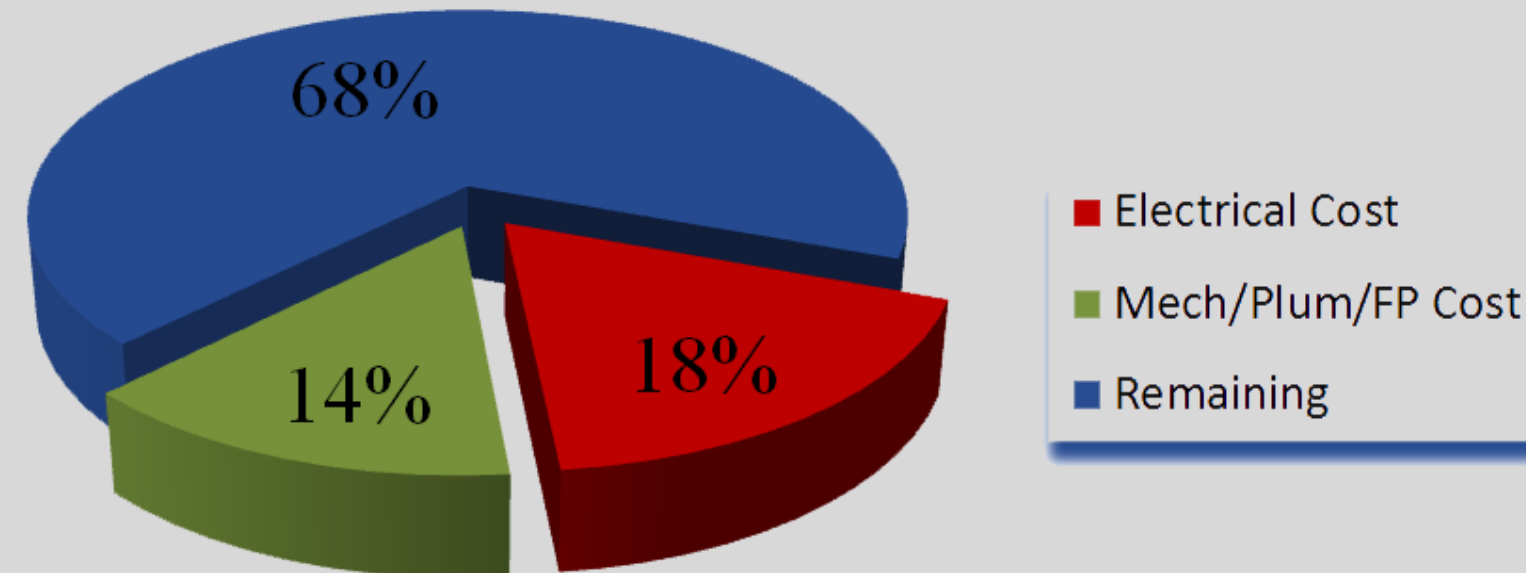
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### Problem Identification

**\$1,223,400 Electrical Cost**  
**Costly Distribution System**  
**Redundant Components**

### % Total Construction





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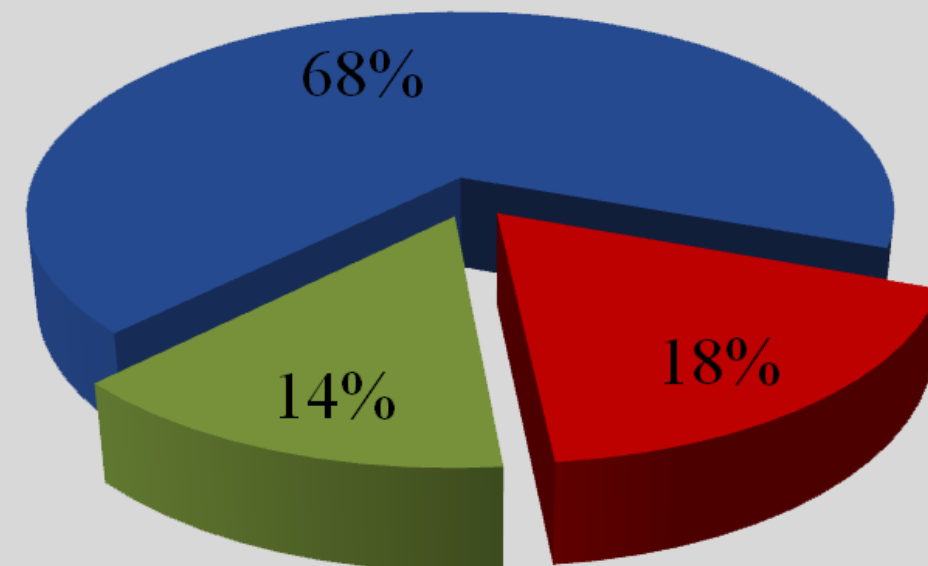
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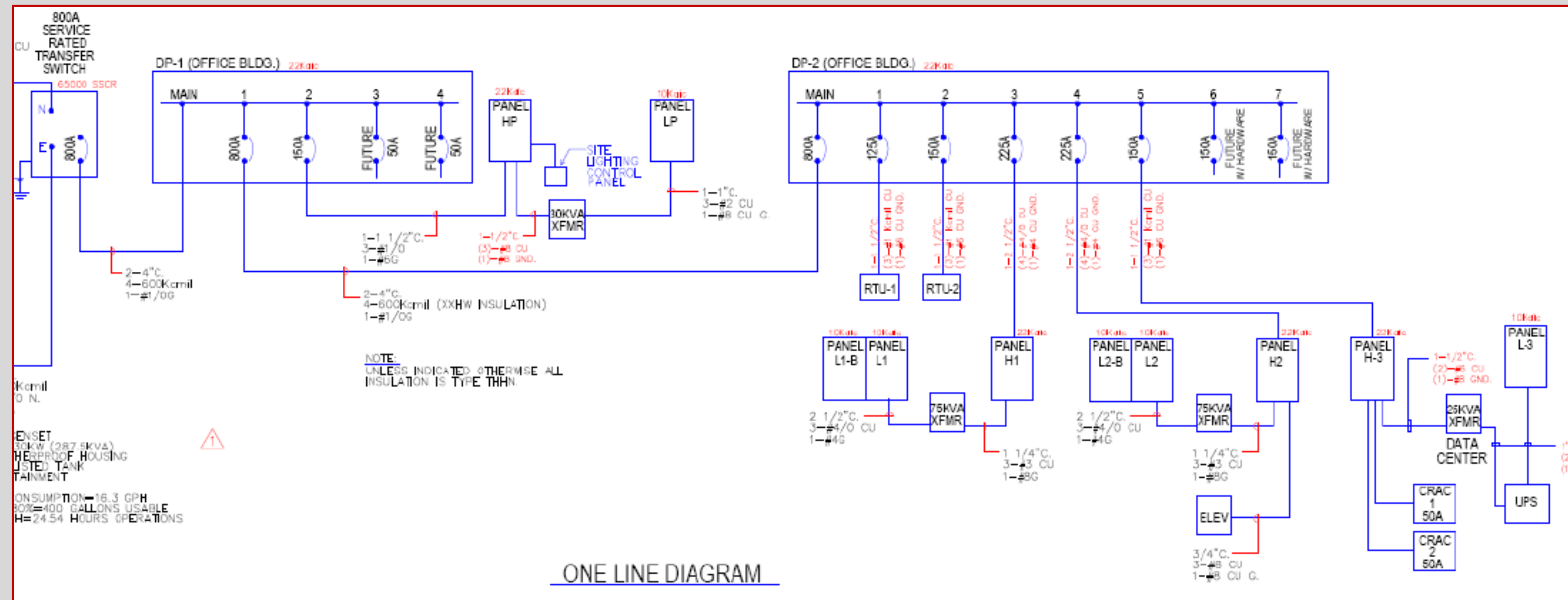
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% Total Construction



Original One-Line Diagram





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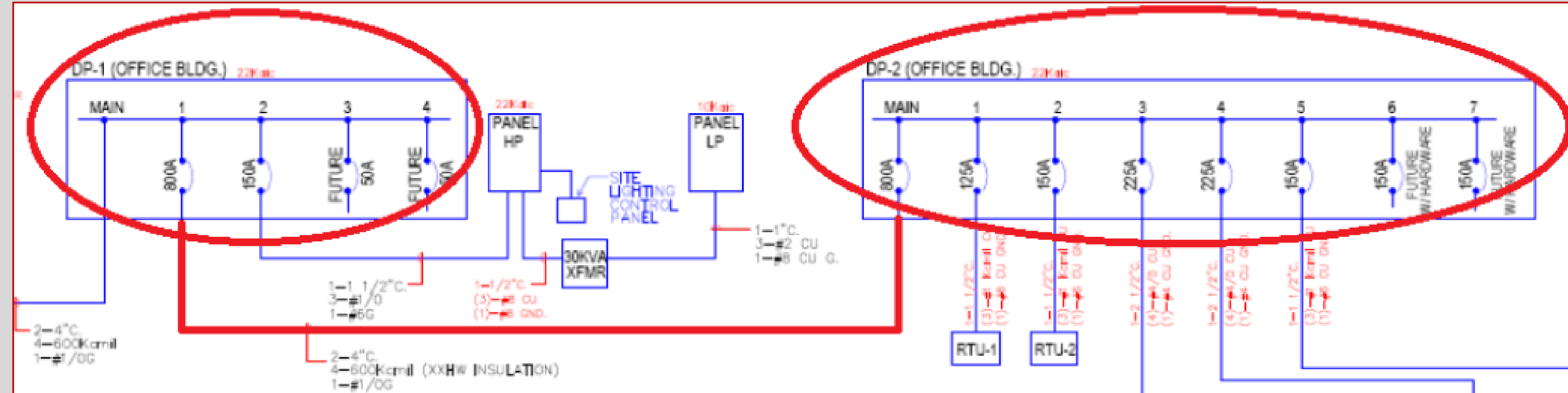
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## Redesign Process

1. Eliminate Distribution Panel Redundancy
2. Streamline Step-Down Voltage System
3. Back-Feed Data Center Distribution System

## Eliminate Distribution Panel Redundancy





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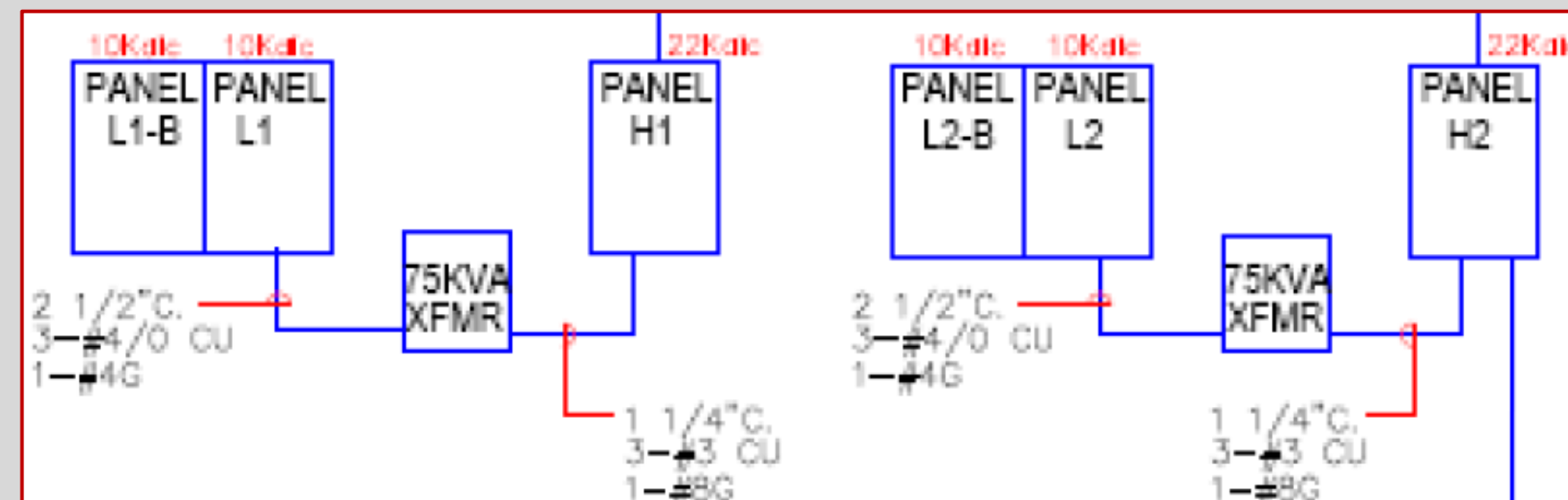
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## Streamline Step-Down Voltage System



			PANEL L1B			208Y/120V, 3 PHASE, 4 WRE, 225 AMPS			
VOLT AMPS	WIRE/ CONDUIT	SERVING	BKR	MLO	BKR	SERVING	WIRE/ CONDUIT	VOLT AMPS	
500	2- #12s+#12gnd, 1/2"C	Sign on Westview	1P-20 1	A	2	1P-20	AV equip rm 309	2- #12s+#12gnd, 1/2"C	720
1176	2- #12s+#12gnd, 1/2"C	Gate Motor 1 East Gate 1/2 hp	1P-20 3	B	4	1P-20	recep mtg room 309	2- #12s+#12gnd, 1/2"C	900
1176	2- #12s+#12gnd, 1/2"C	Gate Motor 2 East Gate 1/2hp	1P-20 5	C	6	1P-20	recep rm 318-320	2- #12s+#12gnd, 1/2"C	1080
1176	2- #12s+#12gnd, 1/2"C	Gate Motor 1 West Gate 1/2 hp	1P-20 7	A	8	1P-20	recep rm 310-314	2- #12s+#12gnd, 1/2"C	1080
1176	2- #12s+#12gnd, 1/2"C	Gate Motor 2 West Gate 1/2 hp	1P-20 9	B	10	1P-20	SPARE		0
1176	2- #12s+#12gnd, 1/2"C	Elev .Sump Pump ESP-1 1/2hp	1P-20 11	C	12	1P-20	Fire Alarm Panel	2- #12s+#12gnd, 1/2"C	360
330	2- #12s+#12gnd, 1/2"C	Elev. Pfl light	1P-20 13	A	14	1P-20	Sprinkler Room Recep	2- #12s+#12gnd, 1/2"C	360
180	2- #12s+#12gnd, 1/2"C	Elev GFCI recep	1P-20 15	B	16	1P-20	SPARE		0
540	2- #12s+#12gnd, 1/2"C	Hallw ay 403	1P-20 17	C	18	1P-20	SPARE		0
800	2- #12s+#12gnd, 1/2"C	Training rm projector	1P-20 19	A	20	1P-20	SPARE		0
800	2- #12s+#12gnd, 1/2"C	Training rm projector	1P-20 21	B	22	1P-20	SPARE		0
720	2- #12s+#12gnd, 1/2"C	Break rm shade	1P-20 23	C	24	1P-20	SPARE		0
720	2- #12s+#12gnd, 1/2"C	Rm 309 proj and screen	1P-20 25	A	26	1P-20	SPARE		0
900	2- #12s+#12gnd, 1/2"C	Recep Hall 202	1P-20 27	B	28	1P-20	SPARE		0
720	2- #12s+#12gnd, 1/2"C	Recep Rm 200	1P-20 29	C	30	1P-20	SPARE		0
1920	2- #12s+#12gnd, 1/2"C	Copier rm 207	1P-20 31	A	32	1P-20	SPARE		0
800	2- #12s+#12gnd, 1/2"C	Laser Printer rm 207	1P-20 33	B	34	1P-20	SPARE		0
720	2- #12s+#12gnd, 1/2"C	recep rm 102	1P-20 35	C	36	1P-20	SPARE		0
720	2- #12s+#12gnd, 1/2"C	Recep rm 103	1P-20 37	A	38	1P-20	SPARE		0
180	2- #12s+#12gnd, 1/2"C	Lobby recep	1P-20 39	B	40	1P-20	SPARE		0
0		SPARE	1P-20 41	C	42	1P-20	SPARE		0
			A	B	C	TOT. CONN. LOAD :		20.93 KVA	
			8.3	6.1	6.5	@ 208V, 3 PHASE :		58.1 AMPS	



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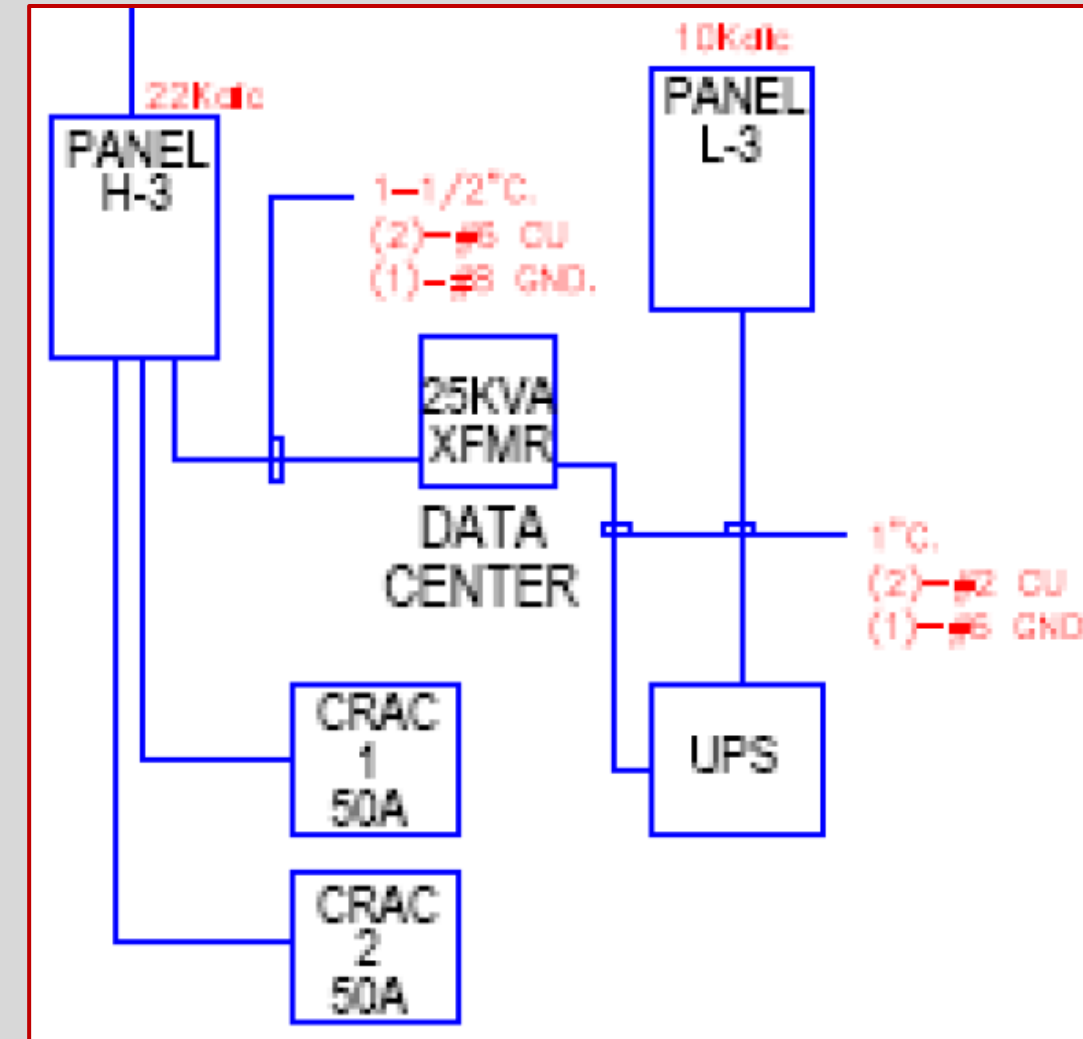
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## Back-Feed Data Center Distribution System





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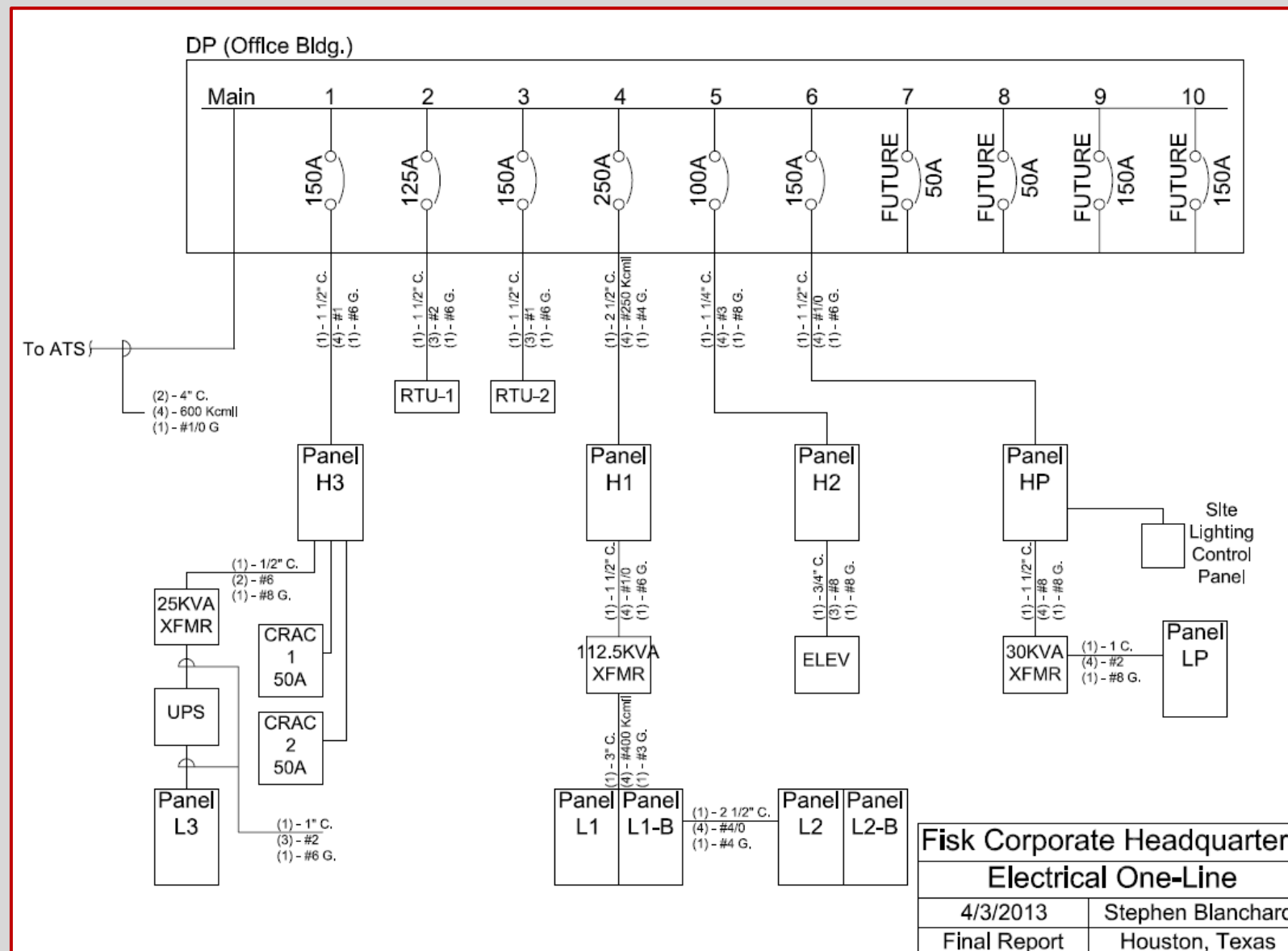
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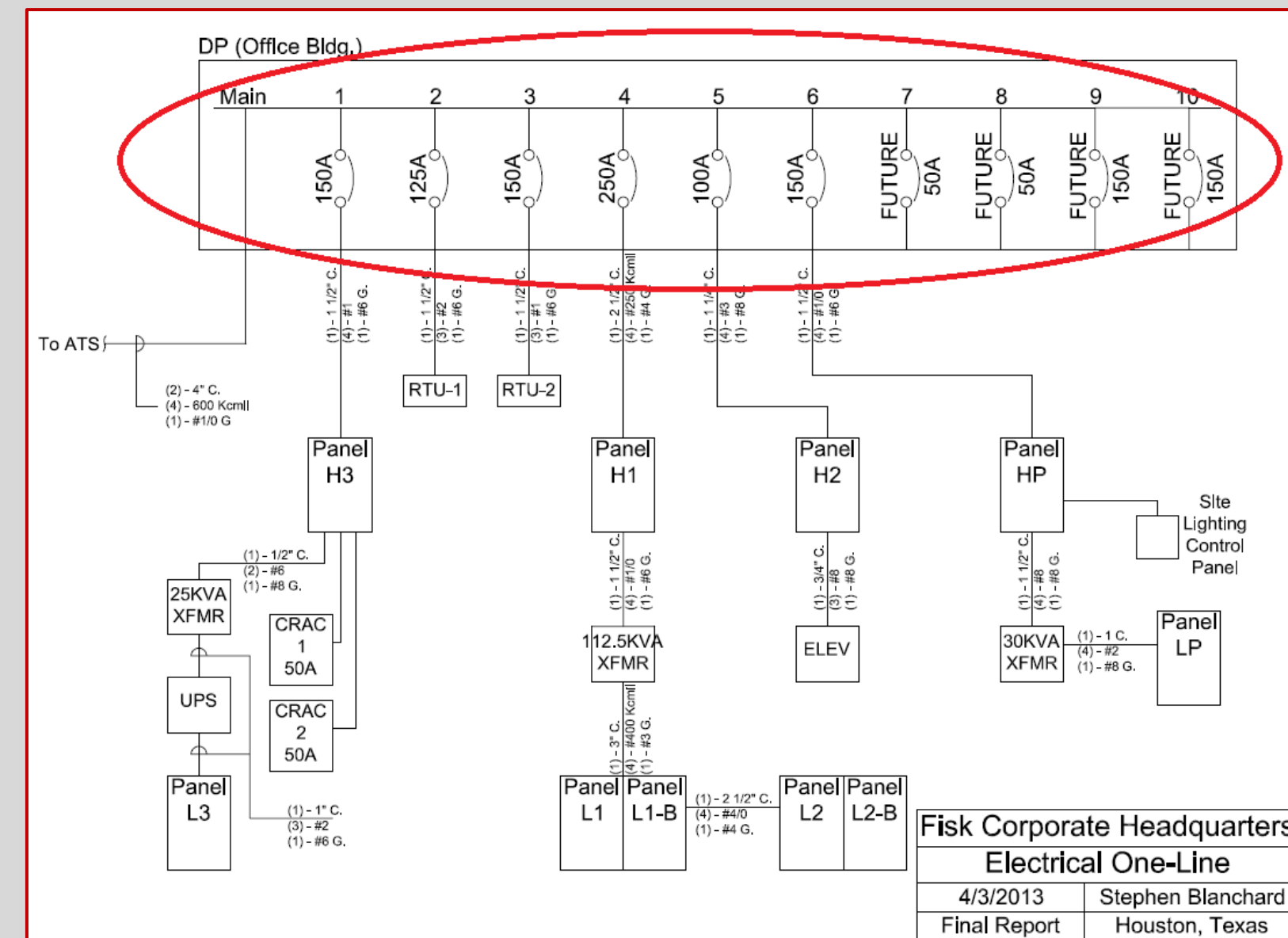
1. Combined Distribution Panel

2. Single Step-Down Voltage Distribution System

3. Changes in Feeder Sizing and Distances

Combined Distribution Panel

DP (800 Amp Panelboard)																	
V:	480Y/277	Rm #	1-505	22000	AIC	3P - 4W	Fdr:	2 x (4) 600 & #1/0G.	2 x 4"C	625 kVA	800 A	MCB					
Designations			VA/Phase			Bkr/Pole/Wire			Designations			VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W		
1	Panel H-3 (1-505)	22750			150	3	#1	2	RTU-1 (Roof)	29550			125	3	#2		
3	-		22750		-	-	-	4	-		29550		-	-	-		
5	-			22750	-	-	-	6	-			29550	-	-	-		
7	RTU-2 (Roof)	34294			150	3	#1	8	Panel H-1 (1-505)	65667			250	3	250		
9	-		34294		-	-	-	10	-		65667		-	-	-		
11	-			34294	-	-	-	12	-			65667	-	-	-		
13	Panel H-2 (2-505)	26000			100	3	#3	14	Panel HP (Fab Shop)	29837			150	3	1/0		
15	-		26000		-	-	-	16	-		29837		-	-	-		
17	-			26000	-	-	-	18	-			29837	-	-	-		
19	Spare	0			50	3	-	20	Spare	0			50	3	-		
21	-		0		-	-	-	22	-		0		-	-	-		
23	-			0	-	-	-	24	-			0	-	-	-		
25	Spare	0			150	3	-	26	Spare	0			150	3	-		
27	-		0		-	-	-	28	-		0		-	-	-		
29	-			0	-	-	-	30	-			0	-	-	-		
31	Space	0			0	0	#####	32	Space	0			0	0	#####		
33	Space		0		0	0	#####	34	Space		0		0	0	#####		
35	Space			0	0	0	#####	36	Space			0	0	0	#####		
37	Space	0			0	0	#####	38	Space	0			0	0	#####		
39	Space			0	0	0	#####	40	Space			0	0	0	#####		
41	Space			0	0	0	#####	42	Space			0	0	0	#####		





## Project Summary

### Analysis #1: Project Sequencing

Sequencing Process

Schedule Results

Cost Implications

### Analysis #2: Electrical System Redesign

Electrical Redesign

Redesign Impacts

### Analysis #3: Implementation of LEED

LEED Cost Analysis

Architectural Breadth

Energy Impacts

BIM Research

Final Recommendations

Acknowledgments

## Redesign Results

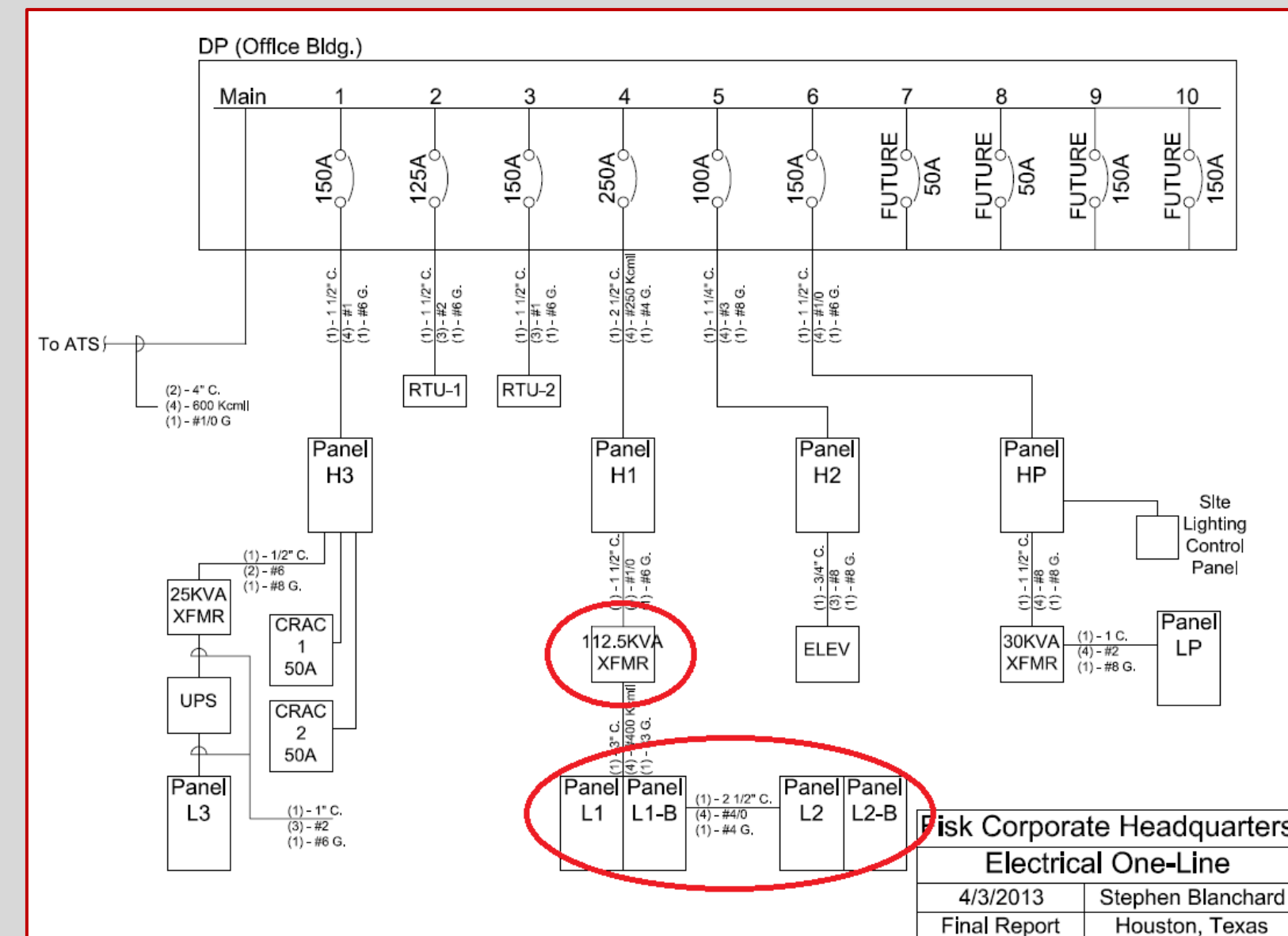
### 1. Combined Distribution Panel

### 2. Single Step-Down Voltage Distribution System

### 3. Changes in Feeder Sizing and Distances

## Single Step-Down Voltage Distribution System

L-1B																	
V:	208Y/120	Rm #	1-505	10000	AIC	3P - 4W	Fdr:	Section #2		73	kVA		MLO				
Designations			VA/Phase			Bkr/Pole/Wire			Designations			VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W		
1	Sign on Westview (Site)	500			20	1	#12	2	AV Equipment (309)	720			20	1	#12		
3	Gate Motor 1 (East)		1176		20	1	#12	4	Receptacles (309)		900		20	1	#12		
5	Gate Motor 2 (East)			1176	20	1	#12	6	Receptacles (318-320)			1080	20	1	#12		
7	Gate Motor 1 (West)	1176			20	1	#12	8	Receptacles (310-314)	1080			20	1	#12		
9	Gate Motor 2 (West)		1176		20	1	#12	10	Spare		0		0	0	#####		
11	Elev. Sump Pump (Elev.)			1176	20	1	#12	12	Fire Alarm Panel (IDF)			360	20	1	#12		
13	Elev. Pit Light (Elev.)	330			20	1	#12	14	Receptacles (Sprinkler)	360			20	1	#12		
15	Elev. GFCI (Elev.)		180		20	1	#12	16	Space		0		0	0	#####		
17	Hallway Power (403)			540	20	1	#12	18	Space			0	0	0	#####		
19	Projector (Training Room)	800			20	1	#12	20	Space		0		0	0	#####		
21	Projector (Training Room)		800		20	1	#12	22	Space		0		0	0	#####		
23	Shade (Break Room)			720	20	1	#12	24	Space			0	0	0	#####		
25	Proj. and Screen (309)	720			20	1	#12	26	Space		0		0	0	#####		
27	Receptacles (202)		900		20	1	#12	28	Space		0		0	0	#####		
29	Receptacles (200)			720	20	1	#12	30	Space			0	0	0	#####		
31	Copier (207)	1920			20	1	#12	32	Space		0		0	0	#####		
33	Laser Printer (207)		800		20	1	#12	34	Space		0		0	0	#####		
35	Receptacles (102)			720	20	1	#12	36	Space			0	0	0	#####		
37	Receptacles (103)	720			20	1	#12	38	Panel L2 & L2B (2-505)	18158			225	3	4/0		
39	Receptacles (Lobby)		180		20	1	#12	40	-		18158		-	-	-		
41	Spare			0	0	0	#####	42	-			18158	-	-	-		





## Project Summary

### Analysis #1: Project Sequencing

Sequencing Process

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Electrical Redesign

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LEED Cost Analysis

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Acknowledgments

## Redesign Results

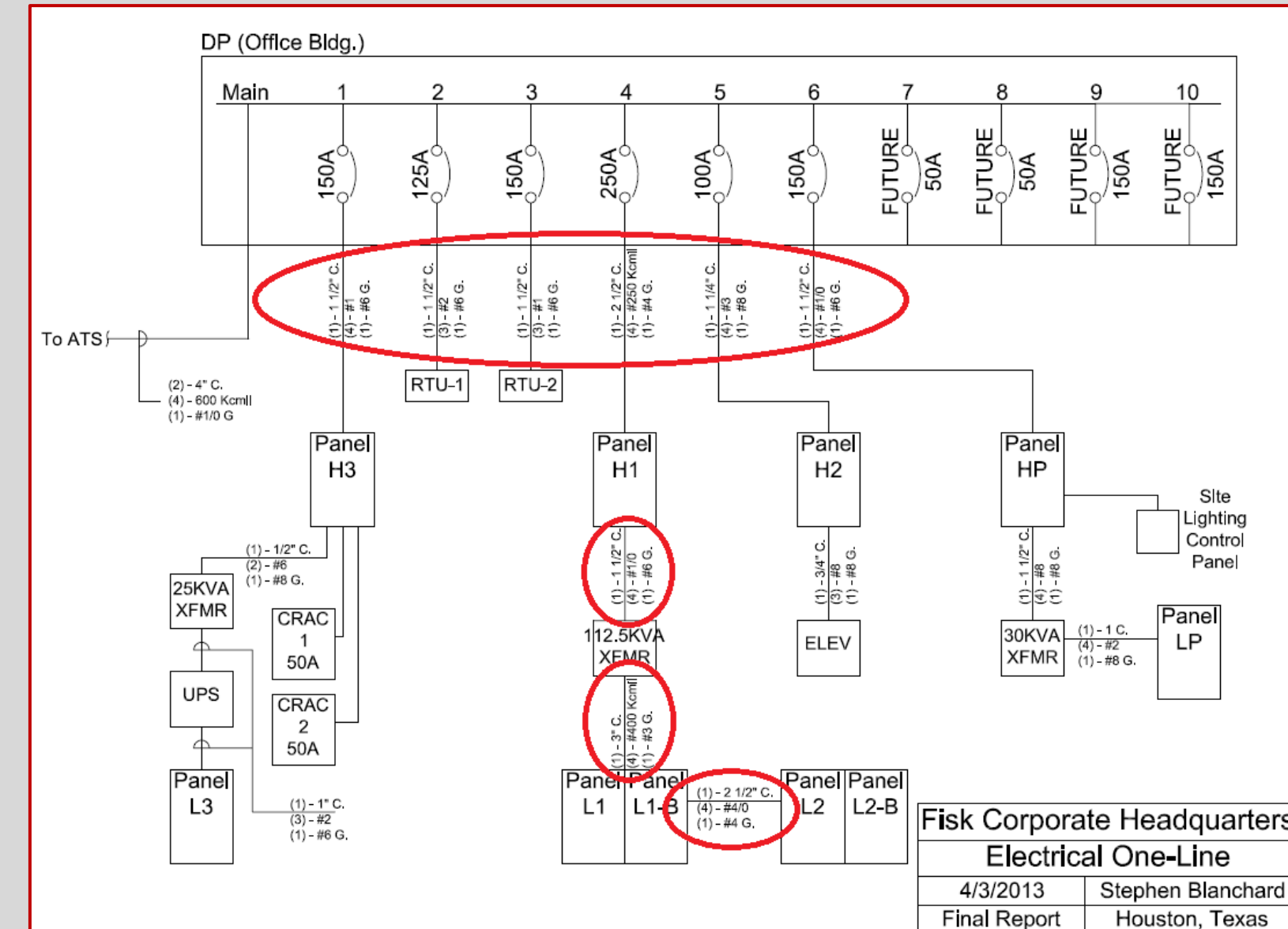
### 1. Combined Distribution Panel

### 2. Single Step-Down Voltage Distribution System

### 3. Changes in Feeder Sizing and Distances

## Changes in Feeder Sizing and Distances

H-2 (100 Amp Panelboard) <span style="color: red;">Original: (4) #4/0 &amp; #4G, 2.5" C</span>																	
V:	480Y/277	Rm #	1-505	22000	AIC	3P - 4W	Fdr:	(4) #3 & #8 G.	1.25" C	78 kVA	100 A	MLO					
Designations			VA/Phase			Bkr/Pole/Wire			Designations			VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W		
1	Workstations - Ltg. (SV)	1904			20	1	#12	2	Workstations - Ltg. (NW)	1128			20	1	#12		
3	Workstations - Ltg. (SE)		1236		20	1	#12	4	Workstations - Ltg. (NW)		1751		20	1	#12		
5	Offices - Ltg. (North)			2091	20	1	#12	6	Offices - Ltg. (North)			1938	20	1	#12		
7	Conf. Rm. - Ltg. (South)	340			20	1	#12	8	Conf. Rm. - Ltg. (North)	308			20	1	#12		
9	Core - Ltg. (West)		704		20	1	#12	10	Core - Ltg. (East)		874		20	1	#12		
11	Egress - Ltg. (Hall)			504	20	1	#12	12	Stairs (East)			234	20	1	#12		
13	FPB 2- 1,2,3,15,16,17	5775			30	3	#10	14	FPB 2-4,5,6,18	3935			20	3	#12		
15	-		5775		-	-	-	16	-		3935		-	-	-		
17	-			5775	-	-	-	18	-			3935	-	-	-		
19	FPB 2- 11,12,13,14,20,	5376			30	3	#10	20	FPB 2- 7,8,9,10,19	5154			30	3	#10		
21	-		5376		-	-	-	22	-		5154		-	-	-		
23	-			5376	-	-	-	24	-			5154	-	-	-		
25	Spare	0			0	0	#####	26	Spare	0			0	0	#####		
27	Spare		0		0	0	#####	28	Spare		0		0	0	#####		
29	Spare			0	0	0	#####	30	Spare		0		0	0	#####		
31	Spare	0			0	0	#####	32	Spare	0			0	0	#####		
33	Spare		0		0	0	#####	34	Spare		0		0	0	#####		
35	Spare			0	0	0	#####	36	Spare		0		0	0	#####		
37	Elevator	9422			50	3	#8	38	Spare	0			0	0	#####		
39	-		9422		-	-	-	40	Spare		0		0	0	#####		
41	-			9422	-	-	-	42	Spare			0	0	0	#####		





**Project Summary**

**Analysis #1: Project Sequencing**

Sequencing Process

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Cost Implications

**Analysis #2: Electrical System Redesign**

Electrical Redesign

**Redesign Impacts**

**Analysis #3: Implementation of LEED**

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**Final Recommendations**

**Acknowledgments**

**Constructability Concerns**

**David Rinehart**

**Ted Robertson**

**208Y/120 kVA Data**

<u>Description</u>	<u>kVA</u>
L-1	34
L-1B	21
L-2	39
L-2B	15
Combined Demand	109
Maximum Capacity	112.5

**Cost Impacts**

<u>Description</u>	<u>Original \$</u>	<u>Redesign \$</u>	<u>Savings \$</u>
DP-1 (800A Distribution Panelboard)	\$5,390		\$5,390
DP-2 (800A Distribution Panelboard)	\$10,133		\$10,133
DP (800A Distribution Panelboard)		\$9,213	(\$9,213)
H-1 (480Y/277V Panelboard)	\$2,883	\$3,770	(\$888)
L-1 (208Y/120V Panelboard)	\$2,180	\$2,759	(\$579)
L-1B (208Y/120V Panelboard)	\$1,308	\$1,895	(\$588)
H-2 (480Y/277V Panelboard)	\$2,960	\$2,675	\$285
75 kVA Step-Down Xfmer	\$8,189		\$8,189
112.5 kVA Step-Down Xfmer		\$5,651	(\$5,651)
Feeder: DP-1 to DP-2	\$7,178		\$7,178
Feeder: DP to H-1	\$1,564	\$1,756	(\$192)
Feeder: DP to H-2	\$1,802	\$810	\$993
Feeder: DP to H-3		\$553	(\$553)
Feeder: DP to RTU-1		\$484	(\$484)
Feeder: DP to RTU-2		\$799	(\$799)
Feeder: L-1B to L-2		\$1,553	(\$1,553)
<b>Totals</b>	<b>\$43,586</b>	<b>\$31,917</b>	<b>\$11,669</b>

**Schedule Impacts**

<u>Description</u>	<u>Original</u>	<u>Redesign</u>	<u>Savings</u>
DP-1 (800A Distribution Panelboard)	30		30
DP-2 (800A Distribution Panelboard)	45		45
DP (800A Distribution Panelboard)		55	(55)
H-1 (480Y/277V Panelboard)	29	28	1
L-1 (208Y/120V Panelboard)	28	27.5	.5
L-1B (208Y/120V Panelboard)	19	24	(.5)
H-2 (480Y/277V Panelboard)	30	30	0
75 kVA Step-Down Xfmer	63		63
112.5 kVA Step-Down Xfmer		46	(46)
Feeder: DP-1 to DP-2	78		78
Feeder: DP to H-1	18	19	(1)
Feeder: DP to H-2	20	12	8
Feeder: DP to H-3		8	(8)
Feeder: DP to RTU-1		7.5	(7.5)
Feeder: DP to RTU-2		11	(11)
Feeder: L-1B to L-2		19	(19)
<b>Totals</b>	<b>360</b>	<b>287</b>	<b>73</b>



## Project Summary

### Analysis #1: Project Sequencing

- Sequencing Process
- Schedule Results
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- Electrical Redesign
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### Analysis #3: Implementation of LEED

- LEED Cost Analysis
- Architectural Breadth
- Energy Impacts
- BIM Research

### Final Recommendations

### Acknowledgments

## Business Case

### Tax Incentives

1% Certified

2.5% Silver

### Contractor Reputation



## Project LEED Facts

A/E Instructed to Design LEED Facility

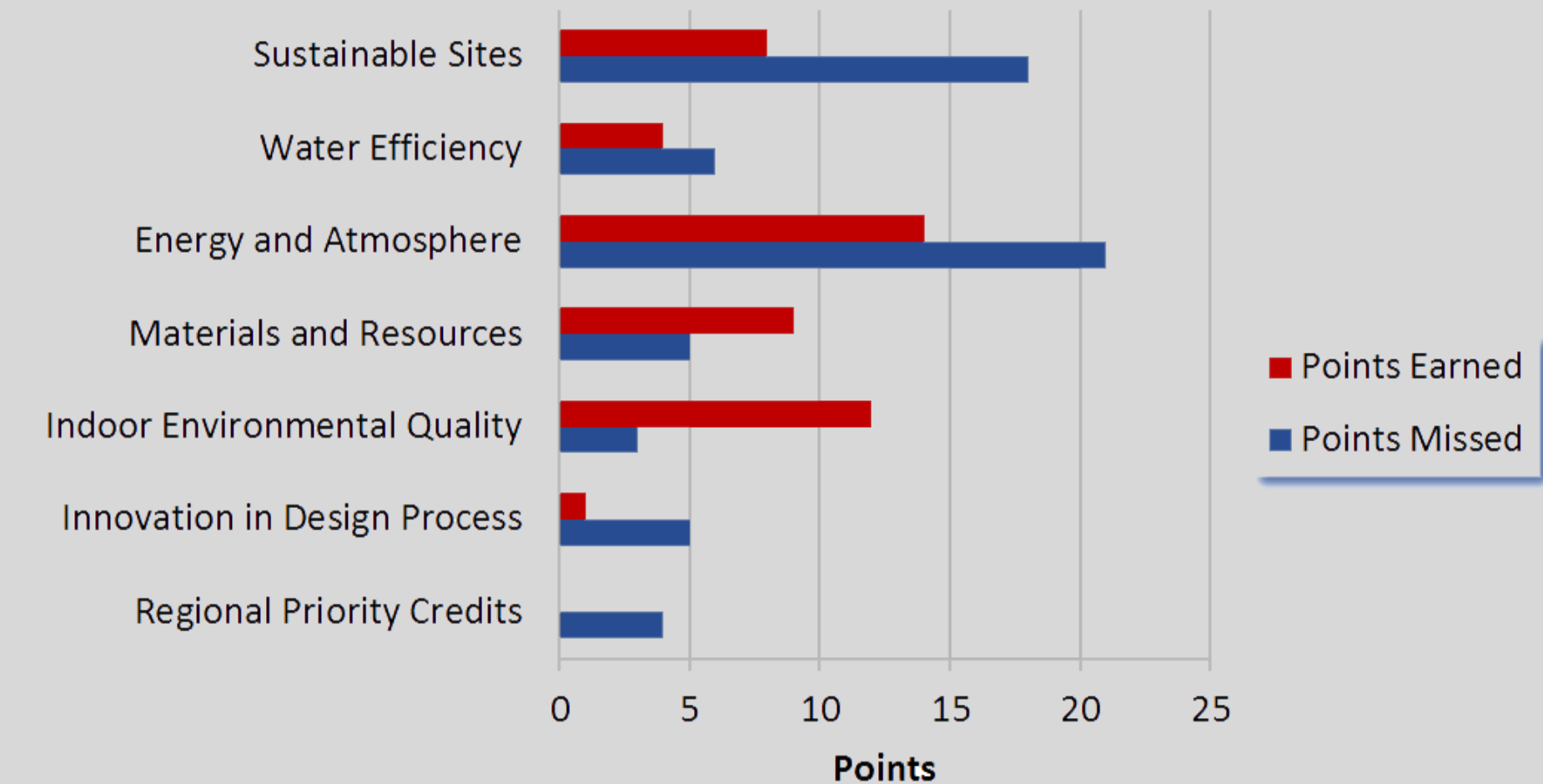
35% Additional Area – 60% of Electric Bill

48 Points Available w/ No Design Changes

Did Not Apply for LEED Building Certification

No Construction LEED Practices Implemented

## Project LEED Summary





Project Summary

Analysis #1: Project Sequencing

Sequencing Process

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Cost Implications

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Final Recommendations

Acknowledgments

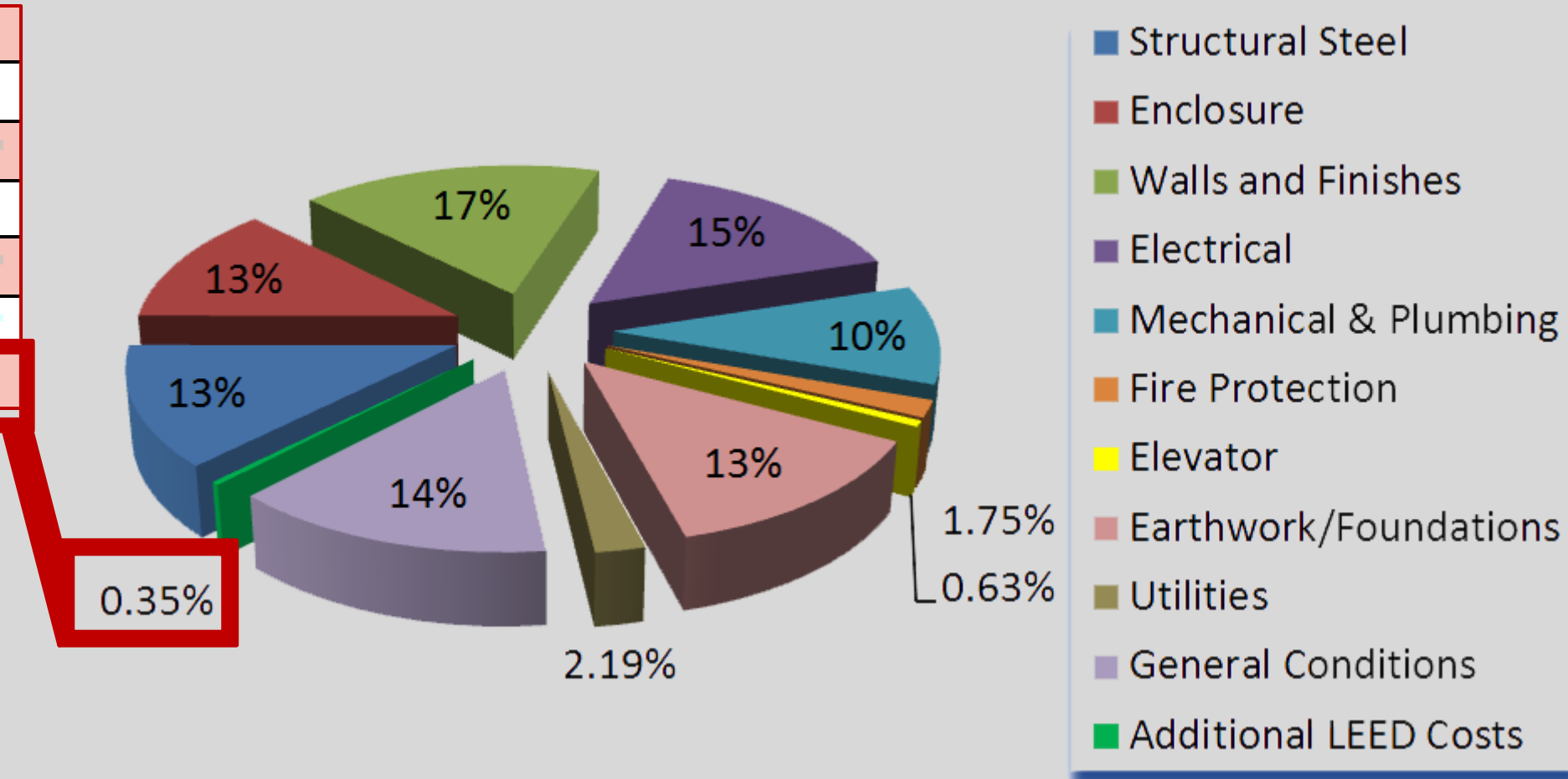
GBCI Fees

	Project <u>Gross Floor Area</u> in Sq Ft (excluding all parking areas)		
	Less than 50,000	50,000- 500,000	More than 500,000
<b>Registration</b>			
USGBC Silver, Gold and Platinum Members		\$900	
Organizational or Non-Members		\$1,200	
<b>Recertification Review</b> (Optional, LEED CS only)			
USGBC Silver, Gold and Platinum Members		\$3,250	
Organizational or Non-Members		\$4,250	
<b>Standard Review</b>	Flat rate	Per Sq Ft	Flat rate
<b>Design &amp; Construction Review</b>			
USGBC Silver, Gold and Platinum Members	\$2,250	\$0.045/sf	\$22,500
Organizational or Non-Members	\$2,750	\$0.055/sf	\$27,500

Construction LEED Implementation Cost Summary

Item Description	Quantity	Unit	Total \$
Project Manager	188	Hourly	\$14,570
Superintendent	75.2	Hourly	\$4,230
Waste Removal	47	Weeks	\$5,288
GBCI Registration Fee	1	Flat Rate	\$1,200
GBCI Standard Review	54160	Sq. Footage	\$2,979
<b>Total Cost</b>			<b>\$28,266</b>

Percentage of Total Costs





## Project Summary

### Analysis #1: Project Sequencing

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- Redesign Impacts

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- LEED Cost Analysis
- Architectural Breadth**
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### Final Recommendations

### Acknowledgments

## Problem Identification

2 Points from LEED Silver

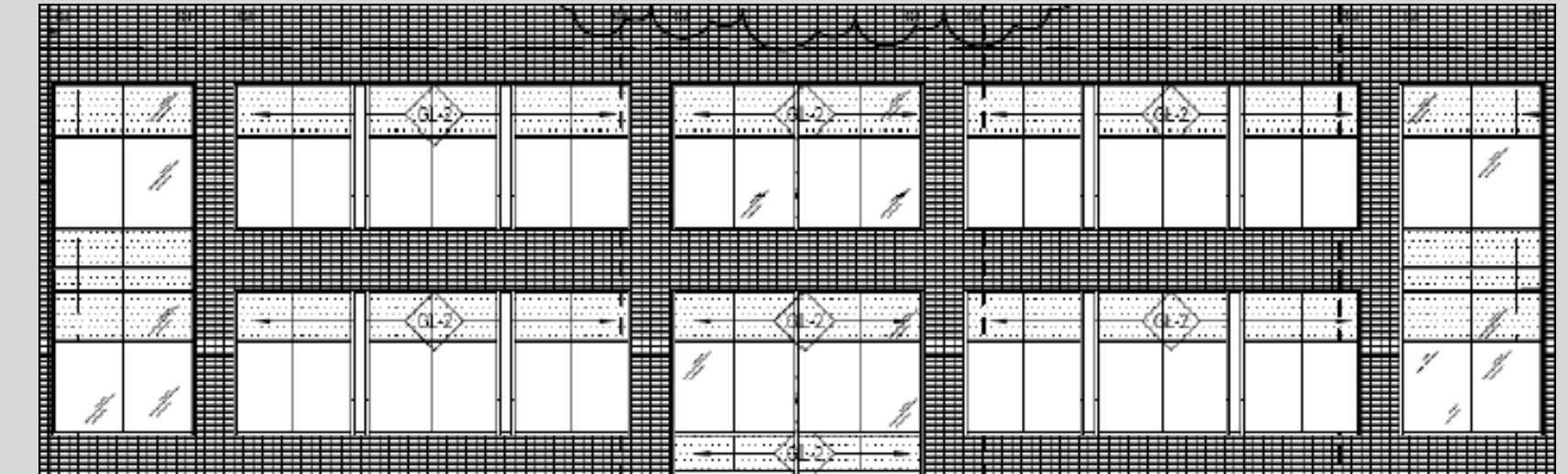
7/19 Optimize Energy Performance Credits

2% Energy Efficiency Increase = 1 LEED Credit

Goal – Improve Energy Efficiency by 4%

Currently No Window Shading System

## Western/Eastern Facade





**Project Summary**

**Analysis #1: Project Sequencing**

- Sequencing Process
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- Electrical Redesign
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- Architectural Breadth**
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- BIM Research

**Final Recommendations**

**Acknowledgments**

**Architectural Shade #1**

**6' Overhang**

**Above Second Story Grazing**

**E, S, & W Facades**

**Material: Solid Black  
Aluminum Paneling**

**Supports: Steel Columns  
Buried in Ground**

**Southeastern Corner Façade Rendering**



**Southwestern Corner Façade Rendering**







**Project Summary**

**Analysis #1: Project Sequencing**

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- Electrical Redesign
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**Final Recommendations**

**Acknowledgments**

**Architectural Shade #2**

**6' Overhang**

**Above Second Story Grazing**

**E, S, & W Facades**

**Material: White, Acrylic  
Translucent Glazing**

**Supports: Steel Columns  
Buried in Ground**

**Southwestern Corner Façade Rendering**



**Southeastern Corner Façade Rendering**





**Project Summary**

**Analysis #1: Project Sequencing**

- Sequencing Process
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- Cost Implications

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- Electrical Redesign
- Redesign Impacts

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**Final Recommendations**

**Acknowledgments**

**Architectural Shade #3**

**6' Overhang**

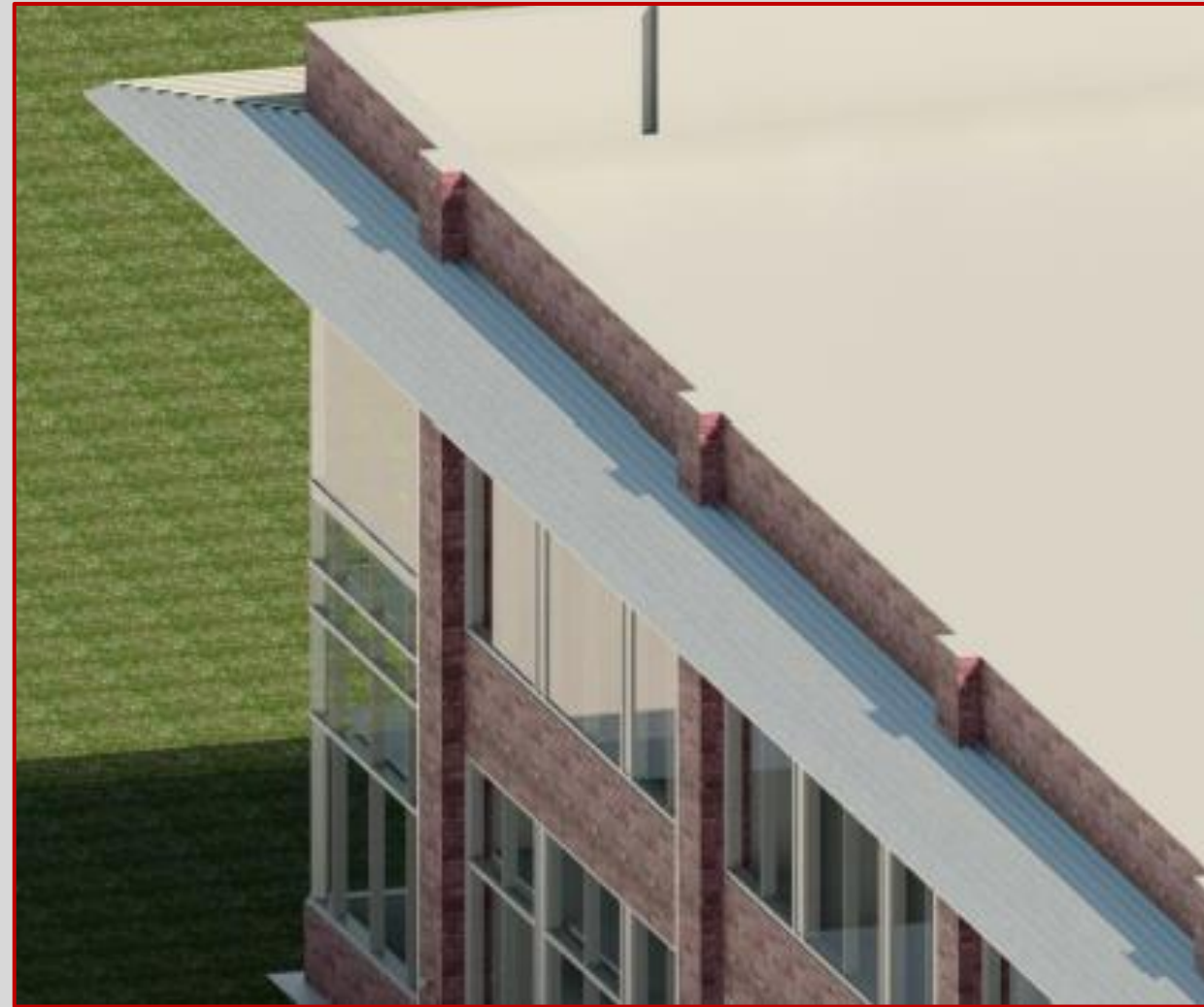
**Above Second Story Grazing**

**E, S, & W Facades**

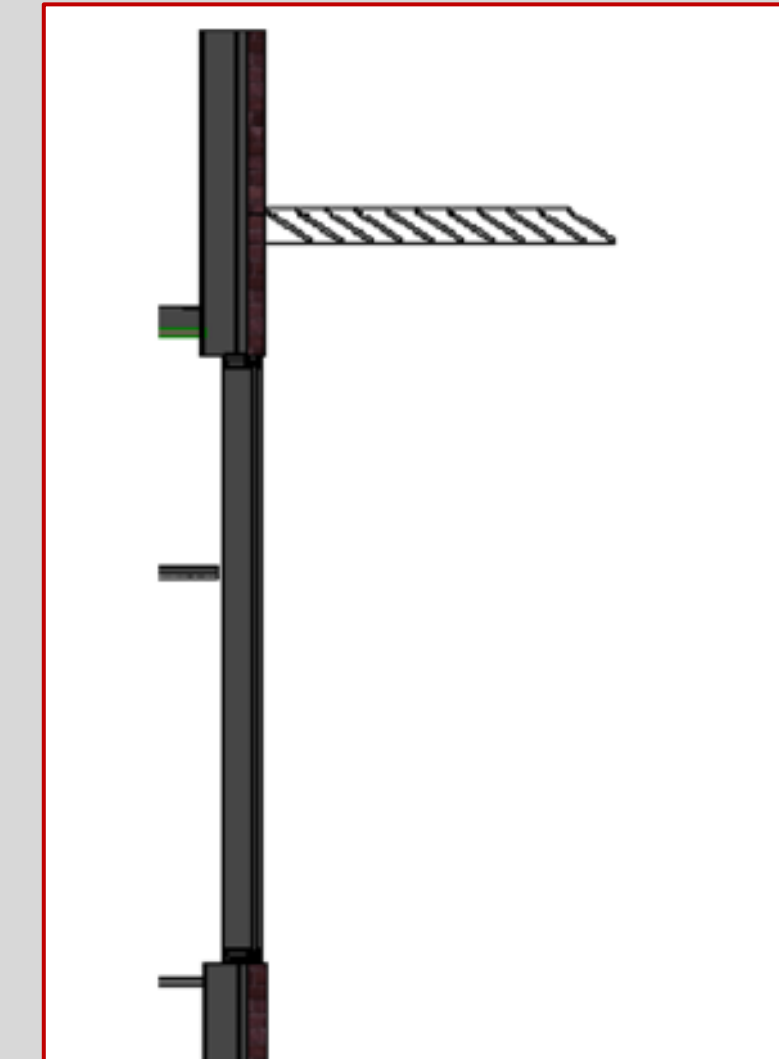
**Material: Louvered Metallic  
Panels**

**Supports: Steel Columns  
Buried in Ground**

**Southern Façade Rendering**



**Louver Detail**





**Project Summary**

**Analysis #1: Project Sequencing**

- Sequencing Process
- Schedule Results
- Cost Implications

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- Electrical Redesign
- Redesign Impacts

**Analysis #3: Implementation of LEED**

- LEED Cost Analysis
- Architectural Breadth
- Energy Impacts**
- BIM Research

**Final Recommendations**

**Acknowledgments**

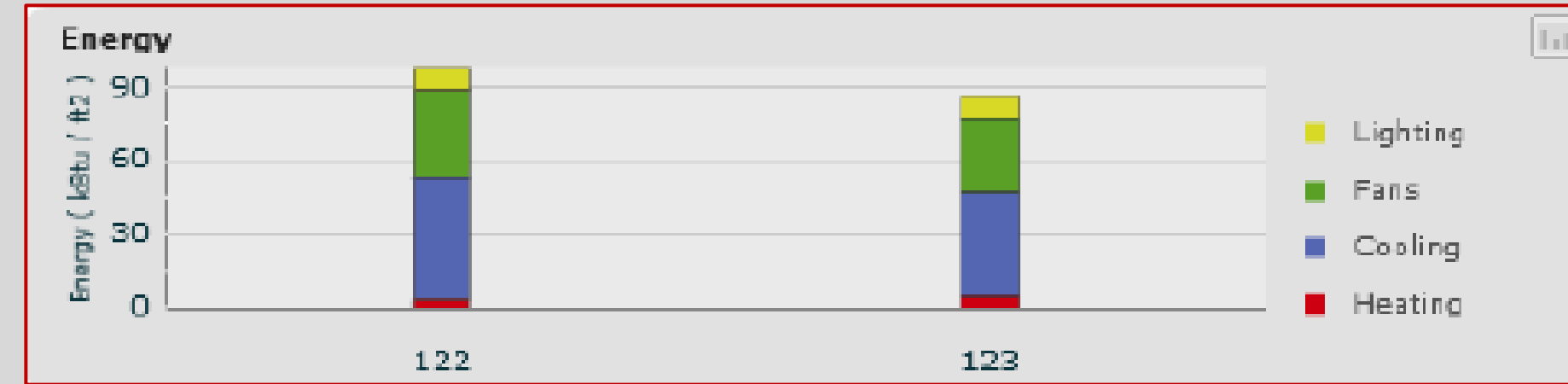
**Eastern Façade Energy Summary**

**Total Annual Energy Savings**  
**11.9 (kBtu/ft<sup>2</sup>)**

**Peak Electric Demand Savings**  
**1.6 (W/ft<sup>2</sup>)**

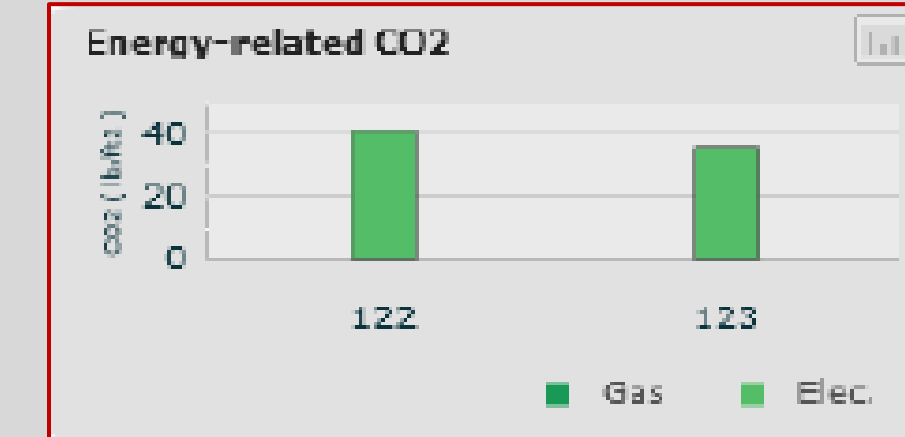
**CO2 Emissions Reduction**  
**5.5 (lbs/ft<sup>2</sup>)**

**Total Annual Energy**

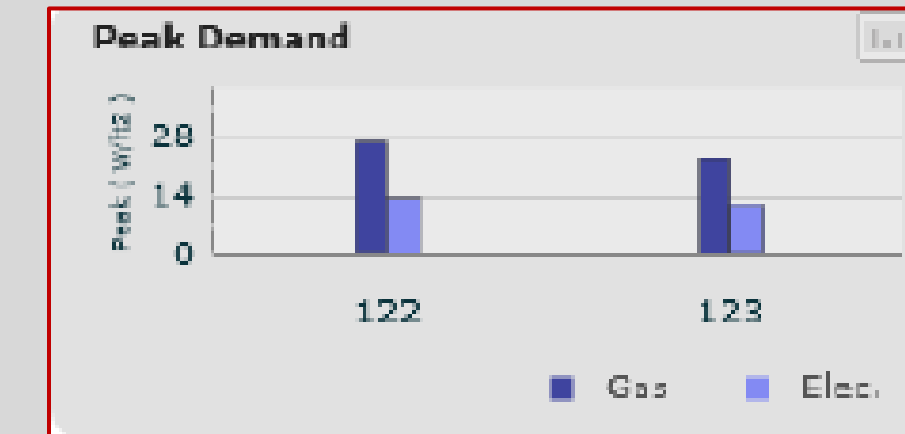


**Left = Before Shading; Right = After Shading**

**CO2 Emissions**



**Peak Energy Demand**





**Project Summary**

**Analysis #1: Project Sequencing**

- Sequencing Process
- Schedule Results
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- Electrical Redesign
- Redesign Impacts

**Analysis #3: Implementation of LEED**

- LEED Cost Analysis
- Architectural Breadth

**Energy Impacts**

- BIM Research

**Final Recommendations**

**Acknowledgments**

**Energy Summary**

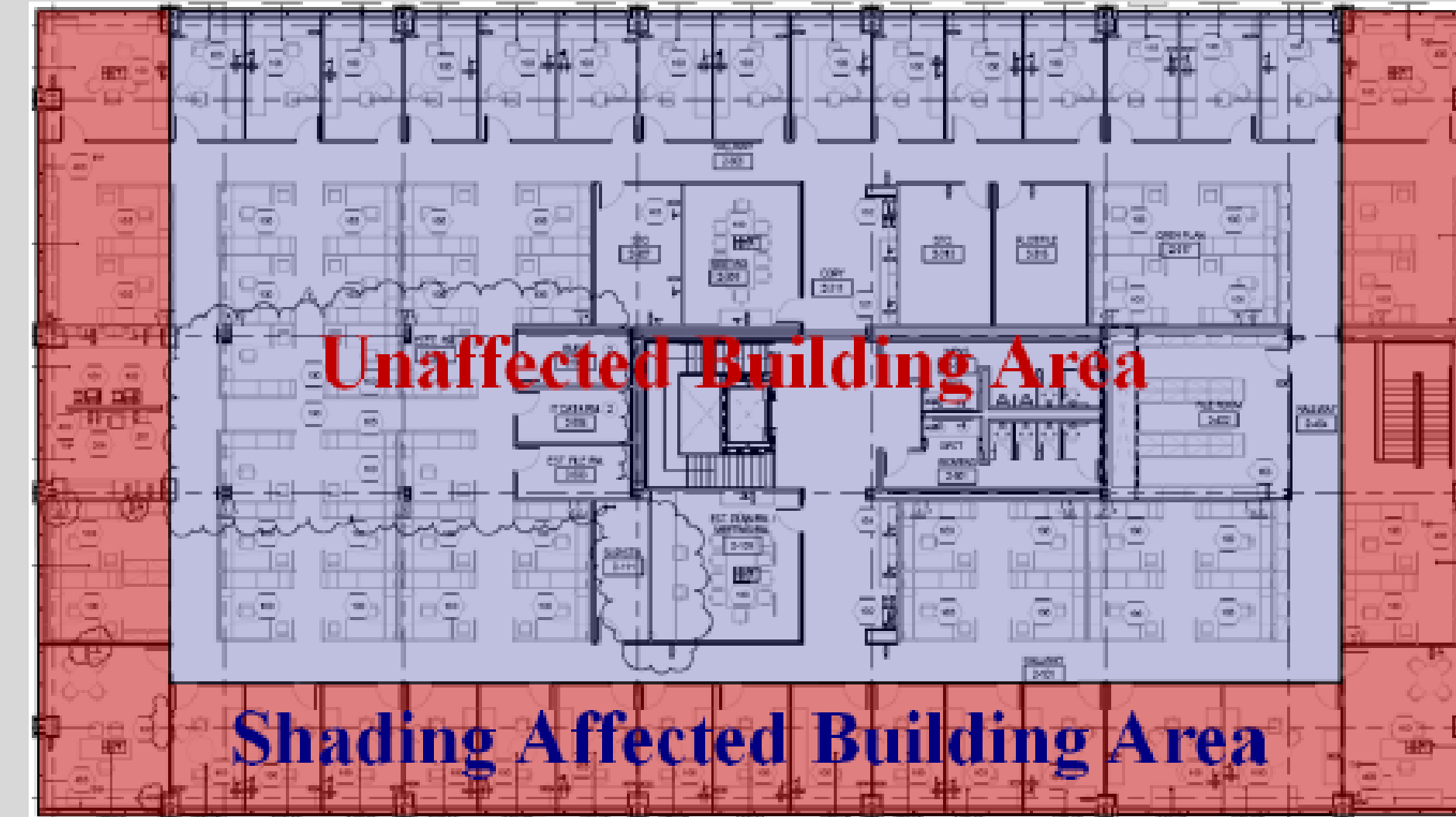
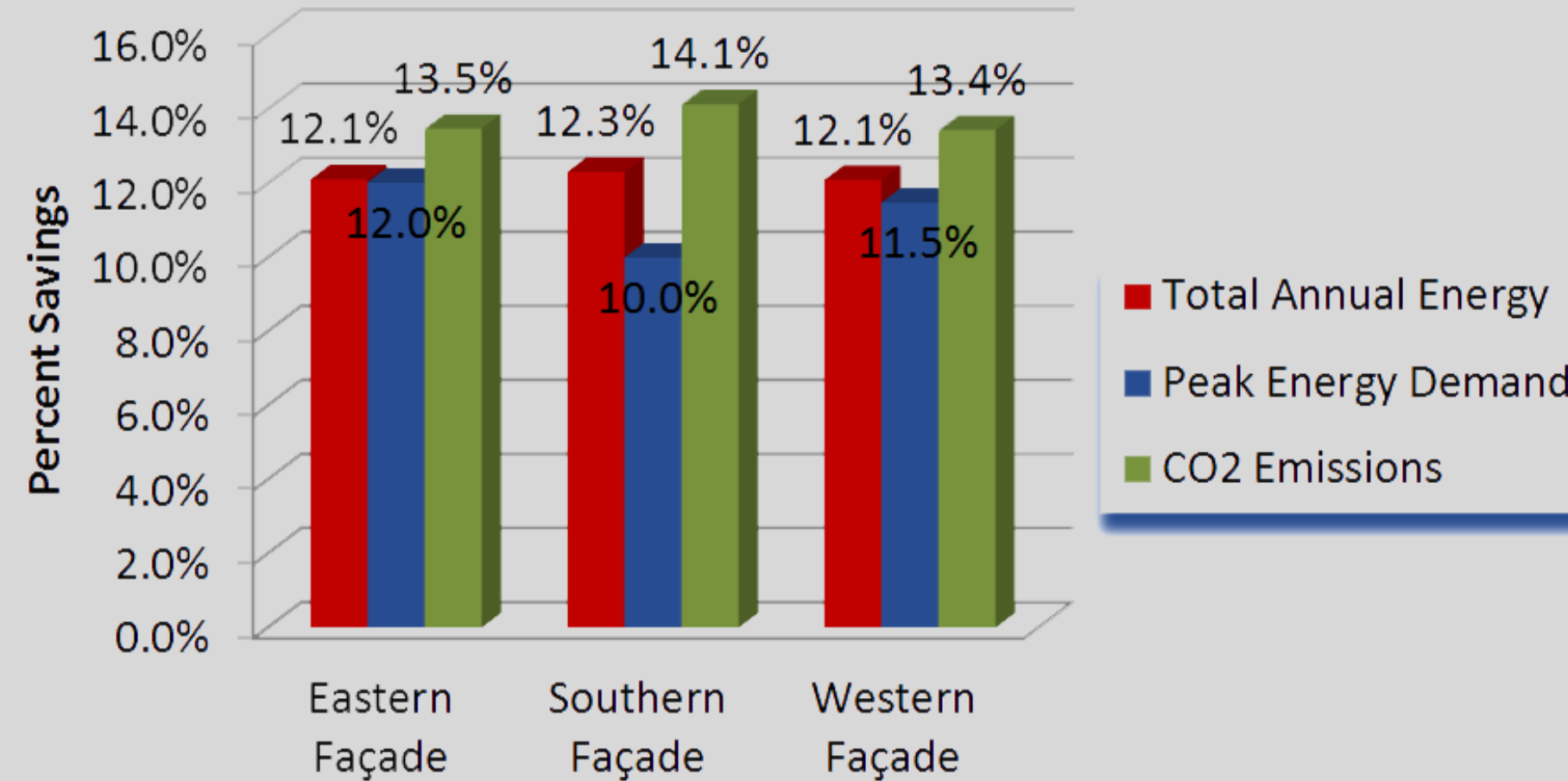
**Average Energy Reduction**  
**12%**

**Affected to Unaffected Ratio**  
**1:2**

**12% \* 1/3 = 4%**

**\*Loading Higher in Solar Areas vs. Non-Solar**

**Shading Savings Summary**





## Project Summary

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## Final Recommendations

## Acknowledgments

## Problem Background

**Unusual Façade Installation**

**\$20,000 in Back Chargers**

**Façade Already Modeled by  
Architect & Structural**

**\$5,280 to Implement BIM  
Façade Detailing**

**Worker Tolerance Error**

## “Two Dimensions”



## BIM to Implement Architectural Overhangs

**Overhangs Designed in Revit**

**Easy to Communicate Technical Overhang Information to Team**

**Quicker Transition Between the Designs**

**4D Installation Sequence**



## Project Summary

### Analysis #1: Project Sequencing

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- Redesign Impacts

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- Energy Impacts
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## Final Recommendations

## Acknowledgments

## Savings Summary

Analysis #1  
\$50,698

Analysis #2  
\$11,669

Analysis #3  
(\$28,266)

**Total Savings**  
**\$34,101**

### Analysis #1: Project Sequencing

**Cost Savings: \$50,698**  
**Schedule Savings: 4 Weeks**  
**5% Reduction in Owner Carried General Conditions**

### Analysis #2: Electrical System Redesign

**Cost Savings: \$11,669**  
**Schedule Savings: 4.5 Days**  
**Fewer Components to Maintain & Service**  
**No Additional Constructability Concerns**

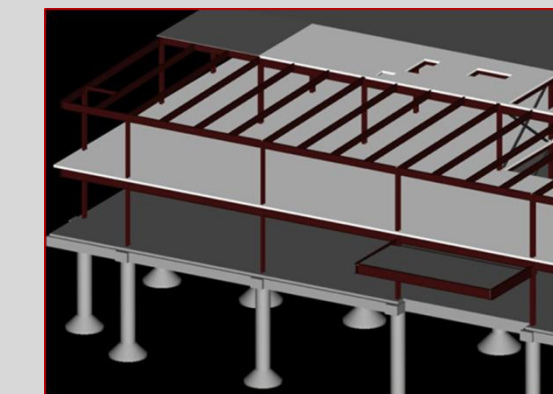


### Analysis #3

**Cost Incurred: \$28,266**  
**Gained LEED Building Certification**  
**1% Reduction in State Property Tax**  
**Improved Specialty Contractor Image**

### Architectural Overhangs Adopted

**Gained LEED Silver**  
**4% Minimum Improvement in Energy Efficiency**  
**BIM Implementation to Ease Design Change**





## Project Summary

### Analysis #1: Project Sequencing

Sequencing Process  
Schedule Results  
Cost Implications

### Analysis #2: Electrical System Redesign

Electrical Redesign  
Redesign Impacts

### Analysis #3: Implementation of LEED

LEED Cost Analysis  
Architectural Breadth  
Energy Impacts  
BIM Research

## Final Recommendations

## Acknowledgments

### Academic

**Dr. John Messner**

**Dr. Robert Leicht**

**Dr. Richard Mistrick**

**Professor Dodson**

**Professor Holland**

**Penn State AE Faculty**

### Industry



### Special Thanks

**Wayne McDonald**

**David Rinehart**

**Ted Robertson**

**Fisk Corporate Headquarters Project Team**

**PACE Industry Members**

**My Family and Friends**



## Project Summary

### Analysis #1: Project Sequencing

- Sequencing Process
- Schedule Results
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## Savings Summary

**Analysis #1**  
**\$50,698**

**Analysis #2**  
**\$11,669**

**Analysis #3**  
**(\$28,266)**

**Total Savings**  
**\$34,101**

## Analysis #1: Project Sequencing

- Cost Savings: \$50,698**
- Schedule Savings: 4 Weeks**
- 5% Reduction in Owner Carried General Conditions**

## Analysis #2: Electrical System Redesign

- Cost Savings: \$11,669**
- Schedule Savings: 4.5 Days**
- Fewer Components to Maintain & Service**
- No Additional Constructability Concerns**

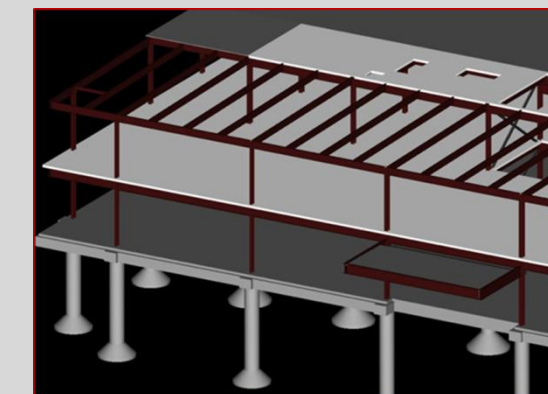


## Analysis #3

- Cost Incurred: \$28,266**
- Gained LEED Building Certification**
- 1% Reduction in State Property Tax**
- Improved Specialty Contractor Image**

## Architectural Overhangs Adopted

- Gained LEED Silver**
- 4% Minimum Improvement in Energy Efficiency**
- BIM Implementation to Ease Design Change**







## Original General Conditions Estimate

General Conditions Estimate				
Description	Quantity	Unit	Cost/Unit	Total \$
Preconstruction Services	1	LS	\$90,000	\$90,000
Project Manager	47	Wks	\$3,100	\$145,700
Project Manager	47	Wks	\$2,625	\$123,375
Superintendent	47	Wks	\$2,250	\$105,750
Laborer/Flagger	47	Wks	\$1,375	\$64,625
Timekeeper	47	Wks	\$1,150	\$54,050
CPM Scheduling	7,276,510	Job	2%	\$145,530
Permit	1	LS	\$38,799	\$38,799
Jobsite Trailer	11	Mo	\$627.81	\$6,906
Temporary Storage	11	Mo	\$93.15	\$1,025
Office Equipment	11	Mo	\$272.33	\$2,996
Small Tools	7,276,510	Job	.05%	\$3,638
Temporary Fencing	1985	L.F.	\$4.57	\$9,071
Project Drawings	1	LS	\$5,000	\$5,000
Continuous Clean	47	Wks	\$570	\$26,790
Final Cleaning	1	LS	\$15,000	\$15,000
Waste Removal	47	Wks	\$375	\$17,625
Job Signs	70	S.F.	\$33.69	\$2,358
Temporary Power	11	Mo	\$1,000	\$11,000
Temporary Water	11	Mo	\$1,000	\$11,000
Equip. Insurance/Repairs	11	Mo	\$1,000	\$11,000
Testing	1	Job	\$4,072.95	\$4,073
Drug Testing	40	EA	\$100	\$4,000
Job Photos	4	Set	\$525.23	\$2,101
Temporary Toilets	11	Mo	\$900	\$9,900
Fire Marshall Inspection	5	EA	\$250	\$1,250
Survey	4	Day	\$492.09	\$1,968
Safety Supplies	11	Mo	\$24.28	\$267
Liability Insurance	7,276,510	Job	2.02%	\$146,986
Builder's Risk	7,276,510	LS	0.24%	\$17,464
Subcontractor Bonds	7,276,510	LS	0.60%	\$43,659
<b>Grand Total</b>				<b>\$1,122,906</b>

## Revised General Conditions Estimate

Revised General Conditions Estimate				
Description	Quantity	Unit	Cost/Unit	Total \$
Preconstruction Services	1	LS	\$90,000	\$90,000
Project Manager	43	Wks	\$3,100	\$133,300
Project Manager	43	Wks	\$2,625	\$112,875
Superintendent	43	Wks	\$2,250	\$96,750
Laborer/Flagger	43	Wks	\$1,375	\$59,125
Timekeeper	43	Wks	\$1,150	\$49,450
CPM Scheduling	7,276,510	Job	2%	\$145,530
Permit	1	LS	\$38,799	\$38,799
Jobsite Trailer	10	Mo	\$627.81	\$6,280
Temporary Storage	10	Mo	\$93.15	\$932
Office Equipment	10	Mo	\$272.33	\$2,723
Small Tools	7,276,510	Job	.05%	\$3,638
Temporary Fencing	1985	L.F.	\$4.57	\$9,071
Project Drawings	1	LS	\$5,000	\$5,000
Continuous Clean	43	Wks	\$570	\$24,510
Final Cleaning	1	LS	\$15,000	\$15,000
Waste Removal	43	Wks	\$375	\$16,125
Job Signs	70	S.F.	\$33.69	\$2,358
Temporary Power	10	Mo	\$1,000	\$10,000
Temporary Water	10	Mo	\$1,000	\$10,000
Equip. Insurance/Repairs	10	Mo	\$1,000	\$10,000
Testing	1	Job	\$4,072.95	\$4,073
Drug Testing	40	EA	\$100	\$4,000
Job Photos	4	Set	\$525.23	\$2,101
Temporary Toilets	10	Mo	\$900	\$9,000
Fire Marshall Inspection	5	EA	\$250	\$1,250
Survey	4	Day	\$492.09	\$1,968
Safety Supplies	10	Mo	\$24.28	\$243
Liability Insurance	7,276,510	Job	2.02%	\$146,986
Builder's Risk	7,276,510	LS	0.24%	\$17,464
Subcontractor Bonds	7,276,510	LS	0.60%	\$43,659
<b>Grand Total</b>				<b>\$1,072,208</b>



## Panelboard DP

DP (800 Amp Panelboard)															
V:	480Y/277	Rm # 1-505	22000 AIC	3P -4W	Fdr:	2 x (4) 600 & #1/0G.	2 x 4"C	625 kVA	800 A	MCB					
Designations		VA/Phase			Bkr/Pole/Wire			Designations		VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W
1	Panel H-3 (1-505)	22750			150	3	#1	2	RTU-1 (Roof)	29550			125	3	#2
3	-	22750			-	-	-	4	-	29550			-	-	-
5	-		22750		-	-	-	6	-		29550		-	-	-
7	RTU-2 (Roof)	34294			150	3	#1	8	Panel H-1 (1-505)	65667			250	3	250
9	-	34294			-	-	-	10	-	65667			-	-	-
11	-		34294		-	-	-	12	-		65667		-	-	-
13	Panel H-2 (2-505)	26000			100	3	#3	14	Panel HP (Fab Shop)	29837			150	3	1/0
15	-	26000			-	-	-	16	-	29837			-	-	-
17	-		26000		-	-	-	18	-		29837		-	-	-
19	Spare	0			50	3	-	20	Spare	0			50	3	-
21	-	0			-	-	-	22	-	0			-	-	-
23	-		0		-	-	-	24	-		0		-	-	-
25	Spare	0			150	3	-	26	Spare	0			150	3	-
27	-	0			-	-	-	28	-	0			-	-	-
29	-		0		-	-	-	30	-		0		-	-	-
31	Space	0			0	0	#####	32	Space	0			0	0	#####
33	Space	0			0	0	#####	34	Space	0			0	0	#####
35	Space		0		0	0	#####	36	Space			0	0	0	#####
37	Space	0			0	0	#####	38	Space	0			0	0	#####
39	Space		0		0	0	#####	40	Space		0		0	0	#####
41	Space		0		0	0	#####	42	Space		0		0	0	#####

## Panelboard H-1

H-1 (400 Amp Panelboard)															
V:	480Y/277	Rm # 1-505	22000 AIC	3P -4W	Fdr:	(4) 250 & #4 G.	2.5" C	197 kVA	250 A	MLO					
Designations		VA/Phase			Bkr/Pole/Wire			Designations		VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W
1	Office Ltg. (North)	2244			20	1	#12	2	Office Ltg. (West)	714			20	1	#12
3	Lobby Ltg.		644		20	1	#12	4	Work Stations Ltg. (SW)		1360		20	1	#12
5	Training Ltg.			576	20	1	#12	6	Work Stations Ltg. (NW)			1164	20	1	#12
7	Core Ltg. (East)	778			20	1	#12	8	Core Ltg. (West)	1036			20	1	#12
9	Break & Corridor Ltg.		660		20	1	#12	10	Boardroom Ltg.		630		20	1	#12
11	Conf. Rm. Ltg. (East)			400	20	1	#12	12	Work Stations Ltg. (East)			732	20	1	#12
13	File Rm. Ltg.	1792			20	1	#12	14	FPB - 3,4,5,6,11	3768			20	3	#12
15	FPB - 1,2,15,16		3160		20	3	#12	16	-		3768		-	-	-
17	-			3160	-	-	-	18	-		3768		-	-	-
19	-	3160			-	-	-	20	FPB - 7,8,9,10	11000			45	3	#8
21	FPB - 12,13,14		2330		20	3	#12	22	-		11000		-	-	-
23	-			2330	-	-	-	24	-		11000		-	-	-
25	-	2330			-	-	-	26	Spare	0			0	0	#####
27	EWH-1		3000		20	1	#12	28	Spare		0		0	0	#####
29	-			3000	-	-	-	30	Spare			0	0	0	#####
31	Spare	0			0	0	#####	32	Spare	0			0	0	#####
33	Spare		0		0	0	#####	34	Spare		0		0	0	#####
35	Egress Lighting (Hall)			702	20	1	#12	36	Spare			0	0	0	#####
37	Spare	0			0	0	#####	38	Panel L1 (1-505)	37500			150	3	1/0
39	Spare		0		0	0	#####	40	-		37500		-	-	-
41	Spare			0	0	0	#####	42	-			37500	-	-	-

## Panelboard H-2

H-2 (100 Amp Panelboard)															
V:	480Y/277	Rm # 1-505	22000 AIC	3P -4W	Fdr:	(4) #3 & #8 G.	1.25" C	78 kVA	100 A	MLO					
Designations		VA/Phase			Bkr/Pole/Wire			Designations		VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W
1	Workstations - Ltg. (SV)	1904			20	1	#12	2	Workstations - Ltg. (NW)	1128			20	1	#12
3	Workstations - Ltg. (SE)		1236		20	1	#12	4	Workstations - Ltg. (NW)		1751		20	1	#12
5	Offices - Ltg. (North)			2091	20	1	#12	6	Offices - Ltg. (North)			1938	20	1	#12
7	Conf. Rm. - Ltg. (South)	340			20	1	#12	8	Conf. Rm. - Ltg. (North)	308			20	1	#12
9	Core - Ltg. (West)		704		20	1	#12	10	Core - Ltg. (East)		874		20	1	#12
11	Egress - Ltg. (Hall)			504	20	1	#12	12	Stairs (East)			234	20	1	#12
13	FPB 2- 1,2,3,15,16,17	5775			30	3	#10	14	FPB 2-4,5,6,18	3935			20	3	#12
15	-		5775		-	-	-	16	-		3935		-	-	-
17	-			5775	-	-	-	18	-			3935	-	-	-
19	FPB 2- 11,12,13,14,20	5376			30	3	#10	20	FPB 2- 7,8,9,10,19	5154			30	3	#10
21	-		5376		-	-	-	22	-		5154		-	-	-
23	-			5376	-	-	-	24	-			5154	-	-	-
25	Spare	0			0	0	#####	26	Spare	0			0	0	#####
27	Spare		0		0	0	#####	28	Spare		0		0	0	#####
29	Spare			0	0	0	#####	30	Spare			0	0	0	#####
31	Spare	0			0	0	#####	32	Spare	0			0	0	#####
33	Spare		0		0	0	#####	34	Spare		0		0	0	#####
35	Spare			0	0	0	#####	36	Spare			0	0	0	#####
37	Elevator	9422			50	3	#8	38	Spare	0			0	0	#####
39	-		9422		-	-	-	40	Spare		0		0	0	#####
41	-			9422	-	-	-	42	Spare			0	0	0	#####



## Panelboard L-1

L1 (400 Amp Panelboard)																	
V:	208Y/120	Rm # 1-505	10000 AIC	3P - 4W	Fdr:	(4) 400 & #3 G.	3" C	109 kVA	350 A	MCB							
Designations			VA/Phase			Bkr/Pole/Wire			Designations			VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W		
1	Receptacles (300301)	1260			20	1	#12	2	Receptacles (32032132)	1080			0	1	#12		
3	Receptacles (203-206)		1440		20	1	#12	4	Receptacles (322)		1080		0	1	#12		
5	Receptacles (304-306)			180	20	1	#12	6	Copier (313)			1620	0	1	#12		
7	Receptacles (208, 302, 720)				20	1	#12	8	Work Stations (313)	720			0	1	#12		
9	Transformer (Bathroom)	340			20	1	#12	10	Work Stations (311)		600		0	1	#12		
11	Receptacles (308-316)			1620	20	1	#12	12	Work Stations (311)			600	0	1	#12		
13	Projector (Board Rm.)	800			20	1	#12	14	Receptacles (309)	900			0	1	#12		
15	Projector (Training Rm.)	1000			20	1	#12	16	Copier (313)		360		0	1	#12		
17	Screen & Shades (Training Rm.)		400		20	1	#12	18	Spare			0	0	0	#####		
19	Receptacles (307)	720			20	1	#12	20	Receptacles (Break Rm)	180			0	1	#12		
21	Work Stations (305)		540		20	1	#12	22	Ice Machine (Break Rm.)		960		0	1	#12		
23	Work Stations			720	20	1	#12	24	Coffee Maker (Break Rm.)			1550	0	1	#12		
25	Work Stations	720			20	1	#12	26	Dishwasher (Break Rm)	1500			0	1	#12		
27	Work Stations		720		20	1	#12	28	Microwave (Break Rm.)		1575		0	1	#12		
29	Work Stations			720	20	1	#12	30	Microwave (Break Rm.)			1575	0	1	#12		
31	Work Stations	720			20	1	#12	32	Receptacles (404)	720			0	1	#12		
33	Work Stations		720		20	1	#12	34	Receptacles (404)		360		0	1	#12		
35	Spare			0	0	0	#####	36	Receptacles (404)			360	0	1	#12		
37	Vending Machine (Bre	960			20	1	#12	38	Receptacles (404)	360			0	1	#12		
39	Vending Machine (Break Rm.)	960			20	1	#12	40	Receptacles (501502401)		900		0	1	#12		
41	Refrigerator (Break Rm.)			960	20	1	#12	42	Refrigerator (Break Rm.)			960	0	1	#12		

## Panelboard L-1B

L-1B																	
V:	208Y/120	Rm # 1-505	10000 AIC	3P - 4W	Fdr:	Section #2		73 kVA		MLO							
Designations			VA/Phase			Bkr/Pole/Wire			Designations			VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W		
1	Sign on Westview (Site	500			20	1	#12	2	AV Equipment (309)	720			20	1	#12		
3	Gate Motor 1 (East)		1176		20	1	#12	4	Receptacles (309)		900		20	1	#12		
5	Gate Motor 2 (East)			1176	20	1	#12	6	Receptacles (318-320)			1080	20	1	#12		
7	Gate Motor 1 (West)	1176			20	1	#12	8	Receptacles (310-314)	1080			20	1	#12		
9	Gate Motor 2 (West)		1176		20	1	#12	10	Spare		0		0	0	#####		
11	Elev. Sump Pump (Elev.)			1176	20	1	#12	12	Fire Alarm Panel (IDF)			360	20	1	#12		
13	Elev. Pit Light (Elev.)	330			20	1	#12	14	Receptacles (Sprinkler	360			20	1	#12		
15	Elev. GFCI (Elev.)		180		20	1	#12	16	Space		0		0	0	#####		
17	Hallway Power (403)			540	20	1	#12	18	Space			0	0	0	#####		
19	Projector (Training Ro	800			20	1	#12	20	Space	0			0	0	#####		
21	Projector (Training Room)	800			20	1	#12	22	Space		0		0	0	#####		
23	Shade (Break Room)			720	20	1	#12	24	Space			0	0	0	#####		
25	Proj. and Screen (309)	720			20	1	#12	26	Space	0			0	0	#####		
27	Receptacles (202)		900		20	1	#12	28	Space		0		0	0	#####		
29	Receptacles (200)			720	20	1	#12	30	Space			0	0	0	#####		
31	Copier (207)	1920			20	1	#12	32	Space	0			0	0	#####		
33	Laser Printer (207)		800		20	1	#12	34	Space		0		0	0	#####		
35	Receptacles (102)			720	20	1	#12	36	Space			0	0	0	#####		
37	Receptacles (103)	720			20	1	#12	38	Panel L2 & L2B (2-50	18158			225	3	4/0		
39	Receptacles (Lobby)		180		20	1	#12	40	-		18158		-	-	-		
41	Spare			0	0	0	#####	42	-			18158	-	-	-		

## Original Bill of Material

Bill of Material for Original Affected Components							
Description	Quantity	Unit	Mat./Unit	Material \$	Lab./Unit	Labor (Hrs.)	Total \$
DP-1 800A	1	E	\$4,115	\$4,115	8.8	8.8	\$4,489
DP-2 800A	1	E	\$8,220	\$8,220	13.2	13.2	\$8,781
225A H-1 PANELBOARD	1	E	\$1,650	\$1,650	24.2	24.2	\$2,678.50
225A L-1 PANELBOARD	1	E	\$990	\$990	27.5	27.5	\$2,158.75
225A L-1B PANELBOARD	1	E	\$500	\$500	18.7	18.7	\$1,294.75
225A H-2 PANELBOARD	1	E	\$1,685	\$1,685	24.2	24.2	\$2,713.50
2 1/2" EMT CONDUIT FEEDERS	49	C	\$245.44	\$120.27	13.2	6.4	\$395.16
4" EMT CONDUIT FEEDERS	90	C	\$422.40	\$380.16	25.3	22.7	\$1347.89
2 1/2" EMT STL SS CONN	4	C	\$391.95	\$15.68	0	0	\$15.68
4" EMT STL SS CONN	4	C	\$88.35	\$3.53	0	0	\$3.53
2 1/2" EMT STL SS CPLG	13	C	\$306.16	\$39.80	0	0	\$39.80
4" EMT STL SS CPLG	18	C	\$471	\$84.78	0	0	\$84.78
2 1/2" EMT 90 DEG ELBOW	4	C	\$1212.51	\$48.50	77	3.0	\$179.40
4" EMT 90 DEG ELBOW	8	C	\$2850.94	\$228.08	220	17.6	\$976.08
1 1/2" PLASTIC BUSHING	4	C	\$12.86	\$0.51	0	0	\$0.51
2 1/2" PLASTIC BUSHING	8	C	\$29.23	\$2.34	0	0	\$2.34
4" PLASTIC BUSHING	4	C	\$37.50	\$1.50	0	0	\$1.50
1 1/2" STEEL FLEX	8	C	\$289.86	\$23.19	12.4	0.9	\$65.27
2 1/2" STEEL FLEX	8	C	\$430.77	\$34.46	20.6	1.6	\$104.59
1 1/2" STL FLEX CONN	2	C	\$755.35	\$15.11	55	1.1	\$61.86
2 1/2" STL FLEX CONN	2	C	\$1933.31	\$38.67	88	1.7	\$113.47
1 1/2" STL 90 DEG FLEX CONN	2	C	\$1924.89	\$38.50	55	1.1	\$85.25
2 1/2" STL 90 DEG FLEX CONN	2	C	\$6414.77	\$128.30	88	1.7	\$203.10
#6 THHN BLACK	20	M	\$568.61	\$11.37	13.2	0.2	\$22.59
#4 THHN BLACK	159	M	\$902.50	\$143.5	14.3	2.2	\$240.13
#1/0 THHN BLACK	60	M	\$2230.02	\$133.8	20.9	1.2	\$187.10
#4/0 THHN BLACK	316	M	\$4444.89	\$1404.59	27.5	8.6	\$1773.92
#250MCM THHN BLACK	80	M	\$5359.13	\$428.73	30.8	2.4	\$533.45
#1/0 XHHW BLACK	60	M	\$2125.54	\$127.53	20.9	1.2	\$180.83
#600MCM XHHW BLACK	240	M	\$10884.45	\$2612.27	48.4	11.6	\$3105.95
1-H CRIMP LUG #6 BLUE	4	C	\$153.53	\$6.14	14.3	0.5	\$30.45
1-H CRIMP LUG #4 GRAY	8	C	\$200.26	\$16.02	16.5	1.32	\$72.12
1-H CRIMP LUG #1/0 PINK	6	C	\$428.64	\$25.72	26.4	1.6	\$93.04



## Original Bill of Material

## Redesigned Bill of Material

## Redesigned Bill of Material

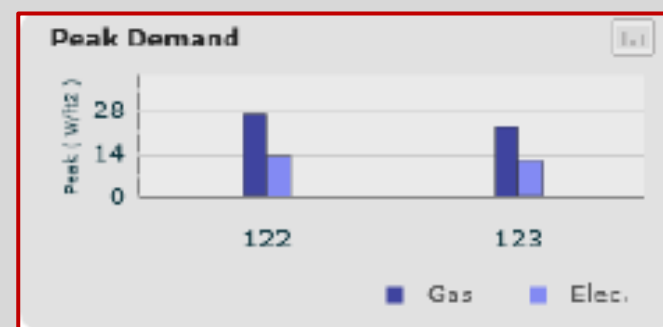
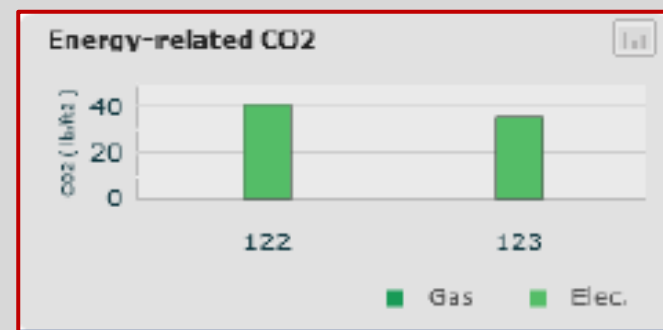
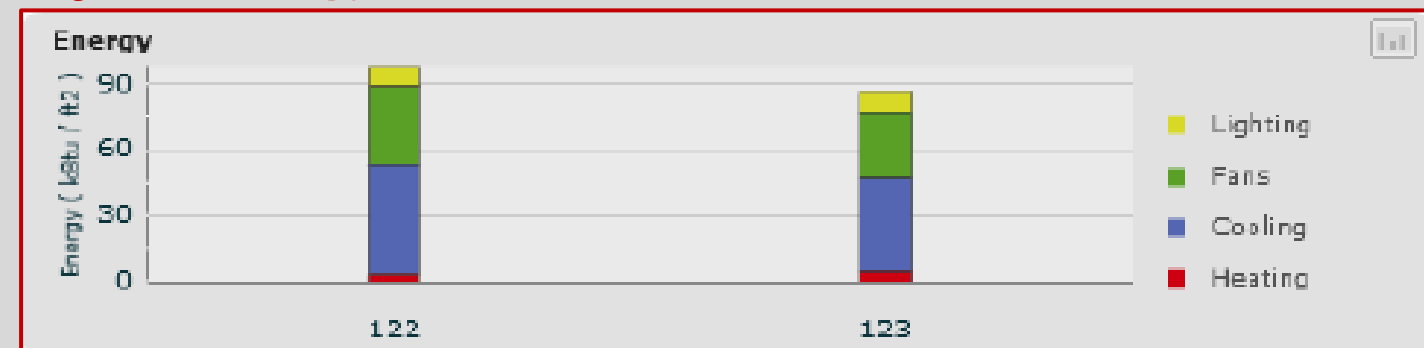
Description	Quantity	Unit	Mat./Unit	Material \$	Lab./Unit	Labor (Hrs.)	Total \$
1-H CRIMP LUG #250 YELLOW	10	C	\$770.24	\$77.02	37.4	3.74	\$235.97
WIRE TERM. 4/0 to 400 MCM	16	E	\$2.29	\$36.64	0.99	15.84	\$709.84
WIRE TERM. 500 to 1000 MCM	8	E	\$8.16	\$65.28	1.32	10.56	\$514.08
1/4" THREADED ROD - PLTD	14	C	\$3.20	\$0.45	2.75	0.385	\$16.81
3/8" THREADED ROD - PLTD	28	C	\$6.84	\$1.92	3.3	0.924	\$41.19
1/4-20 HEX NUT - PLTD STL	10	C	\$1.77	\$0.18	2.2	0.22	\$9.53
3/8-16 HEX NUT - PLTD STL	18	C	\$3.49	\$0.63	2.42	0.4	\$19.14
1/4" FLANGE W/ 1/4" THRD ROD	5	C	\$87.09	\$4.35	7.7	0.4	\$20.71
1/2" FLANGE W/ 3/8" THRD ROD	10	C	\$105.67	\$10.57	7.7	0.77	\$43.30
ERICO 2 1/2" EMT/GRC CLAMP	5	C	\$159.32	\$7.97	22	1.1	\$4.72
ERICO 4" EMT/GRC CLAMP	10	C	\$270.79	\$27.08	33	3.3	\$167.33
50A 3P MOLDED CASE BRKR	3	E	Inc. Above	Inc. Above	1.65	4.95	\$210.38
125A 3P MOLDED CASE BRKR	3	E	Inc. Above	Inc. Above	4.4	13.2	\$561
150A 3P MOLDED CASE BRKR	5	E	Inc. Above	Inc. Above	4.4	22	\$935
225A 3P MOLDED CASE BRKR	2	E	Inc. Above	Inc. Above	4.95	9.9	\$420.75
800A 3P MOLDED CASE BRKR	1	E	Inc. Above	Inc. Above	13.75	13.75	\$584.38
75KVA 3PH 480V DRY XMER	2	E	\$4,395	\$4,395	19.8	39.6	\$6,078
1" GRD CLAMP	4	E	\$16.41	\$65.64	0.8	3.08	\$196.54
BLOCKOUT/SLEEVE/SEAL 500	8	E	\$40	\$320	1.1	8.8	\$694
<b>Grand Total</b>			<b>\$28,286</b>		<b>360</b>		<b>\$43,586</b>

Bill of Material for Revised Components							
Description	Quantity	Unit	Mat./Unit	Material \$	Lab./Unit	Labor (Hrs.)	Total \$
DP 800A	1	E	\$1,685	\$1,685	16.5	16.5	\$7,576.25
400A H-1 PANELBOARD	1	E	\$2,580	\$2,580	24.2	24.2	\$3,608.50
400A L-1 PANELBOARD	1	E	\$1,590	\$1,590	27.5	27.5	\$2,758.75
400A L-1B PANELBOARD	1	E	\$875	\$875	18.7	18.7	\$1,669.75
100A H-2 PANELBOARD	1	E	\$1400	\$1400	24.2	24.2	\$2,428.50
1 1/4" EMT CONDUIT FEEDERS	28	C	\$104.69	\$29.31	6.6	1.8	\$107.85
1 1/2" EMT CONDUIT FEEDERS	48	C	\$128.21	\$61.54	8.8	4.2	\$241.06
2 1/2" EMT CONDUIT FEEDERS	54	C	\$245.44	\$132.54	13.2	7.1	\$435.48
1 1/4" EMT STL SS CONN	2	C	\$65.20	\$1.30	0.0	0.0	\$1.30
1 1/2" EMT STL SS CONN	0	C	\$92.51	\$0	0.0	0.0	\$0
2 1/2" EMT STL SS CONN	4	C	\$391.95	\$15.68	0.0	0.0	\$15.68
1 1/4" EMT STL SS CPLG	7	C	\$65.12	\$4.56	0.0	0.0	\$4.56
1 1/2" EMT STL SS CPLG	17	C	\$102.06	\$17.35	0.0	0.0	\$17.35
2 1/2" EMT STL SS CPLG	14	C	\$306.16	\$42.86	0.0	0.0	\$42.86
1 1/4" EMT 90 DEG ELBOW	2	C	\$341.64	\$6.83	44.0	0.9	\$44.23
1 1/2" EMT 90 DEG ELBOW	4	C	\$358.99	\$14.36	44.0	1.8	\$89.16
2 1/2" EMT 90 DEG ELBOW	4	C	\$1212.51	\$48.50	77.0	3.1	\$179.40
1 1/4" PLASTIC BUSHING	2	C	\$7.82	\$0.16	0.0	0.0	\$0.16
1 1/2" PLASTIC BUSHING	6	C	\$12.86	\$0.77	0.0	0.0	\$0.77
2" PLASTIC BUSHING	6	C	\$15.81	\$0.95	0.0	0.0	\$0.95
2 1/2" PLASTIC BUSHING	4	C	\$29.23	\$1.17	0.0	0.0	\$1.17
2" STRAIGHT FLEX CONN	3	C	\$1071.75	\$32.15	77.0	2.3	\$130.33
2" STEEL FLEX	12	C	\$354.33	\$42.52	16.5	2.0	\$126.67
2" STL 90 DEG FLEX CONN	3	C	\$2417.55	\$72.53	77.0	2.3	\$170.71
#8 THHN BLACK	38	M	\$369.60	\$14.04	11.0	0.4	\$31.81
#6 THHN BLACK	93	M	\$568.61	\$52.88	13.2	1.2	\$105.05
#4 THHN BLACK	84	M	\$902.50	\$75.81	14.3	1.2	\$126.86
#3 THHN BLACK	202	M	\$1130.55	\$228.37	15.4	3.1	\$360.58
#2 THHN BLACK	81	M	\$1415.10	\$114.62	15.4	1.2	\$167.63
#1 THHN BLACK	221	M	\$1876.59	\$414.73	17.6	3.9	\$580.04
#3/0 THHN BLACK	80	M	\$3506.90	\$280.55	25.3	2.0	\$366.57
#4/0 THHN BLACK	143	M	\$4444.89	\$635.62	27.5	3.9	\$802.75
#250MCM THHN BLACK	144	M	\$5359.13	\$771.71	30.8	4.4	\$960.21

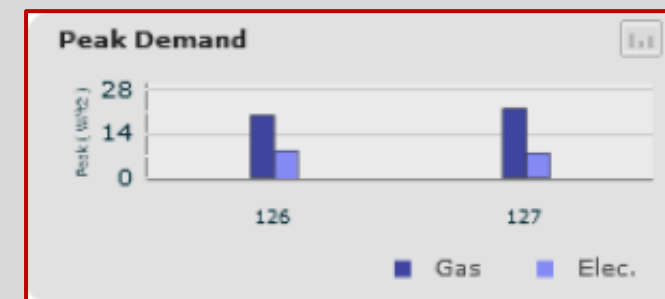
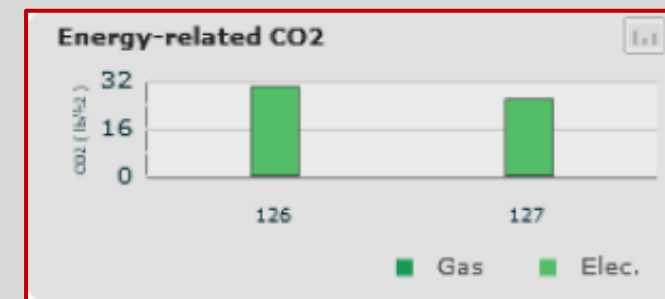
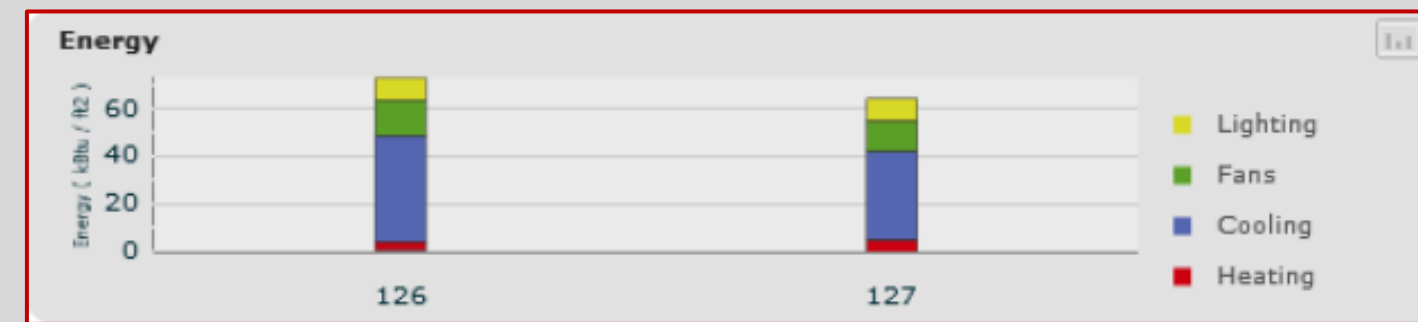
1-H CRIMP LUG #4 GRAY	2	C	\$200.26	\$4.01	16.5	0.3	\$18.04
1-H CRIMP LUG #2 BROWN	6	C	\$391.02	\$23.46	18.7	1.1	\$71.15
1-H CRIMP LUG #3/0 ORANGE	10	C	\$587.78	\$58.78	30.8	3.1	\$189.68
1-H CRIMP LUG #4/0 PURPLE	3	C	\$655.55	\$19.67	33.0	1.0	\$61.75
WIRE TERM #6 THRU #2	14	E	\$0.63	\$8.82	0.6	7.7	\$336.07
WIRE TERM. #1 THRU 3/0	14	E	\$1.24	\$17.36	0.7	9.2	\$410.06
WIRE TERM. 4/0 THRU 400 MCM	16	E	\$2.29	\$36.64	1.0	15.8	\$709.84
1/4" THREADED ROD - PLTD	46	C	\$3.20	\$1.47	2.8	1.3	\$55.23
1/4-20 HEX NUT - PLTD STL	30	C	\$1.77	\$0.53	2.2	0.7	\$28.58
1/4" FLANGE W/ 1/4" THRD ROD	17	C	\$87.09	\$14.81	7.7	1.3	\$70.44
ERICO 1 1/2" EMT/1 1/4" GRC	4	C	\$65.72	\$2.63	11.0	0.4	\$21.33
ERICO 1 1/2" GRC CLAMP	7	C	\$80.42	\$5.63	11.0	0.8	\$38.36
ERICO 2 1/2" EMT/GRC CLAMP	6	C	\$159.32	\$9.56	22.0	1.3	\$65.66
50A 3P MOLDED CASE BRKR	3	E	Inc. Above	Inc. Above	1.7	5.0	\$210.38
100A 3P MOLDED CASE BRKR	1	E	Inc. Above	Inc. Above	3.3	3.3	\$140.25
125A 3P MOLDED CASE BRKR	2	E	Inc. Above	Inc. Above	4.4	8.8	\$374
150A 3P MOLDED CASE BRKR	6	E	Inc. Above	Inc. Above	4.4	26.4	\$1122
225A 3P MOLDED CASE BRKR	1	E	Inc. Above	Inc. Above	5.0	5.0	\$210.38
250A 3P MOLDED CASE BRKR	1	E	Inc. Above	Inc. Above	6.1	6.1	\$257.13
112.5KVA 3PH 480V DRY XMER	1	E	\$2,930	\$2930	28.6	28.6	\$4,145.50
1" GRD CLAMP FOR BARE WIRE	2	E	\$16.41	\$32.82	0.8	1.5	\$98.27
BLOCKOUT/SLEEVE/SEAL 200	2	E	\$30	\$60	0.7	1.3	\$116.10
BLOCKOUT/SLEEVE/SEAL 300	2	E	\$30	\$60	0.7	1.3	\$116.10
<b>Grand Total</b>			<b>\$19,720</b>		<b>287</b>		<b>\$31,918</b>



## Eastern Façade Energy Charts



## Southern Façade Energy Charts



## Western Façade Energy Charts

