Electrical Depth

Branch Circuit Redesign

Copper vs Aluminum Feeder Study

Energy Efficient Transformer Analysis

Protective Device Coordination

Branch Circuit Redesign

Below is a redesign of the panelboards, feeders, and circuit breakers that are affected by the new lighting design system. The panelboards are redesigned to accommodate the new lighting loads. The over current protection device is sized according to the new design ampacity as well as the feeder serving the panel.

Club Room

The dimming panel below is a Lutron Grafik Eye 4000 system. The feeder for this panel below runs from panel A2LNH1.

PANEL A2- DDC01						
DIMMER	ZONE	TYPE	CONTROL	LOAD (W)	VOLTAGE (V)	LOCATION
1	A	LVH WW	Dimmed	1275	120	Along North Wall
2	B	CFL DWNLT	Dimmed	1560	120	Throughout Space
3	B	CFL DWNLT	Dimmed	1365	120	Throughout Space
4	C	LVH DWNLT	Dimmed	400	120	Entrance Corridor
5	D	CFL PENDANT	Dimmed	1120	120	Throughout Space
6	E	CFL PENDANT	Dimmed	150	120	Over Bar Counter
7	F	CFL SCONCE	Dimmed	112	120	Along South Wall
8	G	LV ACCENT	Dimmed	120	120	Entrance Corridor
9	H	LED STRIP	On/Off	100	120	Bar- Back Counter
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
		TOTAL LOAD (w)		6202		
		with growth (W)		7752.50		

Design Load: 38A
Circuit Breaker: 50A
Feeder Size: (3) #8 AWG
Conduit: 3/4" C

Lobby

Below circuits 6, 8, and 10 were redesigned with the new lighting loads.

PANELBOARD SCHEDULE												
VOLTAGE: 480Y/277V,3PH,4W			PANEL TAG: R1LNH1						MIN. C/B AIC: 10K			
SIZE/TYPE BUS: 150A			PANEL LOCATION: R168						OPTIONS: PROVIDE FEED THROUGH LUGS			
SIZE/TYPE MAIN: 150A/3P C/B			PANEL MOUNTING: SURFACE						FOR PANELBOARD 1L1B			
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Gymnasium	2000	20A/1P	1	*			2	20A/1P	1700	Toilet/Lobby	Lighting
Lighting	Gymnasium	3000	20A/1P	3		*		4	20A/1P	1700	Pool Seating	Lighting
Lighting	Gymnasium	2000	20A/1P	5			*	6	20A/1P	480	Entrance/Office	Lighting
Lighting	Gymnasium	3000	20A/1P	7	*			8	20A/1P	2000	Rotunda	Lighting
Lighting	Gymnasium	2000	20A/1P	9		*		10	20A/1P	2150	Juice Bar Area	Lighting
Lighting	Gymnasium	2000	20A/1P	11			*	12	20A/1P	2450	Exterior	Lighting
Lighting	Gymnasium	3000	20A/1P	13	*			14	20A/1P	500	Lobby/Reception	Lighting
Lighting	Gymnasium	2000	20A/1P	15		*		16	20A/1P	2000	Juice Bar	Lighting
Lighting	Gymnasium	3000	20A/1P	17			*	18	20A/1P	1000	Corridor	Lighting
Lighting	Gymnasium	2000	20A/1P	19	*			20	20A/1P	2100	Corridor/Lobby	Lighting
Lighting	Gymnasium	2000	20A/1P	21		*		22	20A/1P	1000	Corridor	Lighting
Lighting	Gymnasium	3000	20A/1P	23			*	24	20A/1P	1400	Rotunda Cove	Lighting
Lighting	Gymnasium	2000	20A/1P	25	*			26	20A/1P	0	Spare	Lighting
Lighting	Gymnasium	3000	20A/1P	27		*		28	20A/1P	0	Spare	Lighting
Lighting	Gymnasium	2000	20A/1P	29			*	30	20A/1P	0	Spare	Lighting
Lighting	Fitness 3	2500	20A/1P	31	*			32	20A/1P	0	Spare	Lighting
Lighting	Fitness 4	3000	20A/1P	33		*		34	20A/1P	0	Spare	Lighting
Lighting	Gymnasium	600	20A/1P	35			*	36	20A/1P	0	Spare	Lighting
Lighting	Exterior	3000	20A/1P	37	*			38	20A/1P	0	Spare	Lighting
Lighting	Spare	0	20A/1P	39		*		40	20A/1P	0	Spare	Lighting
Lighting	Spare	0	20A/1P	41			*	42	20A/1P	0	Spare	Lighting
CONNECTED LOAD (KW) - A		23.80								TOTAL DESIGN LOAD (KW)		95.37
CONNECTED LOAD (KW) - B		21.85								POWER FACTOR		1.00
CONNECTED LOAD (KW) - C		17.93								TOTAL DESIGN LOAD (AMPS)		115

Sizes are based on Design Load and are determined by referencing the NEC Handbook

Design Load: 115A
Circuit Breaker: 125A
Feeder Size: (3) #1 AWG THHW
Conduit: 1-¼" C
Note: Although a smaller feeder size could have been used, I chose to size up for safety.

Gymnasium

Below circuits 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20 were redesigned with the new lighting loads.

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: R3LNH1	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 150A	PANEL LOCATION: R311	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 150A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Corridor	1100	20A/1P	1	*			2	20A/1P	3500	Upper Gym	Lighting
Lighting	Rotunda	800	20A/1P	3		*		4	20A/1P	3500	Upper Gym	Lighting
Lighting	Corridor	300	20A/1P	5			*	6	20A/1P	3500	Upper Gym	Lighting
Lighting	Corridor	300	20A/1P	7	*			8	20A/1P	3500	Upper Gym	Lighting
Lighting	Bathrooms	1100	20A/1P	9		*		10	20A/1P	3500	Upper Gym	Lighting
Lighting	Corridor	1200	20A/1P	11			*	12	20A/1P	3500	Upper Gym	Lighting
Lighting	Rotunda	600	20A/1P	13	*			14	20A/1P	2250	Above Running Track	Lighting
Lighting	Rotunda	1100	20A/1P	15		*		16	20A/1P	2250	Above Running Track	Lighting
Lighting	Rotunda	800	20A/1P	17			*	18	20A/1P	2250	Below Track	Lighting
Lighting	Upper Gym court 3	2000	20A/1P	19	*			20	20A/1P	2250	Below Track	Lighting
Lighting	Fitness Ctr	1200	20A/1P	21		*		22	20A/1P	0	0	Lighting
Lighting	Rotunda	1600	20A/1P	23			*	24	20A/1P	0	0	Lighting
Lighting	Rotunda	800	20A/1P	25	*			26	20A/1P	0	0	Lighting
Lighting	Fitness Ctr	1200	20A/1P	27		*		28	20A/1P	0		Lighting
Lighting	Roof	800	20A/1P	29			*	30	20A/1P	0		Lighting
Lighting	Climbing Wall	1200	20A/1P	31	*			32	20A/1P	0		Lighting
Lighting	Upper Gym	0	20A/1P	33		*		34	20A/1P	0		Lighting
Lighting	Upper Gym	0	20A/1P	35			*	36	20A/1P	0		Lighting
Lighting		0	20A/1P	37	*			38	20A/1P	0		Lighting
Lighting		0	20A/1P	39		*		40	20A/1P	0		Lighting
Lighting		0	20A/1P	41			*	42	20A/1P	0		Lighting

CONNECTED LOAD (KW) - A	17.50	TOTAL DESIGN LOAD (KW)	69.15
CONNECTED LOAD (KW) - B	14.65	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	13.95	TOTAL DESIGN LOAD (AMPS)	83

Sizes are based on Design Load and are determined by referencing the NEC Handbook

Design Load: 83A
Circuit Breaker: 90A
Feeder Size: (3) #3 AWG THHW
Conduit: 1 - ¼" C
Note: Although a smaller feeder size could have been used, I chose to size up for safety.

Exterior

Below circuit 2 was redesigned with the new lighting loads for Layout 1.

PANELBOARD SCHEDULE		
VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: RL1LNH1	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 150A	PANEL LOCATION: RB116A	OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B
SIZE/TYPE MAIN: 150A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS NO.	A	B	C	POS NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Corridor	1100	20A/1P	1	*			2	20A/1P	2695	Exterior Site	Lighting
Lighting	Classroom	2500	20A/1P	3		*		4	20A/1P	900	Classroom	Lighting
Lighting	Fitness Center	1100	20A/1P	5			*	6	20A/1P	2000	Fitness Center	Lighting
Lighting	Passage	1500	20A/1P	7	*			8	20A/1P	900	Corridor	Lighting
Lighting	Rotunda	2000	20A/1P	9		*		10	20A/1P	1500	Rotunda	Lighting
Lighting	Lobby	1700	20A/1P	11			*	12	20A/1P	600	Public Lobby	Lighting
Lighting	Corridor	1000	20A/1P	13	*			14	20A/1P	1000	Corridor	Lighting
Lighting	Rotunda Cove	2900	20A/1P	15		*		16	20A/1P	2400	Fitness Center	Lighting
Lighting	Rotunda	1700	20A/1P	17			*	18	20A/1P	2400	Classroom	Lighting
Lighting	Classroom	1300	20A/1P	19	*			20	20A/1P	800	Corridor	Lighting
Lighting	Corridor	600	20A/1P	21		*		22	20A/1P	2000	Corridor	Lighting
Lighting	Offices	1100	20A/1P	23			*	24	20A/1P	1200	Offices	Lighting
Lighting	Fitness Center	2100	20A/1P	25	*			26	20A/1P	1900	Men Faculty Locker	Lighting
Lighting	Rotunda	2000	20A/1P	27		*		28	20A/1P	2600	Men's Locker room	Lighting
Lighting	Women's Locker	2600	20A/1P	29			*	30	20A/1P	2900	Corridor	Lighting
Lighting	Women Faculty Locker	1900	20A/1P	31	*			32	20A/1P	0		Lighting
Lighting	Exterior Site	1000	20A/1P	33		*		34	20A/1P	0		Lighting
Lighting	Exterior Parking	3000	20A/1P	35			*	36	20A/1P	0		Lighting
Lighting	Exterior Site	700	20A/1P	37	*			38	20A/1P	0		Lighting
Lighting	Corridor	1100	20A/1P	39		*		40	20A/1P	0		Lighting
Lighting	Corridor	2200	20A/1P	41			*	42	20A/1P	0		Lighting

CONNECTED LOAD (KW) - A	16.90	TOTAL DESIGN LOAD (KW)	67.19
CONNECTED LOAD (KW) - B	21.50	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	22.50	TOTAL DESIGN LOAD (AMPS)	81

Sizes are based on Design Load and are determined by referencing the NEC Handbook

Design Load: 81A
Circuit Breaker: 90A
Feeder Size: (3) #3 AWG THHW
Conduit: 1 - ¼" C
Note: Although a smaller feeder size could have been used, I chose to size up for safety.

Exterior Continued

Below circuit 2 was redesigned with the new lighting loads for Layout 2.

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: RL1LNH1
SIZE/TYPE BUS: 150A	PANEL LOCATION: RB116A
SIZE/TYPE MAIN: 150A/3P C/B	PANEL MOUNTING: SURFACE
MIN. C/B AIC: 10K	OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS NO.	A	B	C	POS NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Corridor	1100	20A/1P	1	*			2	20A/1P	1386	Exterior Site	Lighting
Lighting	Classroom	2500	20A/1P	3		*		4	20A/1P	900	Classroom	Lighting
Lighting	Fitness Center	1100	20A/1P	5			*	6	20A/1P	2000	Fitness Center	Lighting
Lighting	Passage	1500	20A/1P	7	*			8	20A/1P	900	Corridor	Lighting
Lighting	Rotunda	2000	20A/1P	9		*		10	20A/1P	1500	Rotunda	Lighting
Lighting	Lobby	1700	20A/1P	11			*	12	20A/1P	600	Public Lobby	Lighting
Lighting	Corridor	1000	20A/1P	13	*			14	20A/1P	1000	Corridor	Lighting
Lighting	Rotunda Cove	2900	20A/1P	15		*		16	20A/1P	2400	Fitness Center	Lighting
Lighting	Rotunda	1700	20A/1P	17			*	18	20A/1P	2400	Classroom	Lighting
Lighting	Classroom	1300	20A/1P	19	*			20	20A/1P	800	Corridor	Lighting
Lighting	Corridor	600	20A/1P	21		*		22	20A/1P	2000	Corridor	Lighting
Lighting	Offices	1100	20A/1P	23			*	24	20A/1P	1200	Offices	Lighting
Lighting	Fitness Center	2100	20A/1P	25	*			26	20A/1P	1900	Men Faculty Locker	Lighting
Lighting	Rotunda	2000	20A/1P	27		*		28	20A/1P	2600	Men's Locker room	Lighting
Lighting	Women's Locker	2600	20A/1P	29			*	30	20A/1P	2900	Corridor	Lighting
Lighting	Women Faculty Locker	1900	20A/1P	31	*			32	20A/1P	0		Lighting
Lighting	Exterior Site	1000	20A/1P	33		*		34	20A/1P	0		Lighting
Lighting	Exterior Parking	3000	20A/1P	35			*	36	20A/1P	0		Lighting
Lighting	Exterior Site	700	20A/1P	37	*			38	20A/1P	0		Lighting
Lighting	Corridor	1100	20A/1P	39		*		40	20A/1P	0		Lighting
Lighting	Corridor	2200	20A/1P	41			*	42	20A/1P	0		Lighting

CONNECTED LOAD (KW) - A	15.59	TOTAL DESIGN LOAD (KW)	65.23
CONNECTED LOAD (KW) - B	21.50	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	22.50	TOTAL DESIGN LOAD (AMPS)	78

Sizes are based on Design Load and are determined by referencing the NEC Handbook

Design Load: 78A
Circuit Breaker: 80A
Feeder Size: (3) #4 AWG THHW
Conduit: 1" C
Note: Although a smaller feeder size could have been used, I chose to size up for safety.

Copper vs Aluminum Conductor Study

The debate between copper and aluminum conductors has been a constant struggle. The following study looks at the disadvantages and advantages of each type of metal wiring. In order to conduct the analysis, 25 different existing copper feeders found throughout Boston University's Fitness and Recreation Center's electrical distribution system were selected. The aluminum wire sizes were determined by the overcurrent protection device from the original feeder, which then determined the new conduit size.

Table 1: Price Comparison Copper vs Aluminum Conductors

FDR ID	OCPD	Length (ft)	Copper Phase Wires	Aluminum Phase Wires	Copper Cost/L.F	Copper Cost	Aluminum Cost/L.F.	Aluminum Cost	Copper Conduit Size	Aluminum Conduit Size
A4	30	80	(3) 10	(3) 8	4.7	376	3.95	316.00	1/2	3/4
A5	30	92	(3) 10	(3) 8	4.7	432.4	4.20	386.40	1/2	3/4
B4	40	56	(3) 8	(3) 6	6.7	375.2	4.20	235.20	3/4	1
C4	50	5	(3) 6	(3) 4	5.1	25.5	4.80	24.00	1	1
D4	60	10	(3) 4	(3) 4	6.35	63.5	4.80	48.00	1	1
E4	70	12	(3) 4	(3) 2	6.35	76.2	5.30	63.60	1	1-1/4
F4	90	6	(3) 2	(3) 1	8.15	48.9	5.95	35.70	1-1/4	1-1/4
G4	100	200	(3) 2	(3) 1 / 0	8.15	1630	7.25	1450.00	1-1/4	1-1/2
H4	125	168	(3) 1 / 0	(3) 2 / 0	12.25	2058	7.55	1268.40	1-1/2	1-1/2
J4	150	125	(3) 2 / 0	(3) 4 / 0	14.5	1812.5	9.95	1243.75	1-1/2	2
K4	175	178	(3) 3 / 0	(3) 4 / 0	16.75	2981.5	9.95	1771.10	2	2
L4	200	5	(3) 4 / 0	(3) 300	19	95	12.75	63.75	2	2-1/2
M4	225	10	(3) 250	(3) 350	21.5	215	13.90	139.00	2-1/2	2-1/2
N4	250	300	(3) 250	(3) 400	21.5	6450	15.30	4590.00	2-1/2	3
P4	300	250	(3) 350	(3) 500	28	7000	16.70	4175.00	2-1/2	3
Q4	350	90	(3) 500	(6) 4 / 0	35.25	3172.5	19.90	1791.00	3	3
R4	400	10	(6) 3 / 0	(6) 300	33.5	335	25.50	255.00	2-1/2	3-1/2
S4	500	30	(6) 250	(6) 400	43	1290	30.60	918.00	3	4
T4	600	150	(6) 350	(6) 500	56	8400	33.40	5010.00	3-1/2	4
U4	700	6	(6) 500	(9) 350	70.5	423	41.70	250.20	4	6
V4	800	6	(9) 300	(9) 500	74.25	445.5	50.10	300.60	4	6
W4	1000	6	(9) 400	(12) 400	94.85	569.1	61.20	367.20	6	6
X4	1200	6	(12) 350	(12) 500	112	672	66.80	400.80	6	6
Y4	1500	6	(12) 500	(15) 500	141	846	83.50	501.00	6	6+
Z4	1600	6	(15) 400	(18) 500	158	948	100.20	601.20	6	6+
					TOTAL	**40,740.80**		**26,204.90**		

**The unit costs per linear foot were taken from CostWorks. The pricing is based on 3 Copper conductors in a PVC jacket or 3 Aluminum conductors in a PVC jacket. In the event there were more than one set of 3 conductors the unit cost was multiplied by the number of sets.*

Table 2: Copper Characteristics

Copper	Higher electrical conductivity than aluminum, therefore smaller wire sizes for the same ampacity
	According to IEEE Standard 835-1994, copper's ampacity is 1.6 times that of aluminum
	Harder and stronger material which can stand much more abuse over time
	Because of the smaller wire sizing; more flexible to install and less effort
	Can withstand tighter twists, harder pulls, and more bends at junction and termination boxes without stretching or breaking
	Higher resistance to corrosion
	Forgiving metal to join electrically
	Better connections than aluminum
	Less bulky which means easier to transport to site and easier to install

Table 3: Aluminum Characteristics

Aluminum	Softer material, lower modulus of elasticity
	Need more critical installation procedures in order to secure bad connections
	Theirs is always an insulating oxide present
	The thermal expansion coefficient is much larger than copper, which causes loose connections when the wire expands and contracts
	Aluminum alloys are more active metals which make them more susceptible to corrode around moisture which causes a shorter life span

From the Table 1 above, aluminum wires are much cheaper than that of copper. For this particular set of feeders, aluminum is 36% cheaper than copper which could save the project a considerable amount of money. Although this seems like it could be very beneficial for the owner, there are many issues associated with aluminum wiring. It is recommended by the NEC that aluminum wires should not be used for distribution systems and only used for utility service feeders or where the design ampacity does not fluctuate. The utility service generally has a constant feed, unlike distribution feeders where the current running through them can have a large range.

Copper and aluminum metal have several differences that create advantages and disadvantages when wiring a building's distribution system. In order to allow the same ampacity, the aluminum wire would need to be sized larger than the copper wire. This could create a problem within the building construction process; ceiling plenum space is limited as it is. Although initial costs of aluminum are much less than copper the life cycle cost of copper is much less. Aluminum is much more difficult to install and is susceptible to damage and failure which requires re-installation of the wire. Overall, I would recommend using copper wire for building distribution systems.

Energy Efficient Transformer Analysis

Transformers tend to have low efficiencies generating electrical losses. Powersmiths manufactures energy efficient transformers which will be compared to status quo transformers in the report below. Each Recreation Center transformer will be replaced with an energy efficient transformer manufacturered by Powersmiths in order to calculate the energy savings as well as pay back period.

Transformer Takeoff

Transformers on Project		Total KW
QTY	kVA	
1	30	30
4	45	180
2	112.5	225
1	150	150
2	225	450
2	2000	4000
		5035

Available Full Load kW	**5035**		
Average kVA (calc)	**420**		
equipment operating hrs/ day	18		
equipment operating days/yr	300	Calc Load kW	Calc Annual kWh
Load during normal operating hours	50%	2518	13,594,500
Load outside operating hours	10%	504	1,691,760
		Total Annual Load kWh:	**15,286,260**

Annual Cost to Operate Load Only			
kWh rate	$ 0.029	Annual Consumption:	$ 440,703
demand rate ($/kW/mo) ex. $10.00	$12.00	Annual Demand:	$ 362,520
		Total Cost to run load	$ **803,223**

Annual Cost of Status Quo Transformer Losses & Associated Air Conditioning (A/C) burden			
Nameplate Linear efficiency (normal op hrs)	98.0%	% electronics or current THD	30.0%
Calculated operating efficiency	97.0%		
Transformer kW Losses (Normal Operation)	78.4	kW	
Status quo Efficiency (Outside op. hrs)	91.0%		
Transformer kW Losses (Outside op. hrs)	49.8	kW	
Annual addititional kWh from transformers	590,656	kWh	
Annual Cost of Transformer Losses	$ 28,318		
A/C System Performance (kW/ton)	1.75		
Additional Tons of Cooling (on peak)	22.27	tons	
Annual addititional kWh from A/C	293,650	kWh	
Annual Cost of Associated A/C	$ 14,078		

Summary with Status Quo Transformer	
Annual Cost of feeding Building Load	$ 803,223
Annual Cost of Transformer Losses	$ 28,318
Annual Cost of Associated A/C	$ 14,078
Electrical Bill (Status Quo Transformer)	$ **845,619**

TOTEL Electric Bill for Current Transformers: $845,619

Annual Cost of POWERSMITH's Transformer, Losses & Associated Air Conditioning (A/C) burden			
Powersmiths Efficiency (Normal Operation)	98.2%		
Powersmiths kW Losses (Normal Operation)	0.0	kW	
Powersmiths Efficiency (Outside op. hrs)	97.6%		
Transformer kW Losses (Outside op. hrs)	0.0	kW	
Annual addititional kWh from transformers	290,787	kWh	
Annual Cost of Powersmiths Losses	$ 15,028		
Additional Tons of Cooling (on peak)	13.11	tons	
Annual addititional kWh from A/C	144,567	kWh	
Annual Cost of Associated A/C	$ 7,471		

Summary with Status Quo Transformer	
Annual Cost of feeding Building Load	$ 803,223
Annual Cost of Transformer Losses	$ 15,028
Annual Cost of Associated A/C	$ 7,471
Electrical Bill (Status Quo Transformer)	**$ 825,722**

TOTEL Electric Bill for Powersmith Transformers: $825,722

Comparing Status Quo & Powersmiths			
	Status Quo	**Powersmiths**	
Annual Cost of feeding Building Load	$ 803,223	$ 803,223	
Annual Cost of Transformer Losses	$ 28,318	$ 15,028	
Annual Cost of Associated A/C	$ 14,078	$ 7,471	**Reduction**
Annual estimated Electrical Bill	**$ 845,619**	**$ 825,723**	**2%**
Peak kW *REDUCTION* (normal op hours)	**32.3**	**kW**	
Annual kWh *REDUCTION*	**448,951**	**kWh**	
***REDUCTION* in Air Conditioning Load (on peak)**	**9.16**	**tons**	

Cost Analysis			
Energy Cost Escalation (above inflation)	3.0%		
	Annual	**Life Cycle Operating Cost & Savings**	
	Operating Cost	**20 years**	**32 years**
Status Quo Transformers	$42,396	$1,531,438	$3,493,543
Powersmiths Transformers	$22,500	$812,744	$1,854,047
Savings with Powersmiths	**$19,896**	**$718,694**	**$1,639,496**

Unit Costs Total	
Powersmiths Transformers	$494,000
Status Quo Transformers	$203,225

Payback Period On Total Costs	**14.61**	**years**	current kWh rate:
Cost of Energy Savings	**$ 0.020**	**/kWh**	$0.029
Cost - Benefit Ratio	**1.4**	**times less to save a kWh than to buy a kWh**	

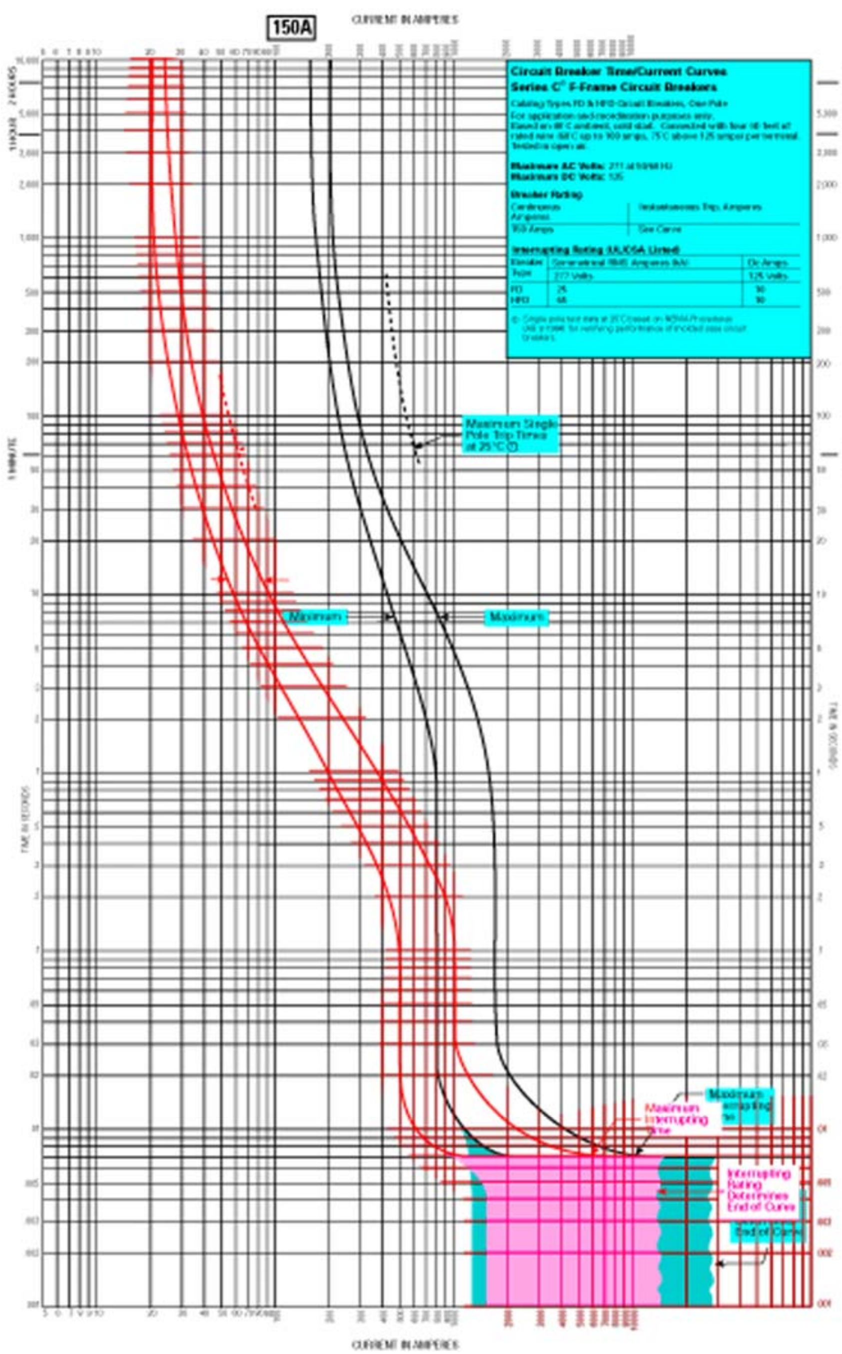
After thoroughly looking at the transformer analysis, I would recommend the high initial costs for Powersmiths transformers, which will ultimately save the owner money in the long run. Although fifteen years seems like a rather long payback period, the transformers will be worth the energy savings for the building as a whole.

Protective Device Coordination

The chart below shows an overcurrent protection coordination study.

AB DE-ION Circuit Breakers

Types FD and HFD 150 Amperes



The Red lines represent a 20A circuit breaker from a lighting load. The Black lines with blue highlights represent a 150A circuit breaker for a panelboard. The two devices are coordinated correctly as this table shows.

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