Alternate 2

Introduction

Alternate 2 will consider changing the existing emergency back-up system, which is connected to the main generator sets and paralleling switchgear, by isolating the North Addition emergency system from the rest of the hospital. Furthermore, the alternate will include the normal power branch as part of the emergency back-up system. To do so, I will be sizing an emergency generator to have enough capacity to supply ample power to all three emergency branches and the normal power. This investigation would be beneficial to the hospital if they were looking into the possibility of isolating the existing hospital power distribution system from the new addition. This could benefit them if they feel the facility is getting large enough that they would want to look into isolating some of the system incase a catastrophic emergency equipment failure took place. Thus, the entire hospital would not lose all power.

Goal

I will determine the cost impact of the resizing of equipment and addition of a separate generator to provide the North Addition with an alternative power supply. In addition, my Construction Management Breadth topic will detail this cost analysis as well as address other installation and sequencing concerns associated with the proposed changes.

Design Criteria

All electrical sizing and calculations were completed using requirements and tables from the 2002 National Electric Code (NEC). Load calculations for existing conditions can be found on enclosed CD-ROM under the file name 'Master Panel Schedule.xls'. Alternate 2 load calculations can be found under the file name 'Alt 2 Panel Schedule.xls'.

Article 517 of the NEC sets out specific emergency system requirements for healthcare facilities. Among these requirements, the article requires three separate emergency branches: life safety, critical, and equipment. Each branch must be fed by its own automatic transfer switch (assuming maximum demand <150 KVA) which in turn is supplied by both the primary and alternative power sources. The transfer switches must have the capability to shut-off its respective branch if the generator cannot handle the current demand of the entire system. Furthermore, the equipment branch must "shed" its load before the critical branch and the critical branch must shed its load before the life safety. The requirements for each emergency branch and what types of loads are permitted are also outlined in Article 517 in detail. In brief, the life safety branch consists of emergency lighting, automatic doors, and any power required to egress people from the building. The critical branch consists of lighting, receptacle, and medical equipment loads essential in the care and well-being of patients where lives would be threatened if power was interrupted. The equipment branch consists of the mechanical equipment loads essential to the operation of critical care areas in the hospital.

Also outlined in Article 517, the addition of non-emergency loads (normal branch) are permitted to connect to the generator equipment if that branch is connected via an automatic transfer switch that will shed first in the priority order of transfer switches.

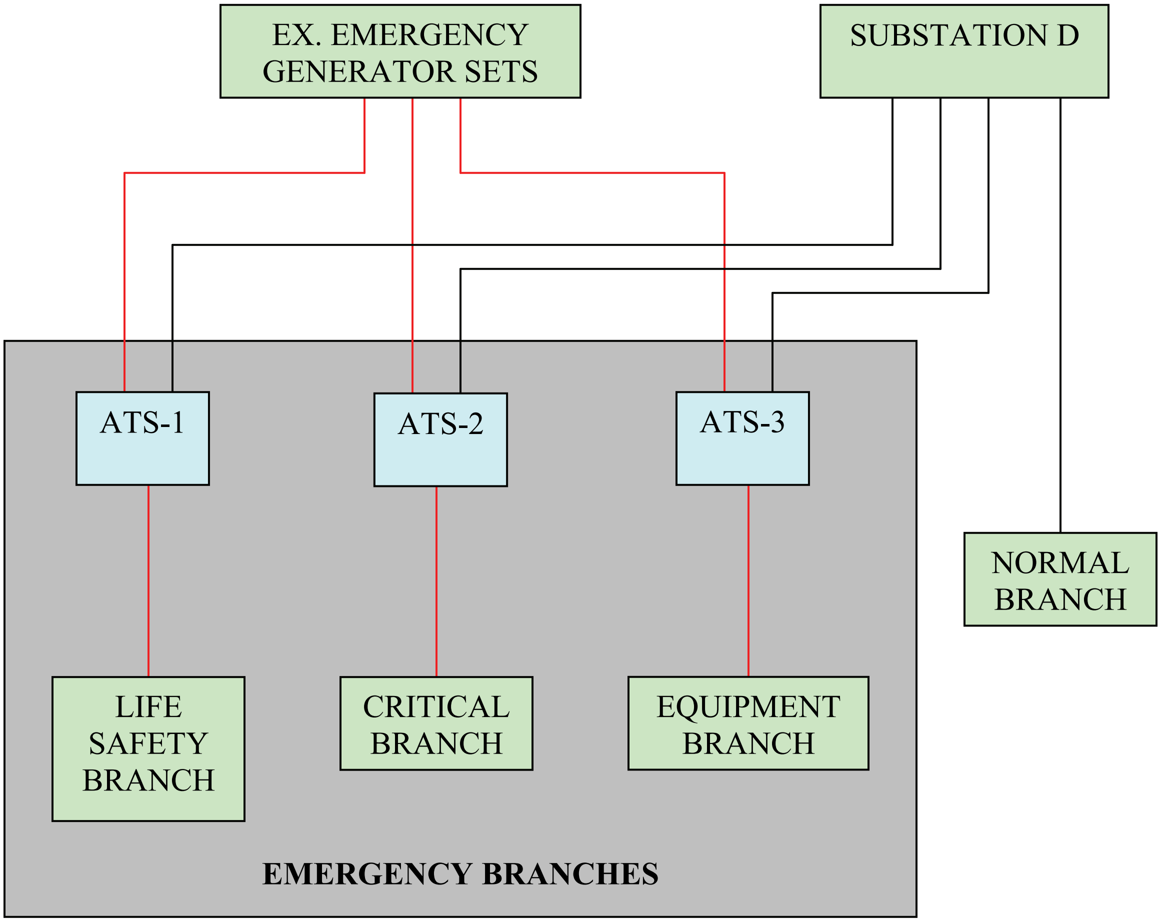
Assumptions

Again, when sizing the existing loads for each Panelboard throughout the system, I had to make a lot of assumptions concerning the known equipment loads. With the assistance of the engineers at Leach Wallace, I assigned load values to these various amounts of equipment. From these assumptions, many of my panels were determined to be loaded past their rated capacity. With respects to the system components I was redesigning and resizing, I accounted for the calculated demand loads determined when surveying the existing system. For simplicity's sake however, I did not resize equipment previously designed and not being touched by my alternates. I am confident the original design was sized correctly and properly and the error was most likely in the many assumptions made concerning equipment loads. Therefore, seemingly undersized equipment as noted was not overlooked but considered and left intact.

Since I am ultimately comparing the cost of the alternate compared with the original design, the direct analysis between the two systems will be hard to accurately portray. Since I do not have all the information for the various other additions and existing power demand, I will not be able to estimate the reduction in size of the initial redesign of the new generator set and associated paralleling switchgear. Therefore, I will not be able to incorporate the deletion or downsizing of any generator set equipment associated with the isolation of the North Addition demand.

Electrical Schematics

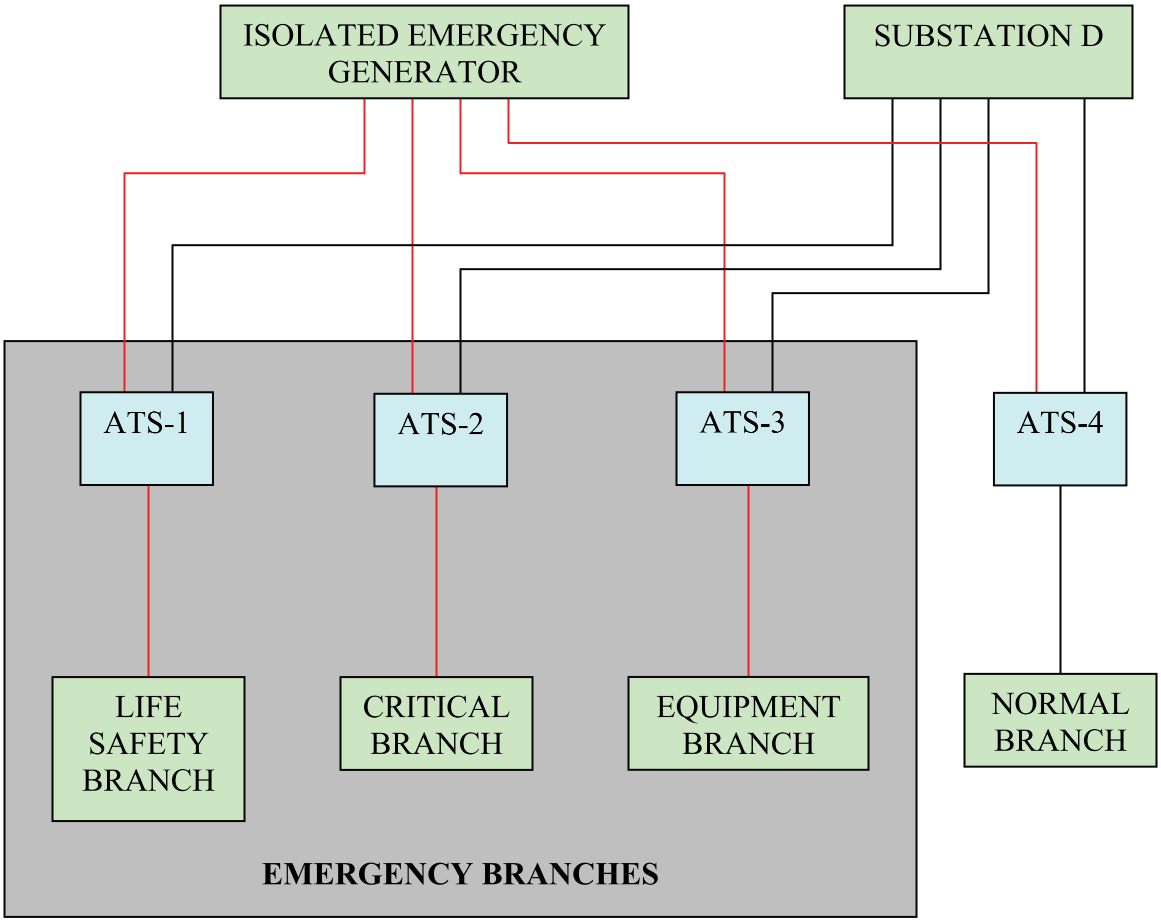
Existing Electrical Distribution Configuration:



Refer to one-line diagram inserts for details of existing and proposed changes to the entire system

Figure 22: Alternate 2 Existing Design Schematic

Proposed Electrical Distribution Configuration:



Refer to one-line diagram inserts for details of existing and proposed changes to the entire system

Figure 23: Alternate 2 Proposed Design Schematic

Feeder Schedules

Feeder Number	Serving	Served From	Conduit	Wire	Ground	Amperage	Wire Ampacity	Connected Load
Feeder Schedule - Existing								
1	PANEL ME1L-N	EX. PANEL ME1L-ED	2"	4#1/0	1#4	100 A	230 A	59.3 A
2	PANEL E2L-3N	EX. PANEL E2L-3A	1 1/4"	4#4	1#6	75 A	125 A	59.0 A
3	PANEL E1L-1N	PANEL ME1L-N	3/4"	4#8	1#10	50 A	70 A	26.1 A
4	XFMR T-5	PANEL E1L-1N	3/4"	3#10	1#10	15 KVA	50 A	11.8 A
5	PANEL E1P-1N	XFMR T-5	3/4"	4#8	1#10	50 A	70 A	27.3 A
6	PANEL E1L-2N	PANEL ME1L-N	3/4"	4#8	1#10	50 A	70 A	14.3 A
7	XFMR T-6	PANEL E2L-2N	3/4"	3#10	1#10	15 KVA	50 A	16.0 A
8	PANEL E2P-2N	XFMR T-6	3/4"	4#8	1#10	50 A	70 A	37.0 A
9	PANEL E1L-3N	PANEL ME1L-N	3/4"	4#8	1#10	50 A	70 A	16.1 A
10	XFMR T-7	PANEL E1L-3N	3/4"	3#10	1#10	15 KVA	50 A	2.4 A
11	PANEL E1P-3N	XFMR T-7	3/4"	4#8	1#10	50 A	70 A	5.4 A
12	XFMR T-8	PANEL E2L-3N	3/4"	3#8	1#10	30 KVA	50 A	36.3 A
13	PANEL E2P-3N	XFMR T-8	1 1/4"	4#3	1#8	100 A	145 A	83.8 A
14	PANEL E1L-4N	PANEL ME1L-N	3/4"	4#8	1#10	50 A	50 A	12.9 A
15	PANEL E3L-N	EX. PANEL ME3L-ED	3"	4#350	1#1	250 A	505 A	205.3 A
16	E6ATS	EX. PANEL EMDP-ED	2"	3#2/0	1#6	110 A	265 A	21.9 A
17	E6ATS	PANEL MDP-N	2"	3#4/0	1#4	225 A	360 A	21.9 A
18	PANEL E6L-N-ELEV	E6ATS	2"	3#4/0	1#4	225 A	360 A	50.5 A
19	XFMR T-8	PANEL E3L-N	3/4"	3#6	1#8	30 KVA	95 A	37.0 A
20	PANEL E3P-N	XFMR T-8	1 1/4"	4#2	1#8	100 A	170 A	85.5 A
21	PANEL E2L-2N	PANEL E2L-3N	3/4"	4#8	1/#10	50 A	70 A	20.5 A
22	EX. PANEL EMDP-ED	EX. PARALLELING SWITCHGEAR	(3) 3"	3 SETS 4#500MCM	3#2/0	1000 A	1860 A	-
23	PANEL MDP-N	EX. SUBSTATION D	(3) 3 1/2"	3 SETS 4#400MCM	3#3/0	800 A	1635 A	-
24	EX. E1ATS	EX. SUBSTATION D	2 1/2"	4#4/0	1#4	225 A	360 A	-
25	EX. E1ATS	EX. PANEL EMDP-ED	2 1/2"	4#4/0	1#4	225 A	360 A	-
26	EX. PANEL ME1L-ED	EX. E1ATS	2 1/2"	4#4/0	1#4	225 A	360 A	-
27	EX. E3ATS	EX. SUBSTATION D	(2) 2 1/2"	2 SETS 4#350MCM	2#1	600 A	1010 A	-
28	EX. E3ATS	EX. PANEL EMDP-ED	(2) 2 1/2"	2 SETS 4#350MCM	2#1	600 A	1010 A	-
29	EX. PANEL ME3L-ED	EX. E3ATS	(2) 2 1/2"	2 SETS 4#350MCM	2#1	600 A	1010 A	-
30	LP-4N	MDP-N	1 1/2"	4#1/0	#6	150 A	150 A	26.0 A
31	XFMR T-4	LP-4N	1"	3#4	#8	45 KVA	85 A	13.9 A
32	PP-4N	XFMR T-4	1 1/2"	4#1/0	#6	150 A	150 A	32.2 A
33	LP-3N	MDP-N	1 1/2"	4#1/0	#6	150 A	150 A	80.6 A
34	XFMR T-3	LP-3N	1"	3#4	#8	45 KVA	85 A	65 A
35	PP-3N	XFMR T-3	1 1/2"	4#1/0	#6	150 A	150 A	150 A
36	LP-2N	MDP-N	1 1/2"	4#1/0	#6	150 A	150 A	84.7 A
37	XFMR T-2	LP-2N	1"	3#4	#8	45 KVA	85 A	64.2 A
38	PP-2N	XFMR T-2	1 1/2"	4#1/0	#6	150 A	150 A	148.2 A
39	LP-1N	MDP-N	2"	4#3/0	#6	200 A	230 A	277.6 A
40	XFMR T-11	LP-1N	1 1/2"	3#1	#8	75 KVA	150 A	24.2 A
41	HCK	XFMR T-11	2 1/2"	4#4/0	#4	200 A	200 A	55.8 A
42	XP	LP-1N	1"	4#6	#10	60 A	65 A	53.6 A
43	XFMR T-1	LP-1N	1"	3#4	#8	45 KVA	85 A	72.8 A
44	PP-1N	XFMR T-1	1 1/2"	4#1/0	#6	150 A	150 A	168 A
45	DIM	LP-1N	3/4"	4#10	#10	30 A	30 A	30 A
46	XFMR T-9	LP-1N	1"	3#4	#8	45 KVA	85 A	78.1 A
47	PP-1N1	XFMR T-9	1 1/2"	4#1/0	#6	150 A	150 A	180 A

Feeder Schedule - Alternates								
Feeder Number	Serving	Served From	Conduit	Wire	Ground	Amperage	Wire Ampacity	Connected Load
1N	XFMR T-L	MDP-N	(2) 1 1/2"	2 SETS 3#1/0	(2) #6	200 KVA	300 A	279 A
2N	MDP-L	XFMR T-L	(3) 2 1/2"	3 SETS 4#300MCM	(3) #2	800 A	855 A	644 A
3N	PP-4N	MDP-L	1 1/2"	4#1/0	#6	150 A	150 A	32.2 A
4N	PP-3N	MDP-L	1 1/2"	4#1/0	#6	150 A	150 A	150 A
5N	PP-2N	MDP-L	1 1/2"	4#1/0	#6	150 A	150 A	148.2 A
6N	HCK	MDP-L	2 1/2"	4#4/0	#2	200 A	230 A	55.8 A
7N	PP-1N	MDP-L	1 1/2"	4#1/0	#6	150 A	150 A	168 A
8N	PP-1N1	MDP-L	2"	4#3/0	#4	150 A	200 A	180 A
9N	EMDP	GENERATOR	(4) 3"	4 SETS 4#400	4#1/0	1200 A	1340 A	1035 A
10N	ATS-4	EMDP	(3) 2 1/2"	3 SETS 4#300MCM	3#2	800 A	855 A	723 A
11N	E6ATS	EMDP	2"	3#4/0	#4	225 A	230 A	50.5 A
12N	ATS-2	EMDP	1 1/4"	4#3	#8	100 A	100 A	52.5 A
13N	ATS-3	EMDP	2 1/2"	4#250MCM	#2	250 A	255 A	205.3 A
14N	ATS-1	EMDP	1 1/4"	4#3	#8	100 A	100 A	59.3 A
15N	MDP-N	ATS-4	(3) 2 1/2"	3 SETS 4#350MCM	3#2	800 A	930 A	723 A
16N	E2L-3N	ATS-2	1 1/4"	4#2	#8	100 A	130 A	52.5 A
17N	E3L-N	ATS-3	2 1/2"	4#300MCM	#2	250 A	285 A	205.3 A
18N	ME1L-N	ATS-1	1 1/2"	4#1	#6	100 A	130 A	59.3 A
19N	ATS-4	SUBSTAT. D	(3) 2 1/2"	3 SETS #350MCM	3#2	800 A	930 A	723 A
20N	ATS-3	SUBSTAT. D	2 1/2"	4#300MCM	#2	250 A	285 A	205.3 A
21N	E6ATS	SUBSTAT. D	2"	3#4/0	#4	225 A	230 A	50.5 A
22N	ATS-2	SUBSTAT. D	1 1/4"	4#2	#8	100 A	115 A	52.5 A
23N	ATS-1	SUBSTAT. D	1 1/2"	4#1	#6	100 A	130 A	59.3 A

[yellow] - denotes upsized feeder to shown size due to voltage drop

[green] - denotes demand load larger than equipment rating (see "Assumptions" above)

Generator Design

To determine the proper size generator needed for Alternate 2, I enlisted the help of Cummins Power Generation's generator sizing program: Power Suite v. 4.0. To properly determine the size of generator needed, all loads have to be inputted into the software (based on load type and load demand) and assigned to a specific sequence determined by the operator. In this case, I used 4 steps to mirror each transfer switch being used. The software determined the running load to be 744.1 KW and the effective step KW to be 629.5 KW. These values correspond to a single 750 KW generator (Product #750DFGE) to be the best fit for this particular application. Therefore, I will be utilizing a single 480Y/277V 3-phase 750 KW generator to provide emergency power to the North Addition.

NORTH ADDITION EMERGENCY POWER ONE-LINE DIAGRAM

NORTH ADDITION ALTERNATE 2 ONE-LINE DIAGRAM

Electrical Equipment Schedules

To determine the financial impact of the proposed change stated above, I first had to determine what components I would be deleting from the initial design to accommodate for the new changes. The following table summarizes these deletions:

Electrical Cost Analysis - Deleted System Components (Existing)						
Equipment Type	Feeder					
	Name	Size	Rating (A)	Ground	Conduit Size	Length (ft)
FEEDER	#1	3 SETS (4) #400 MCM	1005	(3) #1/0	(3) 3 1/2"	500
FEEDER	#2	(4) #1/0	150	#4	2"	500
FEEDER	#3	(4) #4	85	#6	1 1/4"	500
FEEDER	#35	(4) #350 MCM	310	#1	3"	500
FEEDER	#36	(3) #2/0	175	#6	2"	40

Similarly, I needed to determine what components I would be adding to the current system. The following table summarizes those additions:

Electrical Cost Analysis - Added System Components (Proposed)													
Equipment Type	Panelboard							Feeder					
	Name	Load Connected (A)	Rating (A)	# Poles	Spaces	Voltage	Protection (A)	Name	Size	Rating (A)	Ground	Conduit Size	Length (ft)
PANEL	EMDP	828	1200	3	24	480Y/277	1000						
FEEDER								ATS-1	(4) #1	130	#8	1 1/2"	500
FEEDER								ATS-2	(4) #2	115	#8	1 1/4"	500
FEEDER								ATS-3	(4) #300 MCM	285	#2	2 1/2"	500
FEEDER								ATS-4	3 SETS (4) #300 MCM	855	(3) #2	(3) 2 1/2"	500
FEEDER								EATS-1	(4) #3	100	#8	1 1/4"	20
FEEDER								EATS-2	(4) #3	100	#8	1 1/4"	35
FEEDER								EATS-3	(4) #250 MCM	255	#2	2 1/2"	20
FEEDER								EATS-4	3 SETS (4) #300 MCM	855	(3) #2	(3) 2 1/2"	20
FEEDER								EMDP	4 SETS (4) #400 MCM	1340	(3) #1/0	(3) 3 1/2"	500
FEEDER								E6ATS (E)	(3) #2/0	175	#6	2"	40
FEEDER								E6ATS (N)	(3) #2/0	175	#6	2"	40
CIRCUIT BREAKER													
CIRCUIT BREAKER													
CIRCUIT BREAKER													
CIRCUIT BREAKER													
PARALLELING SWITCHGEAR													

Electrical Cost Analysis - Added Cont'd (Proposed)

Equipment Type	Automatic Transfer Switch					Circuit Breaker			
	Name	Rating (A)	Priority	Voltage	Phase	Feeding	Size (A)	Phase	Voltage
PANEL									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
FEEDER									
CIRCUIT BREAKER	ATS-1	100	1	480Y/277	3				
CIRCUIT BREAKER	ATS-2	100	2	480Y/277	3				
CIRCUIT BREAKER	ATS-3	250	3	480Y/277	3				
CIRCUIT BREAKER	ATS-4	800	4	480Y/277	3				
PARALLELING SWITCHGEAR						EMDP	1200	3	480Y/277

Voltage Drop Calculations

Since my proposed redesign deals with some significantly long feeder runs, I had to make sure the voltage drop for the feeders did not exceed 2% as recommended by NEC Article 215.2 (A) (4). The following table summarizes the voltage drop calculations and what wires were resized to maintain a 2% drop or less:

Voltage Drop Calculations - Alt. 2							
Feeder	Size	V_{L-N}	Amperage	Length	Factor	V_{drop} Factor*	% Vd_{rop}
ATS-1	#1	277	59	500	0.156	4.602	1.66
ATS-2	#2	277	52.5	500	0.196	5.145	1.86
ATS-3	#300 MCM	277	205	500	0.0545	5.586	2.02
ATS-4	(3) #350 MCM	277	241	500	0.047	5.664	2.04
EATS-1	#3	277	59	20	0.2495	0.294	0.11
EATS-2	#3	277	52.5	35	0.2495	0.458	0.17
EATS-3	#250 MCM	277	205	20	0.062	0.254	0.09
EATS-4	(3) #300 MCM	277	241	20	0.0545	0.263	0.09
EMDP	(4) #400 MCM	277	259	500	0.043	5.563	2.01
E6ATS(E)	#2/0	277	50.5	40	0.104	0.210	0.08
E6ATS(N)	#2/0	277	50.5	40	0.104	0.210	0.08

* Assumed a P.F. of 0.95

[yellow box] - denotes upsized feeder to shown size due to voltage drop

Pricing

Since I will be discussing my detailed cost analysis in the following section (Construction Management Breadth), I will briefly summarize my results that can be investigated further in my breadth work.

Existing System Credits = $73,232
Proposed System Changes = $426,547
Total Increased Budget = $353,315

Conclusions

Since Alternate 2 is not as straight forward as Alternate 1, I cannot necessarily recommend the addition or declination of the alternate. Although it would cost the client approximately $353,000 more than the existing system, the net cost (including the credits given for an overall smaller generator set for the rest of the hospital) would be less. From the information I could gather, I was not able to determine all the cost savings in isolating the North Addition from the rest of the hospital because I was unable to determine the existing hospital demand and associated downsizing of the designed generator set. However, $353,000 would be a 15% increase in the entire project's electrical budget, assuming the electrical portion of the MEP Budget ($7.8 million) is 30% (as quoted by Leach Wallace). Therefore, the proposed changes to the alternative power supply can be considered a reasonable alternative for the client to consider, but would ultimately have to be their choice depending upon their degree of necessity for power isolation.