

The Montgomery County Conference Center and Hotel



5701 Marinelli Road, Rockville, MD

The Montgomery County Conference Center and Hotel

Jessica R. Baker

**The Pennsylvania State University
Architectural Engineering
Mechanical Option**

Senior Thesis Presentations 2005



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Presentation Outline

- Building Overview
- Mechanical System Existing Conditions
- Mechanical System Redesign Goals / Analysis
 - Central Chiller Plant Optimization
- Electrical System Analysis
 - Modification due to Mechanical Redesign
- Lighting System Analysis
 - Decreasing Mechanical Cooling Load
- Construction Management Analysis
 - S.I.P.S - Hotel
- Summary
- Acknowledgements
- Questions

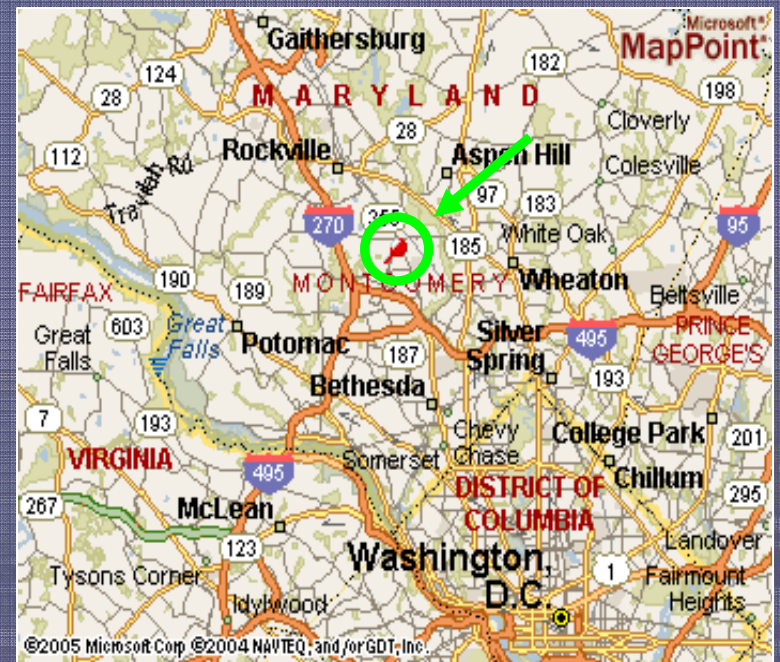


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Building Overview

- Names: MCCCH or Bethesda North Marriott Hotel and Conference Center
- Location: Rockville, MD
- Size: 240,000 sq. ft.
- Owners: Montgomery County of Maryland and IRP/QDC White Flint Associates L.C.C. for Marriott International
- Architect: RTKL Associates
- MEP Engineers: Engineering Design Group



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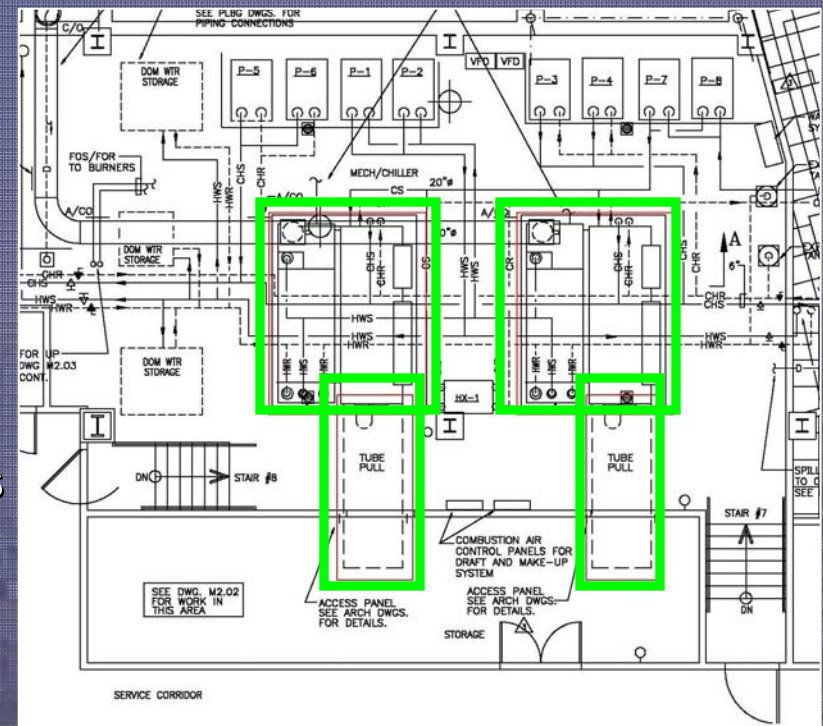
Mechanical System Existing Conditions

Airside:

- 11 AHUs (1,400-50,000 cfm)
- VAV w/ electric reheat in C.C. & Hotel Lobby
- VFC units in hotel guestrooms

Waterside:

- 2-300 ton/5,000 MBH natural gas direct-fired abs. chillers/heaters
- 2-1300 gpm cooling towers
- 8 large end suction pumps

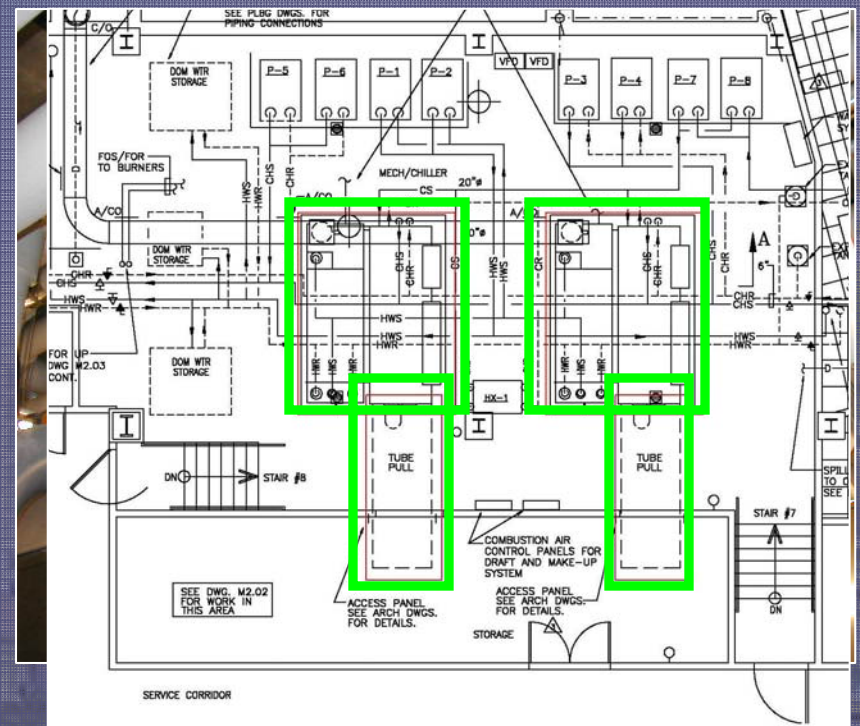


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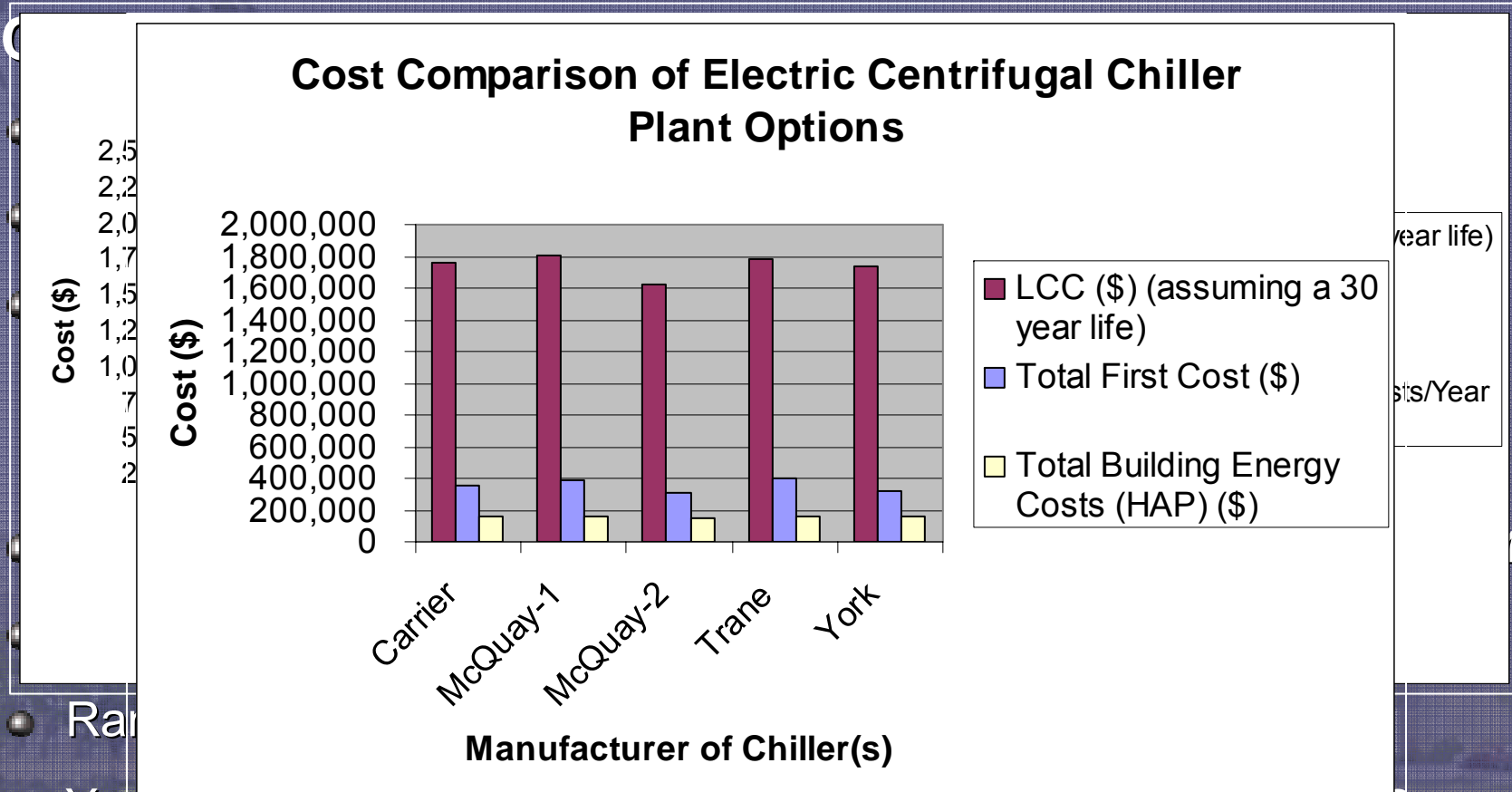
Mechanical System Redesign Goals / Analysis

- Main area of improvement
 - Absorption central chilling plant
 - High yearly operating & L.C.C.
 - Main mech. room layout / maintenance strategy
 - Operation strategy
- Redesign Goals
 - Optimize central chilling plant
 - Reduce operating & L.C.C.
 - Increase redundancy
 - Improve mech. room layout / maintenance & operation strategies



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● Rank

● York → optimum w/ 2-300 ton centrifugal → L.C.C. = \$1,738,472

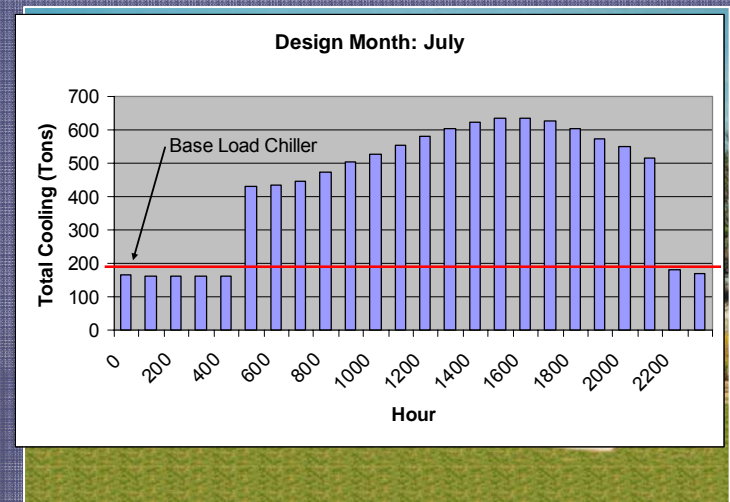


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Cool Thermal Storage Analysis

- Reasons: further savings, increase redundancy, & independence from grid
- ASHRAE - daily partial storage, load leveling, glycol ice
- Design
 - 4-Calmac IceBank tanks (model 1500)
 - 1-York 300 ton centrifugal ice-maker/chiller
 - 1-York 180 ton screw chiller (base loaded)
 - 165 gallons ethylene glycol
 - 1-Mueller plate & frame HTX



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Cool Thermal Storage Analysis / Final Recommendation

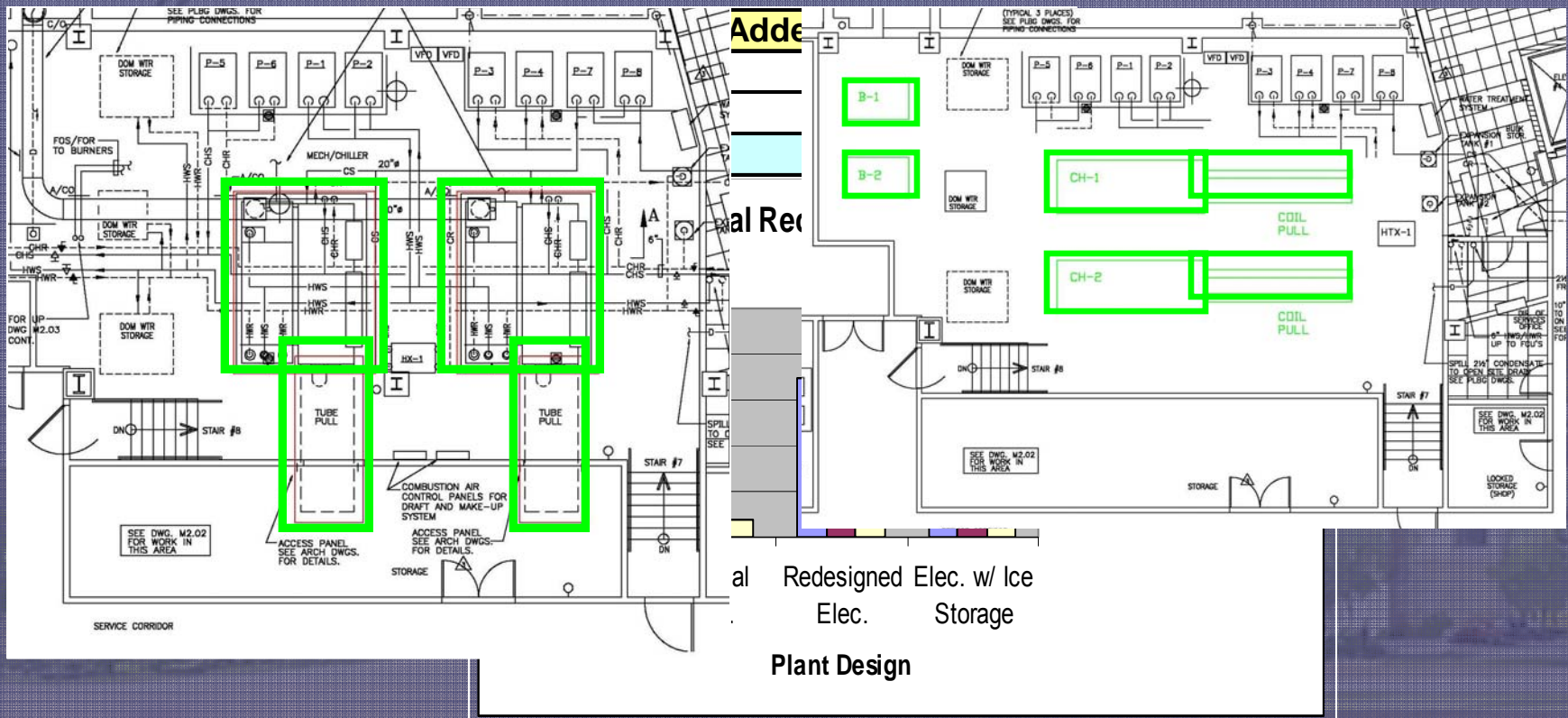
- HAP 3.27 (DOS) building energy simulation
- Ice storage saved **\$3,800** in op. cost/year → 28 year payback
- Chiller plant w/ ice storage → L.C.C. = ~~\$1,851,714~~
> **\$1,738,472** (L.C.C. central plant w/o ice storage)
- Electric peak kW demand charge (**\$2.20/peak kW**) not high enough to justify ice storage plant
- To justify ice storage plant, op. cost savings ~**\$21,500/year** (for a 5 year payback) → peak kW demand charge = **\$15.35/peak kW**
- Therefore, select electric central chiller plant w/o ice storage



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Mechanical Redesign Cost Analysis/Recommendations

Goals met?



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Electrical System Analysis

- New 800A motor control center, MCC2 - electric chillers (one 400A switch & fuse/chiller)
- Original chiller panel, ML1, 225A-100A
- Smaller cooling towers on original 400A panel, MP, circuit breakers resized from 100A to 30A
- Smaller condenser water pumps on original 800A MCC1, circuit breakers resized from 100A to 30A
- All electrical feeders and conduit resized accordingly
- Added electrical system first costs (R.S. Means): **\$10,618.20**
- Added first cost only ~1% increase in plant's L.C.C.



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Lighting System Analysis

- Conference Center Ballroom ~23,296 sq. ft.
- 4 types of decorative, custom incandescent fixtures - size from 12"x28" to 14'x24' (4-124 lamps/fixture)
- Original lamp(s): standard 60W incandescent (2700K), avg. life hrs = 1000, 850 l. lumens
- Replacement lamp(s): 20W C.F. (2700K), avg. life hrs = 8000, 965 mean lumens
- Equal lumens/fixture on workplane
- Lowered power density by 1.5W/sq.ft.
- Mechanical cooling saved: 10 tons
- Mechanical system first cost savings: **\$10,000** (~ \$1,000/ton, S.A. Mumma)
- First cost of C.F. vs. Incandescent lamps: **\$3,877.20** (more)
- Total first cost savings: **\$6,122.80**



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Construction Management Analysis

- Short Interval Production Scheduling (S.I.P.S.) – hotel 2nd-10th levels
- Selected due to hotel's repetitive construction process → maximum efficiency/minimized learning curve
- Specific construction activities identified and assigned production rates using original construction schedule
- Logical combining of trades - detailed 'mini-schedules'
- Time-scaled, resource-loaded bar chart
- S.I.P.S. hotel construction = 45 weeks vs. original schedule's 51 weeks
- Savings calculated from general conditions costs: **\$193,548.39**



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Summary

- Overall Savings \$\$\$:
 - Mechanical chiller plant redesign → \$430,516
 - Electrical system redesign → (-\$10,618)
 - Lighting system redesign → \$6,123
 - Construction Management Scheduling → \$193,548
- Total Redesign Savings

\$619,569



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Acknowledgements

Thesis Building Sponsors:

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HITT Contracting
Quadrangle Development Corporation



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Dr. Jae-Weon Jeong – Mechanical Faculty



Special Thanks To...

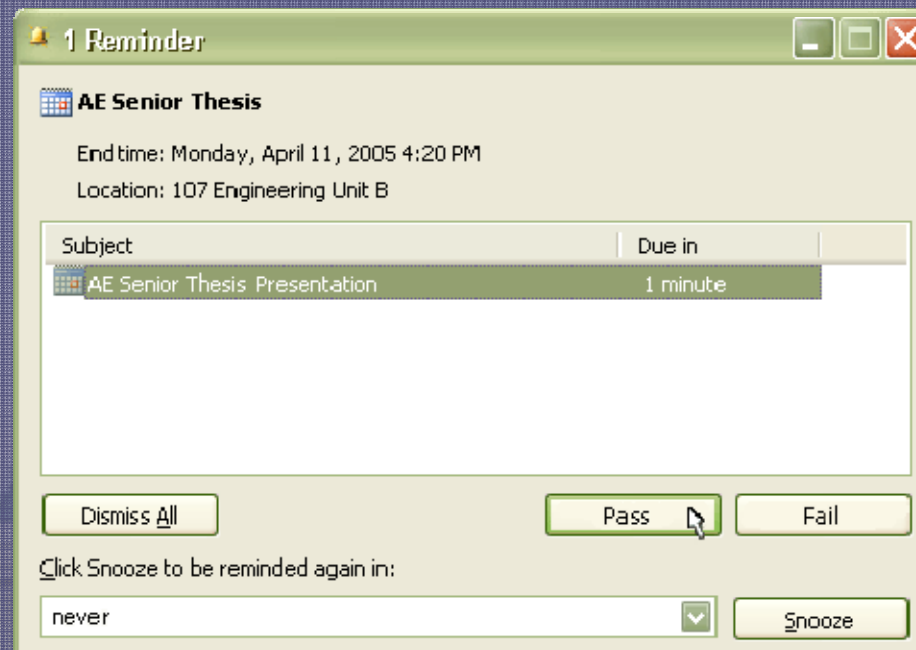
...all of my friends and family for their endless amounts of love and support throughout my years here at Penn State.

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Any Questions?



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Utility Rate Schedules:

● Electric – Pepco (Summer)

(Winter)

Distribution Service

Customer Charge	\$290.18 per month	\$290.18 per month
All kwh	\$0.00753 per kwh	\$0.00753 per kwh
Kilowatt Charge		
On Peak	\$2.2050 per KW	
Maximum	\$0.9114 per KW	\$0.9114 per KW
Delivery Tax	\$0.00062 per kwh	\$0.00062 per kwh
Md. Environmental Surcharge	\$0.00015 per kwh	\$0.00015 per kwh
Md. GPC	-\$0.0016695 per kwh	-\$0.0016695 per kwh
Montgomery County Surc.	\$0.0128658 per kwh	\$0.0128658 per kwh
or		
Prince Georges County Surc,	\$0.004946 per kwh	\$0.004946 per kwh

● Natural Gas – Washington Gas

Distribution Charge

All therms delivered during the billing month:

First 300 therms	31.58¢ per therm
Next 6,700 therms	21.52¢ per therm
Over 7,000 therms	15.73¢ per therm



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Absorption Chiller Costs:

Absorption Chillers		
	First Cost	LCC
Thesis Project	\$270,000	\$2,168,998
Owner	\$227,000	\$2,095,988
Difference	\$43,000	\$73,010
No change in optimum central chilling plant selection		

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Plant Types-First Cost Breakdowns:

Absorption Plant		
	<i>Equipment Cost</i>	<i>Installation Cost</i>
Chillers (2)	\$270,000.00	\$23,300.00
Cooling Towers (2)	\$68,400.00	\$6,100.00
Pumps (2)	\$15,200.00	\$2,620.00
Piping (200'-10" CW)	\$15,600.00	\$8,000.00
<i>Total w/o chiller equipment cost:</i>		\$139,220.00

Hybrid Plant		
	<i>Equipment Cost</i>	<i>Installation Cost</i>
Chillers (2)	\$240,000.00	\$22,050.00
Cooling Towers (2)	\$56,900.00	\$5,375.00
Pumps (2)	\$7,225.00	\$1,880.00
Piping (200'-8" CW)	\$6,500.00	\$5,900.00
Boiler (1)	\$25,000.00	\$3,500.00
<i>Total w/o chiller equipment cost:</i>		\$134,330.00

Electric Plant		
	<i>Equipment Cost</i>	<i>Installation Cost</i>
Chillers (2)	\$210,000.00	\$20,800.00
Cooling Towers (2)	\$45,400.00	\$4,650.00
Pumps (2)	\$6,850.00	\$1,140.00
Piping (200'-8" CW)	\$6,500.00	\$5,900.00
Boiler (2)	\$50,000.00	\$7,000.00
<i>Total w/o chiller equipment cost:</i>		\$148,240.00



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Electric Plants-First Cost Breakdown:

Electric Plant		
	Equipment Cost	Installation Cost
Chillers (2)	(manufacturer)	\$20,800.00
Cooling Towers (2)	\$45,400.00	\$4,650.00
Pumps (2)	\$6,850.00	\$1,140.00
Piping (200'-8" CW)	\$6,500.00	\$5,900.00
Boiler (2)	\$50,000.00	\$7,000.00
Total w/o chiller equipment cost:		\$148,240.00

***McQuay plant with one 600 ton chiller has less first cost due to having only one chiller and not two.
All other first costs for it are relatively the same.*



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Ice Storage Plant-First Cost Breakdown:

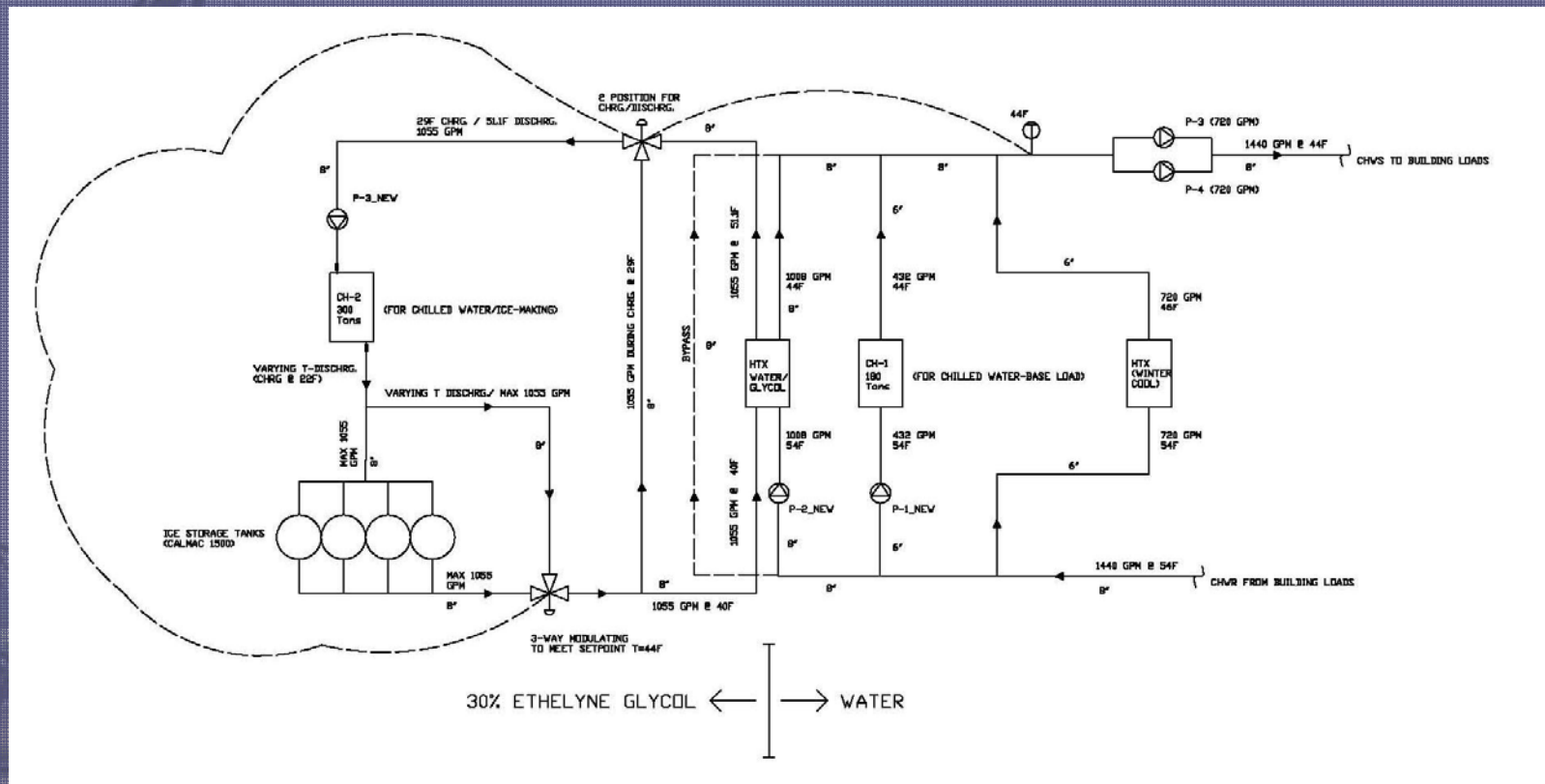
Electric Plant w/ Ice Storage (Base Load Chiller and Ice-making, etc.)		
	<i>Equipment Cost</i>	<i>Installation Cost</i>
<i>Chillers (2)</i>	\$145,000.00	\$19,800.00
<i>Cooling Towers (2)</i>	\$38,800.00	\$3,850.00
<i>Pumps (2)</i>	\$5,925.00	\$960.00
<i>Piping (200'-6" CW)</i>	\$6,500.00	\$5,900.00
<i>Boiler (2)</i>	\$50,000.00	\$7,000.00
<i>Heat Exchanger</i>	\$15,000.00	\$1,500.00
<i>Ethylene Glycol</i>	\$792.00	\$1,815.00
<i>Added Pump Cost</i>	\$8,425.00	\$855.00
<i>Ice Storage</i>	\$86,400.00	\$15,000.00
<i>Piping (200'-6" CW)</i>	\$6,500.00	\$5,900.00
<i>Total w/o chiller equipment cost:</i>		\$280,922.00
<i>Total w/ chiller equipment cost:</i>		\$425,922.00



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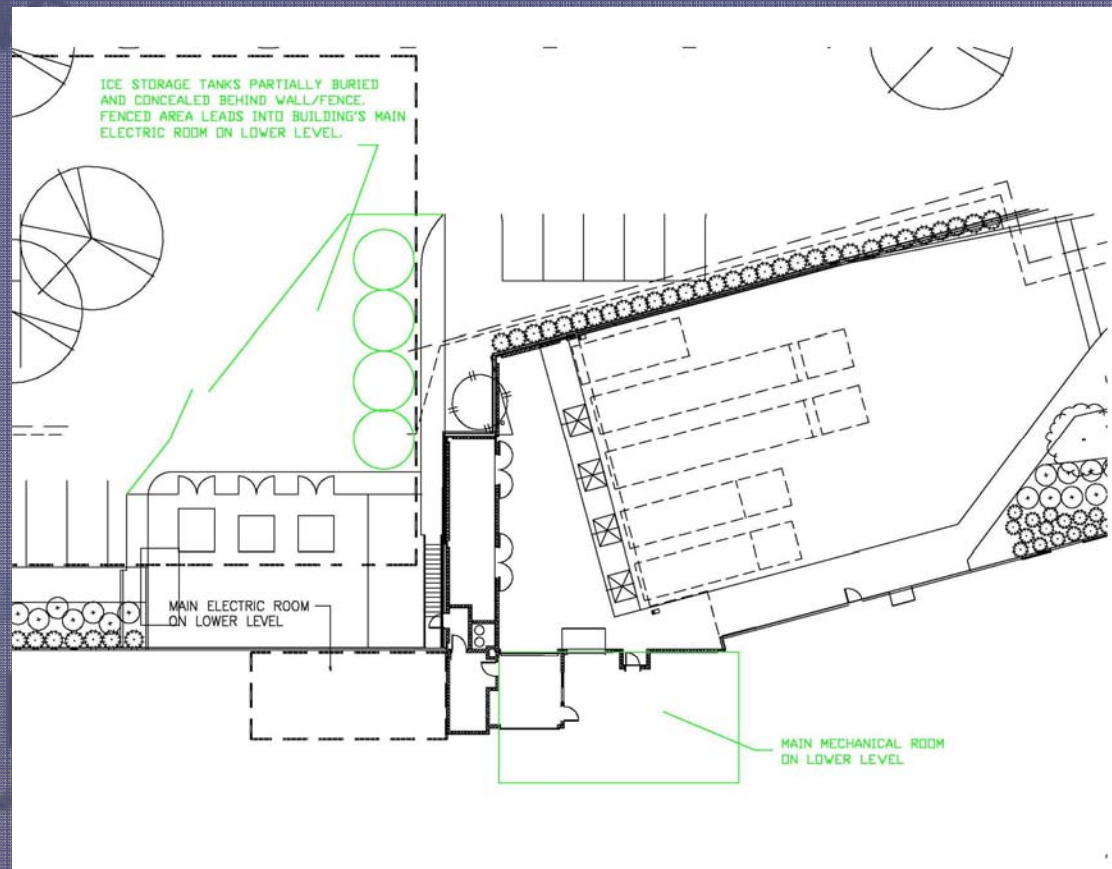
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Ice Storage Diagrams:



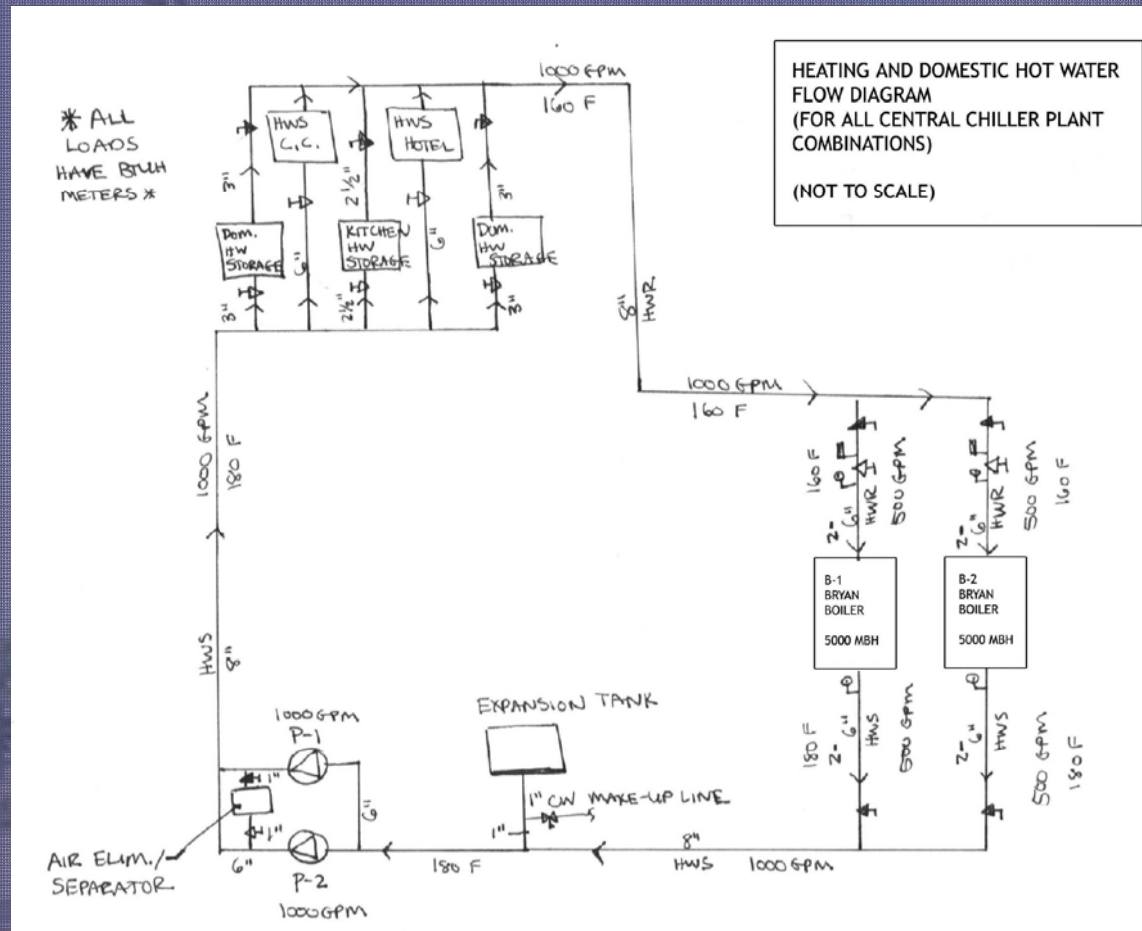
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Ice Storage Diagrams Continued:



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Chiller Plant Redesign Flow Diagram (HW):



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DOE Indices:

Escalation Factors



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Sensitivity ?

Natural Gas Absorption Chiller Plant				
DOE Indices - 5% increase electricity costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$409,220.00	1	-	\$ 409,220.00
Fuel	\$ 61,954.00	17.27	Table Bb-3 OMB UPV*	\$ 1,069,945.58
Electric	\$ 62,354.00	18.52	Table Bb-3 OMB UPV*	\$ 1,154,796.08
Maintenance	\$ 15,000.00	18.39	Table A-2 UPV	\$ 275,850.00
LCC:				\$ 2,909,811.66
Electric Vapor Compression Chiller Plant				
DOE Indices - 5% increase electricity costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$318,240.00	1	-	\$ 318,240.00
Fuel	\$ 12,168.00	17.27	Table Bb-3 OMB UPV*	\$ 210,141.36
Electric	\$ 71,041.00	18.52	Table Bb-3 OMB UPV*	\$ 1,315,679.32
Maintenance	\$ 11,500.00	18.39	Table A-2 UPV	\$ 211,485.00
LCC:				\$ 2,055,545.68
Difference:				\$ 854,265.98

Natural Gas Absorption Chiller Plant				
DOE Indices - 10% decrease natural gas costs, 10% increase electricity costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$409,220.00	1	-	\$ 409,220.00
Fuel	\$ 55,759.00	17.27	Table Bb-3 OMB UPV*	\$ 962,957.93
Electric	\$ 65,324.00	18.52	Table Bb-3 OMB UPV*	\$ 1,209,800.48
Maintenance	\$ 15,000.00	18.39	Table A-2 UPV	\$ 275,850.00
LCC:				\$ 2,857,828.41
Electric Vapor Compression Chiller Plant				
DOE Indices - 10% decrease natural gas costs, 10% increase electricity costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$318,240.00	1	-	\$ 318,240.00
Fuel	\$ 10,951.00	17.27	Table Bb-3 OMB UPV*	\$ 189,123.77
Electric	\$ 74,424.00	18.52	Table Bb-3 OMB UPV*	\$ 1,378,332.48
Maintenance	\$ 11,500.00	18.39	Table A-2 UPV	\$ 211,485.00
LCC:				\$ 2,097,181.25
Difference:				\$ 760,647.16



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Sensitivity ?

Natural Gas Absorption Chiller Plant				
DOE Indices - 30% decrease natural gas costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$409,220.00	1	-	\$ 409,220.00
Fuel	\$ 43,368.00	17.27	Table Bb-3 OMB UPV*	\$ 748,965.36
Electric	\$ 59,385.00	18.52	Table Bb-3 OMB UPV*	\$ 1,099,810.20
Maintenance	\$ 15,000.00	18.39	Table A-2 UPV	\$ 275,850.00
LCC:				\$ 2,533,845.56
Electric Vapor Compression Chiller Plant				
DOE Indices - 30% decrease natural gas costs				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$318,240.00	1	-	\$ 318,240.00
Fuel	\$ 8,518.00	17.27	Table Bb-3 OMB UPV*	\$ 147,105.86
Electric	\$ 67,658.00	18.52	Table Bb-3 OMB UPV*	\$ 1,253,026.16
Maintenance	\$ 11,500.00	18.39	Table A-2 UPV	\$ 211,485.00
LCC:				\$ 1,929,857.02
Difference:				\$ 603,988.54

Natural Gas Absorption Chiller Plant				
DOE Indices - 30% decrease natural gas costs, 20% increase in electric				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$409,220.00	1	-	\$ 409,220.00
Fuel	\$ 43,368.00	17.27	Table Bb-3 OMB UPV*	\$ 748,965.36
Electric	\$ 71,262.00	18.52	Table Bb-3 OMB UPV*	\$ 1,319,772.24
Maintenance	\$ 15,000.00	18.39	Table A-2 UPV	\$ 275,850.00
LCC:				\$ 2,753,807.60
Electric Vapor Compression Chiller Plant				
DOE Indices - 30% decrease natural gas costs, 20% increase in electric				
An OMB of 3.5% was used for all calculations given the 30 year maturity.				
	\$ Amount	Multiplier	From	Total
First Cost	\$318,240.00	1	-	\$ 318,240.00
Fuel	\$ 8,518.00	17.27	Table Bb-3 OMB UPV*	\$ 147,105.86
Electric	\$ 81,190.00	18.52	Table Bb-3 OMB UPV*	\$ 1,503,638.80
Maintenance	\$ 11,500.00	18.39	Table A-2 UPV	\$ 211,485.00
LCC:				\$ 2,180,469.66
Difference:				\$ 573,337.94



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Electrical Calculations:

Original Electrical System First Costs:					
	Size	Unit	# Units	Cost (\$)/Unit	First Cost (\$)
Panel Board ML1	225A	Each	1	2500.00	2500.00
Feeder for ML1	4-#4/0	C.L.F.	4	217.00	868.00
Ground for ML1	1-#4G	C.L.F.	1	48.50	48.50
Conduit for ML1	2 1/2"	L.F.	100	5.40	540.00
CT Wire	3-#2	C.L.F.	6	75.50	453.00
CT Ground	1-#8	C.L.F.	2	19.30	38.60
CT Conduit	1 1/4"	L.F.	200	2.22	444.00
CT Circuit Breaker	100A	Each	2	495.00	990.00
CW Pump Wire	3-#4	C.L.F.	6	48.50	291.00
CW Pump Ground	1-#8	C.L.F.	2	19.30	38.60
CW Pump Conduit	1 1/4"	L.F.	200	2.22	444.00
CW Pump Circuit Breaker	100A	Each	2	495.00	990.00
Chiller Wire	3-#10	C.L.F.	6	12.55	75.30
Chiller Ground	1-#10	C.L.F.	2	12.55	25.10
Chiller Conduit	3/4"	L.F.	200	1.04	208.00
Chiller Circuit Breaker	30A	Each	2	400.00	800.00
				Total:	\$8,754.10



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Electrical Calculations continued:

New Electrical System First Costs (w/ Mechanical Redesign):					
	Size	Unit	# Units	Cost (\$)/Unit	First Cost (\$)
Panel Board ML1	100A	Each	1	1800.00	1800.00
Feeder for ML1	4-#2	C.L.F.	4	75.50	302.00
Ground for ML1	1-#6G	C.L.F.	1	54.50	54.50
Conduit for ML1	1 1/2"	L.F.	100	2.54	254.00
MCC2	800A	Each	1	5275.00	5275.00
Feeder for MCC2	2 sets, 4-#3/0	C.L.F.	8	175.00	1400.00
Ground for MCC2	2 sets, 1-#3G	C.L.F.	2	60.00	60.00
Conduit for MCC2	2"	L.F.	100	3.20	320.00
CT Wire	3-#10	C.L.F.	6	12.55	75.30
CT Ground	1-#10	C.L.F.	2	12.55	25.10
CT Conduit	3/4"	L.F.	200	1.04	208.00
CT Circuit Breaker	30A	Each	2	400.00	800.00
CW Pump Wire	3-#10	C.L.F.	6	12.55	75.30
CW Pump Ground	1-#10	C.L.F.	2	12.55	25.10
CW Pump Conduit	3/4"	L.F.	200	1.04	208.00
CW Pump Circuit Breaker	30A	Each	2	400.00	800.00
Chiller Wire	3-500KCMIL	C.L.F.	6	505.00	3030.00
Chiller Ground	1-#3	C.L.F.	2	60.00	120.00
Chiller Conduit	2"	L.F.	200	3.20	640.00
Chiller Circuit Breaker	400A	Each	2	1950.00	3900.00
Total:					\$19,372.30



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Lighting Calculations:

Results:		
Total Original Lumens:	714000	lumens
New Total Wattage:	744980	lumens
Difference:	30980	lumens (more)
Total Original Wattage:	50400	W
New Total Wattage:	15440	W
Difference:	34960	W (less)
Ballroom Sq. Ft.:	23296	sq. ft.
Original Power Density:	2.16	W/sq. ft.
New Power Density:	0.66	W/sq. ft.
Difference:	1.50	W/sq. ft. (less)
Original Btu/h given off by lamps:	171955	Btu/h
New Btu/h given off by lamps:	52679	Btu/h
Difference:	119276	Btu/h (less)
Difference (tons):	9.94	Tons (less)
Original Ballroom Cooling Load:	39.2	Tons
New Ballroom Cooling Load with C.F.'s:	29.26	Tons



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Lighting Calculations continued:

Costs:		
Incandescent Lamp First Cost:	3.38 / lamp	
# Incandescent Lamps:	840	
Total First Cost for Incandescent Lamps:	\$2,839.20	
Compact Fluorescent Lamp First Cost:	8.70 / lamp	
# Compact Fluorescent Lamps:	772	
Total First Cost for Compact Fluorescent Lamps:	\$6,716.40	
Difference:	\$3,877.20	(more)
However, Cooling Saved:	10 tons	
Original Ballroom Cooling Sized at:	40 tons	
New Ballroom Cooling Sized at:	30 tons	
Initial Cost of Cooling (First Cost - \$ / Ton):	\$1,000.00	
Cost of Original Ballroom Cooling:	\$40,000.00	
Cost of New Ballroom Cooling:	\$30,000.00	
Difference:	\$10,000.00	(less)
Total F.C. Savings (Cooling Savings - Extra Lamp Expense):	\$6,122.80	
Also, if Lamps Replaced at Average Life Hours:		
Incandescent Average Life Hours:	1000	
C.F.'s Average Life Hours:	8000	
Incandescent Maintenance/Replacement Efforts per Year (Approximately):	4.24	~4 times a year
C.F. Maintenance/Replacement Efforts per Year (Approximately):	0.53	~1 in two years

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Construction Management Specific Activities Table:

One Floor - Example (2nd Floor) Original Schedule			
Structure - Concrete Frame:			
Columns (Pour 2A)	2 days		
Frame Deck (Pour 2A)	3 days		
Install Rebar (Pour 2A)	2 days		
Columns (Pour 2B)	2 days		
Place Concrete (Pour 2A)	1 days		
Frame Deck (Pour 2B)	3 days		
Concrete Cure and Strip Letter (Pour 2A)	3 days		
Install Rebar (Pour 2B)	2 days		
Strip and Reshore (Pour 2A)	3 days		
Place Concrete (Pour 2B)	1 days		
Concrete Cure and Strip Letter (Pour 2B)	3 days		
Strip and Reshore (Pour 2B)	3 days		
Remove Reshores after 21 days (2A)	1 days		
Remove Reshores after 21 days (2B)	1 days		
Core Systems - HVAC Distribution - HVAC/Plumbing Riser System RI and INSP			
Riser Rough-In begins	1 days		
10" CS + CR Piping up to CT	2.25 days		
HCH-1-14 Guestroom Risers	2.25 days		
HCH 15,16 to Rooftop AHU's	2.25 days		
CS/1 and CS/2 Corridor Supply Duct	2.25 days		
SE-1 Corr. Exhaust Duct	2.25 days		
SP-1 and SP-2 Stair Supply Ducts	2.25 days		
LE and VME Exhaust Ducts	2.25 days		
TE-1 - TE-14 Toilet Exhaust Ducts	2.25 days		
Linen Chute	2.25 days		
All Plumbing Risers / Stacks	2.25 days		
Riser Systems Inspected / Ready for Close-in	1 days		

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Construction Management Specific Activities Table continued:

<i>Sprinkler Distribution</i>				
Second Floor	5 days			
<i>Electrical Distribution</i>				
Second Floor - Busway, Riser, Panels - A	2.5 days			
Second Floor - Busway, Riser, Panels - B	2.5 days			
<i>Interior Build-Out - Second Floor</i>				
Layout Drywall Partitions	5 days			
Shaftwall at (Guestroom Duct Risers)	4 days			
Frame and 1-Side (Corr. and Bath Walls)	8 days			
Install Door Frames	4 days			
Perim. Firestopping and INSP	4 days			
MEP Wall R/I and Tubs (Bath and Corr. Walls)	10 days			
Wall Close-in Inspections	3 days			
Hang and Finish Bath / Corr. Walls	10 days			
Drywall Ceiling Framing	10 days			
MEP Ceiling R/I	8 days			
MEP Ceiling R/I and INSP	3 days			
Hang and Finish Drywall Ceilings	10 days			
Guestroom Dimising and Exterior Wall Framing	10 days			

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Construction Management Specific Activities Table continued:

Millwork and Trim	5 days		
Set and Pipe FCU's (Guestrooms)	5 days		
Prime Painting of Bathrooms	2 days		
Ceramic Tile (Bathrooms)	8 days		
MEP R/I and INSP (dimising and ext. walls)	8 days		
Vanity Tops	4 days		
Hang and Finish (Guestroom Walls)	10 days		
Mirrors	4 days		
Prep. Conc. Ceilings	7 days		
Prime Painting of Guestrooms	4 days		
Orange Peel Ceiling Finish	5 days		
Wallcoverings	10 days		
MEP Finishes and Caulking	8 days		
Bath and Room Accessories	10 days		
Carpet and Base	5 days		
Install Doors and Hardware	5 days		
Finish Paint	5 days		
Final INSP	5 days		
Final Clean	3 days		
Punch-Out	15 days		
Owner Furnishings	10 days		
Total:	291.5 days		
	58.3 weeks		
With Overlap:	51 weeks		



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Construction Management Cost Calculations:

Results:	
Entire Building Construction Schedule Length (weeks):	62
General Condition Costs for Entire Schedule Length:	\$2,000,000
Average General Condition Costs per Week:	\$32,258.06
Weeks Saved in Schedule by using SIPS (weeks):	6
Savings Calculated:	\$193,548.39



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