

DASCO Medical Office Building

Saint Joseph Medical Center

Architectural Engineering Senior Thesis
Mechanical System Redesign

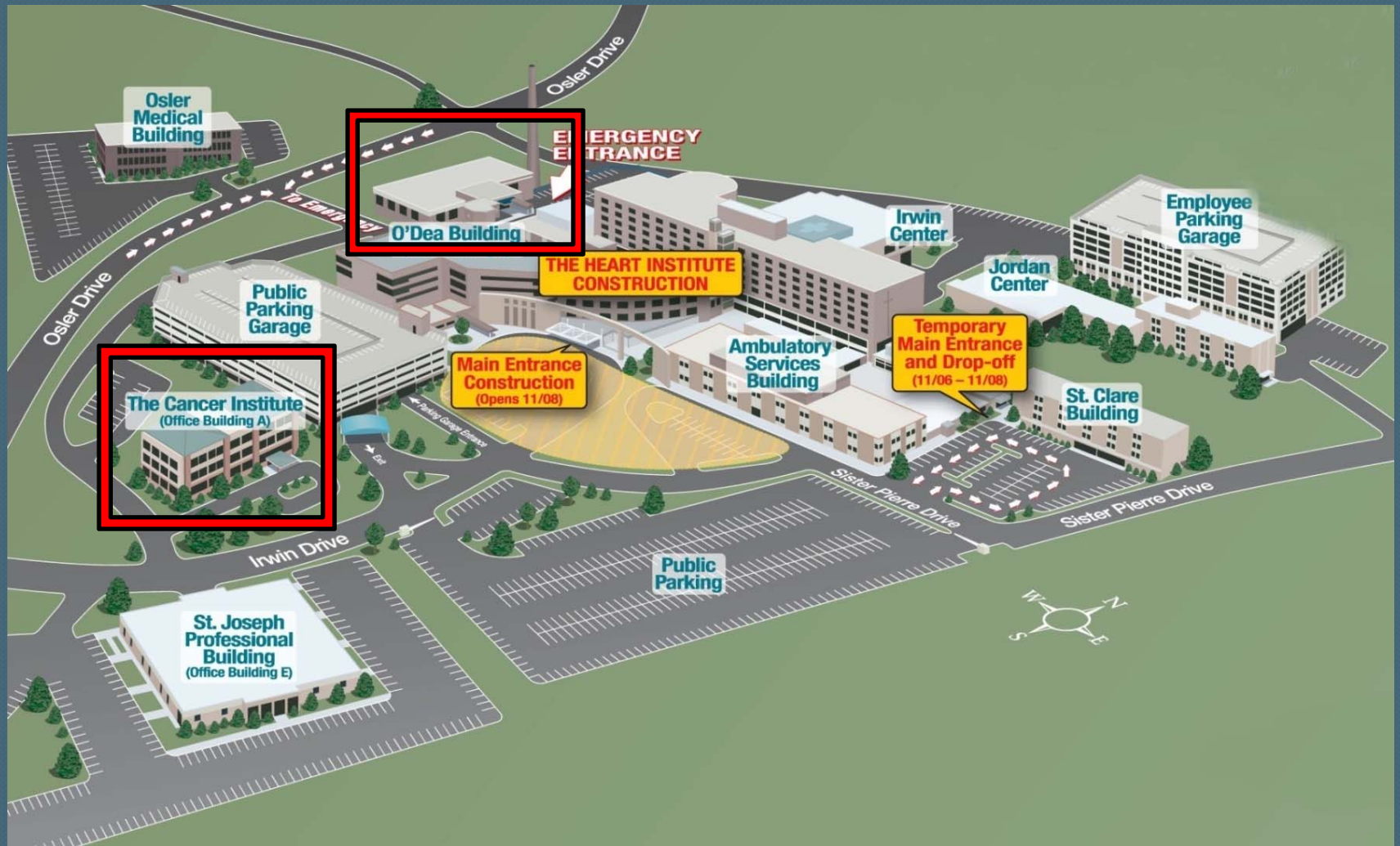


Chris Nicolais

Topics

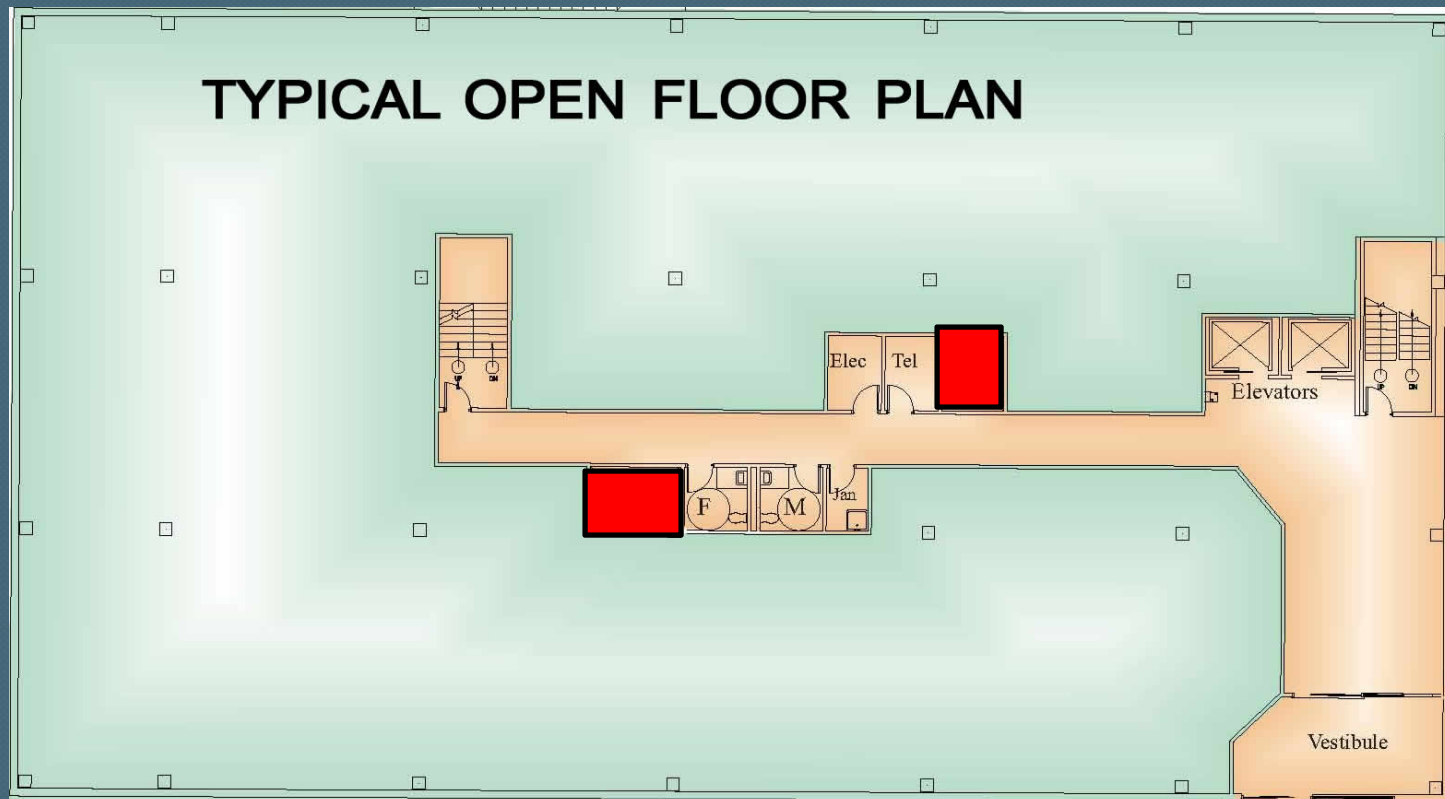
- Building Description
- Existing Mechanical System
- Proposed Redesign
- Alternative Option
- Emergency Power System
- Equipment Installation
- Redesign Conclusions

Saint Joseph Medical Center



Building Design Issues

- Shell and Core construction
- 4 Story, 64,000 square feet
- Fit-outs based on tenant needs
- Keep construction cost low
- Maximize leasable area
 - 12,700 ft² open, 3,300 ft² core



Fit-out projects

- Multi-disciplinary offices
- Conference and waiting rooms
- Patient exam rooms
- 2 Linear accelerators
- PET/CT scanner
- Nuclear lab
- Infusion suites
- Radiology rooms

Engineered Systems

○ Structure

- Steel superstructure
- Reinforced, composite concrete slabs

○ Electrical

- 1500kVA utility transformer
- 480Y/277V, 2,500 amp main switchboard

○ Construction

- AIA 111, Guaranteed cost plus fee

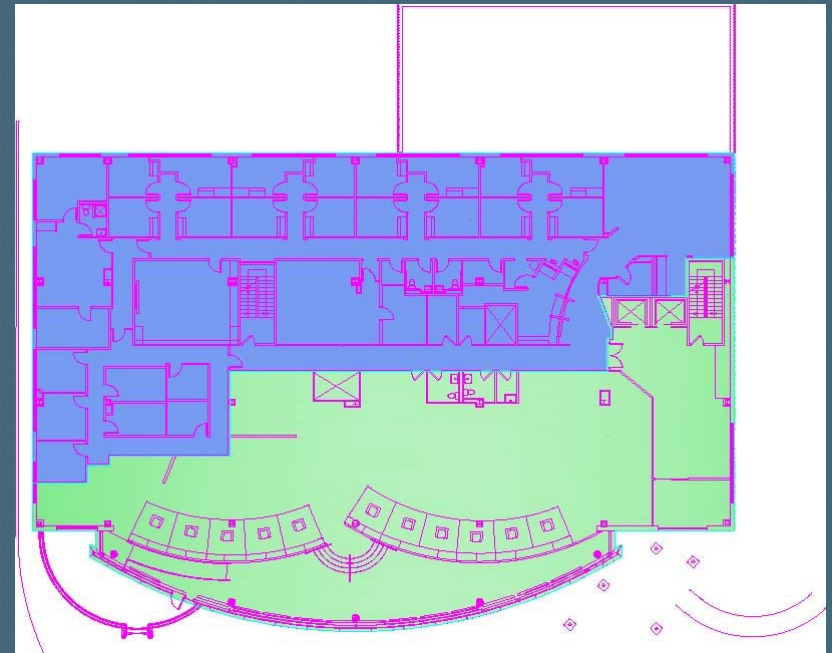
Existing Mechanical System

- 3 packaged roof top AHUs
 - Direct expansion electric cooling
 - 20% outdoor air
- Fan powered VAV terminal units
 - Electric reheat coils at each box
 - Ducted supply, plenum return
- 9 Domestic water heaters
 - 2 - 3000 watt elements

Space Breakdown



Ground Floor



First Floor

AHU-1	37,000 cfm	130 ton	Green
AHU-3	10,680 cfm	30 ton	Blue

Space Breakdown



Second Floor



Third Floor

AHU-2

36,000 cfm

130 ton

Existing System Performance

	Design	Simulation	Design	Simulation
AHU-1	37,000 cfm	25,070 cfm	130 tons	78.3 tons
AHU-2	36,000 cfm	15,915 cfm	130 tons	70.6 tons
AHU-3	10,680 cfm	5,278 cfm	30 tons	19.2 tons
Total	83,680 cfm	46,263 cfm	290 tons	168.1 tons
Difference		37,417 cfm		121.9 tons

Energy Consumption

Component	Site Energy (kBTU)
Air System Fans	1,186,868
Cooling	38,102
Heating	1,018,467
Pumps	0
Cooling Towers	0
HVAC Sub-Total	2,243,437
Lights	863,853
Electric Equipment	0
Misc. Electric	365,803
Misc. Fuel Use	0
Non-HVAC Sub-Total	1,229,656
Grand Total	3,473,093

- All electric energy consumption
- Electric heating coils
- Domestic water heaters

Fit-Out Mechanical Additions

- 2 Computer room ACUs
 - Nuclear lab equipment cooling
- Fan powered HEPA ceiling modules
 - Clean and ante rooms
- 3 Chillers with closed loop glycol systems
 - Direct cooling for both linear accelerators and the PET/CT scanner

Proposed Redesign

○ Goals

- Reduce energy consumption
- Improve system efficiency
- Decrease annual operating cost
- Reduce emissions

○ Concerns

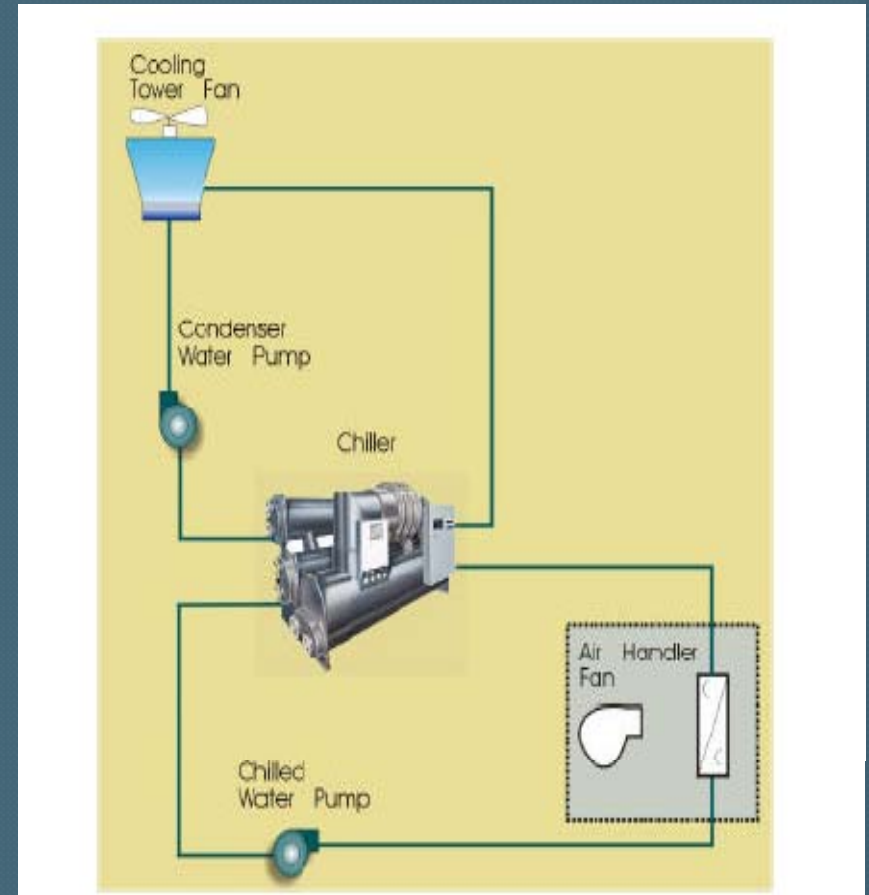
- System cost

Proposed Redesign

- Create a dedicated chiller plant
 - Cool using chilled water
 - Heat using boiler water
- Equipment Necessary
 - Chiller
 - Cooling Tower
 - Boiler
 - Chilled Water AHU

Cooling Production

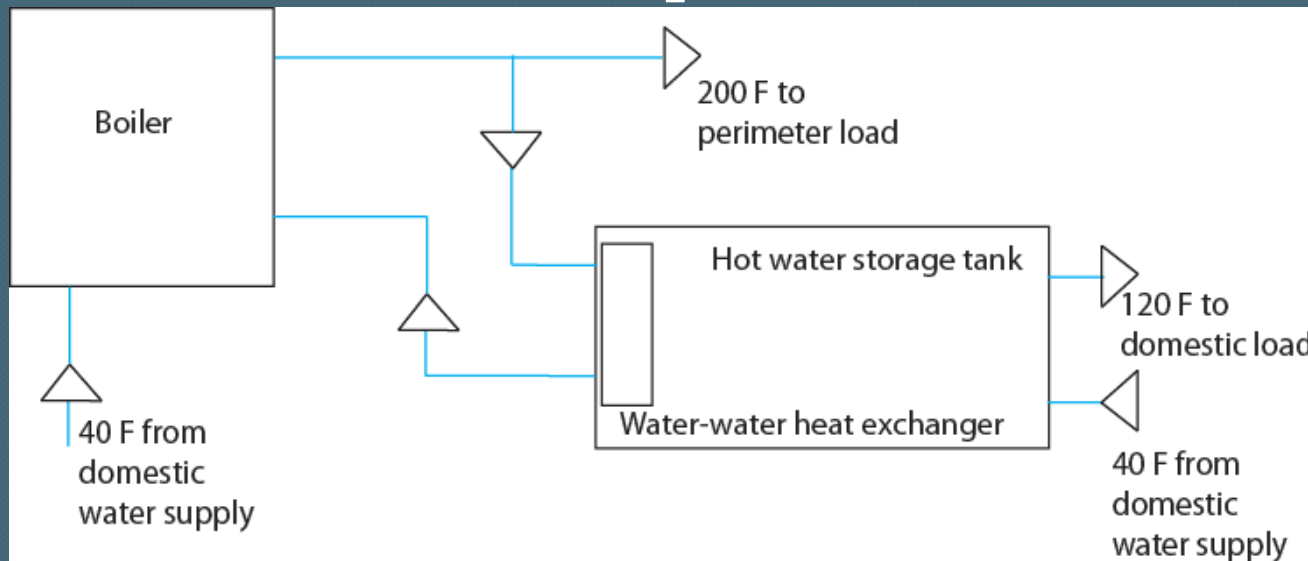
- AHU
 - 125.4 ton, 45,488 cfm
- Chiller
 - 136 ton electric screw chiller
 - R-134a refrigerant
 - 85°F EWT / 44°F LWT
 - Single load constant flow primary pump
- Cooling Tower
 - Design 3 gpm per ton
 - 409.5 gpm induced draft crossflow



Heating Production

• Gas-fired boiler

- Sized for space heating and service hot water using ASHRAE Applications Handbook
- 865,534 BTU per hour
- Fin-tube radiators at perimeter loads

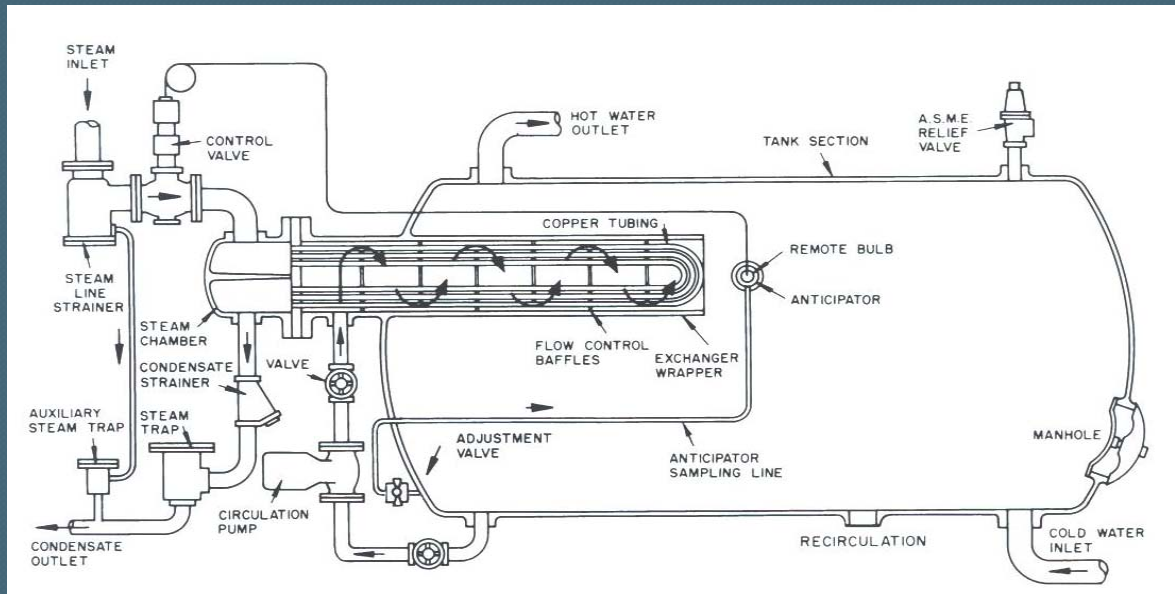


Service Hot Water

Hot water storage tank

- 492 gallon capacity
- Water – water heat exchanger uses boiler water

Fixture	Number	Required Flow (gallons per hour)
Basin, Private Lav	30	2
Service Sink	4	20
Shower	1	30
Wash Sink	65	10
Total		820



Annual Energy Consumption

Existing v. Redesign

Energy Consumption by Energy Source			
Component	Existing	Redesign	Percent Difference
	Site Energy (kBTU)	Site Energy (kBTU)	
Electric	2,243,550	1,913,656	15.87 decrease
Natural Gas	0	750,619	200.00 increase
HVAC Sub-Total	2,243,550	2,664,275	17.15 increase
Electric	1,229,660	863,858	34.95 decrease
Natural Gas	0	0	0
Non-HVAC Sub-Total	1,229,660	863,858	34.95 decrease
Grand Total	3,473,210	3,528,133	1.57 increase

Redesigned system consumes 1.57% more energy

Emissions Data			
	Annual Emissions		Percent Difference
	Existing	Redesign	
CO ₂ (lb)	1,404,722	1,418,149	0.95 increase
SO ₂ (g)	3,481	2,785	22.22 decrease
No _x (g)	2,046	1,890	7.93 decrease

Redesigned System
produces less SO₂ and NO_x

Equipment Cost

- Data based on RS Means 2008 Mechanical Cost Data and contractor payment sheet provided by engineer
- Redesigned system equipment costs \$14,047 less than existing system equipment, no payback period

Mechanical Equipment Cost					
Existing			Redesign		
Item	Cost (\$) 2008	Cost (\$) 2006	Item	Cost (\$) 2008	Cost (\$) 2006
Domestic Water Heaters*	-	3,350	Boiler	10,412	9,746
Air Handlers*	-	202,900	Hot Water Storage Tank	8,518	7,973
Fan Powered VAV, w/ rehe	140,448	131,459	Water-Water Heat Exchang	136	127
			Air Handler	196,050	183,503
			Chiller	59,096	55,314
			Cooling Tower	15,205	14,232
			Expansion Tank	740	693
			Fin-Tube Radiators	11,396	10,667
			VAV Boxes	44,240	41,409
Total System First Cost		337,709			323,662

Operating Cost

Component	Cost (\$)		Percent Difference	
	Existing	Redesign		
Air System Fans	34,718	35,623	2.57	increase
Cooling	1,153	13,859	169.28	increase
Heating	28,758	1,924	174.92	decrease
Pumps	0	1,560	200.00	increase
Cooling Tower Fans	0	6,258	200.00	increase
HVAC Sub-Total	64,629	59,224	8.73	decrease
Lights	25,241	25,681	1.73	increase
Electric Equipment	0	0	0.00	
Misc. Electric	10,689	0	200.00	decrease
Misc. Fuel Use	0	0	0.00	
Non-HVAC Sub-Total	35,930	25,681	33.27	decrease
Grand Total	100,559	84,905	16.88	decrease

Redesigned system operating costs \$15,654 less each year

System Cost

Cost data associated with hydronic distribution						
Item	Units	Amount	Material Cost (\$)	Labor Cost (\$)	Total Cost (\$)	Total Cost (\$) 2006
Site Earthwork	Per linear foot	680	0.74	0.56	884.00	827.42
Black Steel Service Pipe	Per linear foot	680	109.00	37.50	99,620.00	93,244.32
Venturi Flow Measuring Device	Each	1	835.00	264.00	1,099.00	1,028.66
Total					101,603.00	95,100.41

- Eliminate purchase of new chiller and cooling tower total savings \$69,536
 - More costly to connect to existing plant
- Complications
 - Connecting healthcare and non-healthcare buildings to the same plant
 - Different building codes
 - Owner would prefer stand-alone building for resale
 - Hospital retains capacity for future expansion

Equipment Installation

- RS Means 2008 Mechanical Cost Data

Existing Mechanical System Equipment Construction Costs						
Item	Amount	Daily Output (items per day)	Labor Cost (\$ per item)	Installation Time (days)	Total Labor Cost (\$) base	Total Labor Cost (\$) Baltimore
31 ton AHU	1	0.497	2,825	2.01	2,825	2,494
124 ton AHU*	2	0.125	11,730	16.00	23,460	20,715
Domestic Water Heaters	9	2.60	345	3.46	3,103	2,740
Fan Powered VAV Boxes w/ reheat	112	6.94	106	16.14	11,823	10,440
Total				37.62	41,211	36,389

Existing equipment: 38 days, \$36,389

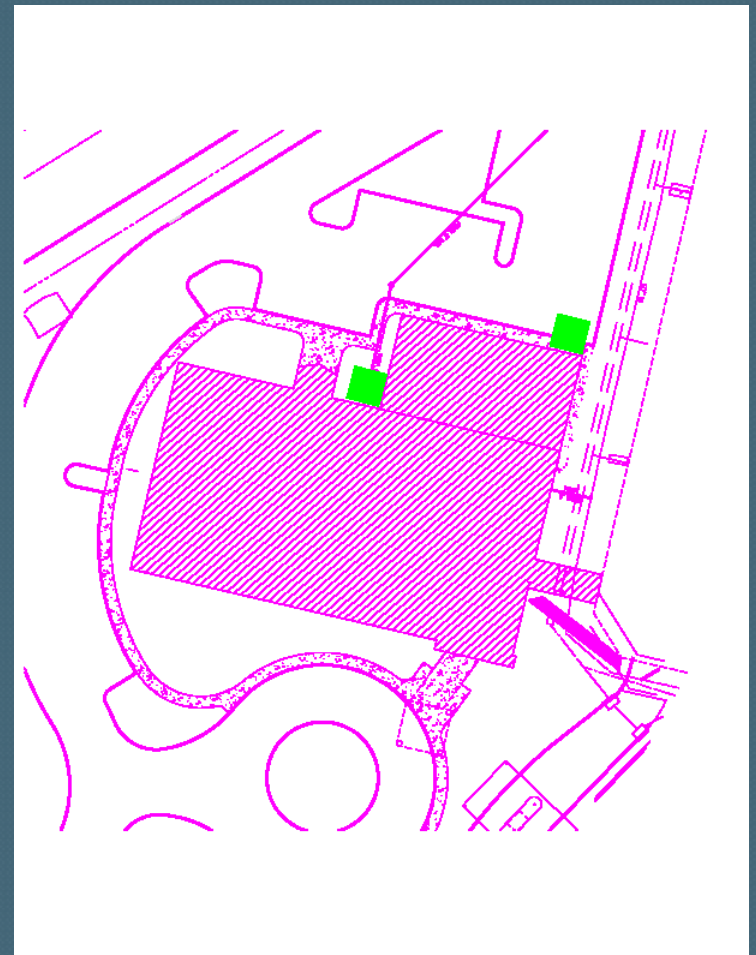
Equipment Installation

Redesigned Mechanical System Equipment Construction Costs						
Item	Amount	Daily Output (items per day)	Labor Cost (\$ per item)	Total Installation Time (days)	Total Labor Cost (\$)	Total Labor Cost (\$)
AHU	1	0.077	17,940.00	12.99	17,940	15,841
Chiller	1	0.133	10,660.00	7.53	10,660	9,413
Cooling Tower*	136	121.900	8.67	1.12	1,179	1,041
VAV Boxes	112	8.330	81.33	13.45	9,109	8,043
Boiler	1	0.419	3,459.29	2.39	3,459	3,055
Hot Water Storage Tank	1	3.080	219.52	0.32	220	194
Expansion Tank	1	17.000	40.00	0.06	40	35
Fin-Tube Radiators**	308	38.000	17.85	8.11	5,498	4,855
Total				35.08	48,105	42,476

Redesigned equipment: 35 days, \$42,476

Equipment Space

- Maximize leasable space
- Existing floor plans leave no room for mechanical equipment
 - Construct a 200 square foot mechanical housing



Equipment Space

Mechanical Room Construction Cost			
Item	Material and Labor (\$/ft ²)	Total (2008)	Total(2006)
Slab on Grade	12.06	2,472.30	2,314.07
Roof	3.16	647.80	606.34
Brick Face Composite	27.1	14,634.00	13,697.42
Steel Doors	-	3,450.00	3,229.20
Total		21,204.10	19,847.04

- Equipment housing increases mechanical system first cost by \$5,500
- Make area in ground floor plan
 - Requires 0.4 percent reduction in leasable space
 - Approximately 79.3% open for tenant use
 - 80% ideal for MOB

Conclusions

- **Engineers limited by shell and core design**
 - Low first cost mechanical equipment
 - Approximate occupant loads for system sizing
 - Easily adaptable equipment for fit-out floor plans
- **Redesign system**
 - 1.57% energy consumption increase
 - Reduced emissions
 - \$15,654 annual operating cost savings
 - Even equipment and installation costs
- **Redesigned system would be preferred to optimize performance**

Questions



Thanks to Leach Wallace Associates, DASCO
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