Hilton Baltimore
Convention Center Hotel

Andrew Rhodes
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Faculty Advisor: Dr. Bahnfleth

Presentation Outline

- Project Background
- Existing Mechanical System
- Design Objective
- Mechanical Design Alternatives
- Energy Analysis
- First Costs
- Life-Cycle Cost Analysis
- Electrical Breadth
- Final Recommendation

Project Background

- Project Cost: $250 Million
- Groundbreaking: February 2006
- Completion: August 2008
- Owner: Hilton Hotels
- Adjacent to Oriole Park at Camden Yards and the Baltimore Convention Center

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Project Background

Guest Room Floors
- Levels 3 through 21
- Rooms, Junior Ballroom, Meeting Rooms, Hotel Management

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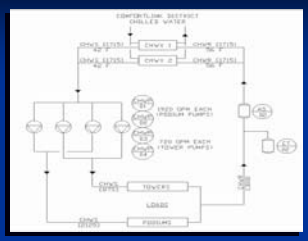
Existing Mechanical System



Cooling
- Comfort Link District Chilled Water System
- (2) Plate and Frame Heat Exchangers
  - 1,000 tons each
  - District Side – 37 F to 54 F
  - Building Side – 42 F to 56 F
- Two pumping zones with (2) pumps each

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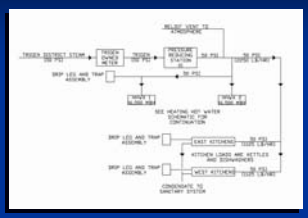

Heating

- Trigen District Steam System
  - 150 psi steam from Trigen
  - 50 psi steam after pressure reducing valve
- (2) Shell and Tube Heat Exchangers
  - 810 gpm each
  - Entering Water Temp – 140 F
  - Leaving Water Temp – 180 F
- Kitchens served by steam directly

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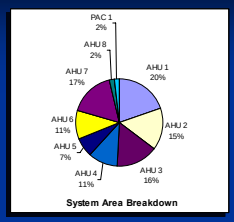

Air Handling

- (8) Air Handling Units
  - AHUs 1-7 – VAV units with economizers
  - AHU 8 – CAV unit with economizer
- (4) Makeup Air Units
  - MAUs 1-2 – Serve Guest Room Towers
  - MAUs 3-4 – Serve Kitchen Spaces
- (1) Pool Air Conditioner

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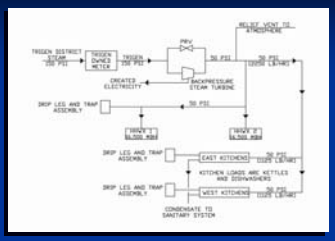
Design Objective

Chiller Plant Optimization Study

- Consider numerous chiller plant design alternatives in order to quantitatively prove which alternative is the most cost-effective.
- A Life-Cycle Cost Analysis, based on first and yearly operating costs, will be the basis of the optimization.

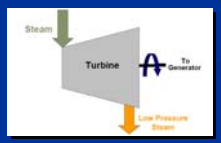
Lowest Life-Cycle Cost = Most Cost-Effective System

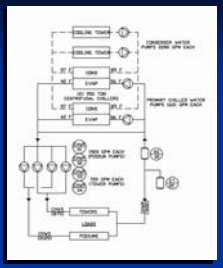
Mechanical Design Alternatives



Option 1: District System with Backpressure Steam Turbine

- Replaces Pressure Reducing Valve with a Backpressure Steam Turbine





Mechanical Design Alternatives

Option 2: On Site Centrifugal Chilling

- Replaces Comfort Link District Chilled Water System with (2) 950 ton centrifugal chillers
- (2) condenser water pumps along with two-celled cooling tower added
- Primary / Secondary pumping arrangement
  - (2) primary pumps added
  - All secondary pumps remain

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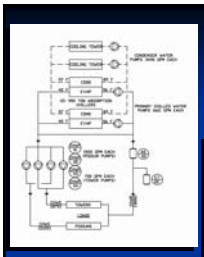

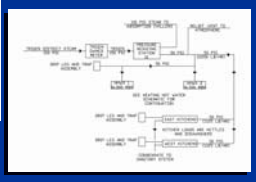

Mechanical Design Alternatives

Option 3: On Site Absorption Chilling

- Replaces Comfort Link District Chilled Water System with (2) 950 ton double-effect absorption chillers
  - Chillers utilize steam at 100 psi
- (2) condenser water pumps along with two-celled cooling tower added
- Primary / Secondary pumping arrangement
  - (2) primary pumps added
  - All secondary pumps remain

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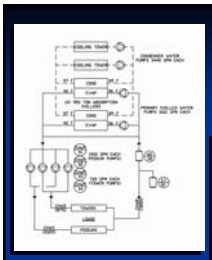
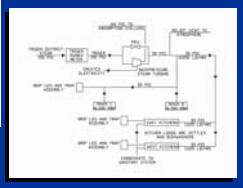
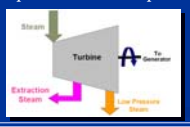




Mechanical Design Alternatives

Option 4: On Site Absorption Chilling with Backpressure Steam Turbine

- Identical to previous design alternative, but with Backpressure Steam Turbine added
- Extraction type Backpressure Steam Turbine required, allowing for 2 separate outlet steam pressures



Energy Analysis

In order to calculate the yearly operating costs of all the systems, two factors must be known…

- Cost of energy (Utility Rates)
- Amount of energy (Hourly energy usage data)

Energy Analysis

Utility Rates

Actual utility rates were obtained from Comfort Link, Trigen, and Baltimore Gas & Electric.

Electric Utility Rate

Charge	Rate	
	Summer	Non-Summer
Minimum Customer Charge	$110	$110
Delivery Service Charge (cents/kWh)	1.239	1.239
Demand Charges (per kW)		
Generation Charge	-	-
Transmission Charge	$1.05	$1.05
Delivery Service	$2.67	$2.67
Energy Charges (cents/kWh)		
Peak	9.319	5.534
Intermediate	8.802	5.406
Off-Peak	8.464	5.118
Hours		
Peak	10am-6pm	7am-11am 6pm-9pm
Intermediate	7am-10am 6pm-11pm	11am-6pm
Off-Peak	11pm-7am	9pm-7am

District Chilled Water Rate

Charge	Monthly Rate
Capacity Charge	$210/ton of capacity
Usage Charge	$0.15/tonhr

District Steam Rate

Charge	Monthly Rate
Capacity Charge	$15,000
Usage Charge	$0.43/Therm

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Energy Analysis

Hourly Energy Usage Data

- eQuest 3-6 used in order to create a detailed model of the Hilton Baltimore Convention Center Hotel
- Once the building model was completed, only the plant information was changed
- Backpressure Steam Turbine modeled in Microsoft Excel using data imported from eQuest 3-6

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Energy Analysis

Mechanical System Operating Costs					
	District System, no CHP	District System w/ CHP	Centrifugal Chilling	Absorption Chilling, no CHP	Absorption Chilling w/ CHP
Electrical Utility Cost	$519,061	$511,225	$628,147	$537,072	$520,438
Steam Utility Cost	$344,812	$344,812	$344,812	$477,028	$477,028
Chilled Water Utility Cost	$450,924	$450,924	$0	$0	$0
Yearly Operating Cost	$1,314,797	$1,306,961	$972,959	$1,014,100	$997,466
Overall Rank	5	4	1	3	2

The on site centrifugal chilling design alternative has the lowest yearly operating cost, while the current district system has the highest.

Savings of $ 24,507 compared to next lowest yearly operating cost.

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First Costs

Mechanical System First Costs					
	District System, no CHP	District System w/ CHP	Centrifugal Chilling	Absorption Chilling, no CHP	Absorption Chilling w/ CHP
Chillers	$0	$0	$707,000	$879,000	$879,000
Cooling Towers	$0	$0	$174,000	$174,000	$174,000
Primary Pumps + Piping	$0	$0	$142,500	$249,375	$249,375
Condenser Water Pumps + Piping	$0	$0	$142,500	$249,375	$249,375
Backpressure Steam Turbine	$0	$21,000	$0	$0	$30,000
Total System First Cost	$0	$21,000	$1,166,000	$1,551,750	$1,581,750
Overall Rank	1	2	3	4	5

The current district system has the lowest associated first cost, while absorption chilling with backpressure steam turbine has the highest.

Savings of $ 21,000 compared to next lowest first cost.

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Life-Cycle Cost Analysis

Life-Cycle Cost Analysis					
	District System, no CHP	District System w/ CHP	Centrifugal Chilling	Absorption Chilling, no CHP	Absorption Chilling w/ CHP
Mechanical First Cost	$0	$21,000	$1,166,000	$1,551,750	$1,581,750
Electrical Utility Cost	$519,061	$511,225	$628,147	$537,072	$520,438
Steam Utility Cost	$344,812	$344,812	$344,812	$477,028	$477,028
Chilled Water Utility Cost	$450,924	$450,924	$0	$0	$0
Discount Rate	0.05	0.05	0.05	0.05	0.05
Life-Cycle Length	20	20	20	20	20
PV of Utility Costs	$16,385,277	$16,287,623	$12,125,220	$12,637,928	$12,430,631
Total Life-Cycle Cost	$16,385,277	$16,308,623	$13,291,220	$14,189,678	$14,012,381
Overall Rank	5	4	1	3	2

The on site centrifugal chilling design alternative has the lowest life-cycle cost, while the current district system has the highest.

Savings of $ 721,161 compared to next best design alternative.

Savings of $ 3,094,057 compared to current district system.

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Life-Cycle Cost Analysis

What Steam Rate Would Be Needed to Make CHP Worthwhile?						
Usage Rate ($/Therm)	# Therms	Set Rate ($)	Current Price ($/Therm)	Current Steam Cost	Reduction in Steam Cost to make CHP Worthwhile	Steam Price Required to make CHP Worthwhile
$0.43	688,200	$180,000.00	**$0.69**	$475,926.00	$55,926.00	**$0.61**

Current Fuel Prices ($/Therm)			
Fuel	Unit Price ($/ft^3)	Heating Value (Btu/ft^3)	Price ($/Therm)
Natural Gas	$0.0121	0.001078749	**$1.31**
Fuel	Unit Price ($/lb)	Heating Value (Btu/lb)	Price ($/Therm)
Coal	$0.03	12500	**$0.22**
Fuel	Unit Price ($/gallon)	Heating Value (Btu/gallon)	Price ($/Therm)
Oil	$2.00	140000	**$1.43**

Unit prices from www.eia.doe.gov

Surprising Results…

- Hilton Hotels will pay $0.69 per therm of Trigen district steam, while a rate of $0.61 per therm would make absorption chilling with backpressure steam turbine worthwhile.
- Both of these rates are lower than the price of producing steam using natural gas or oil.
- How does Trigen produce its steam?

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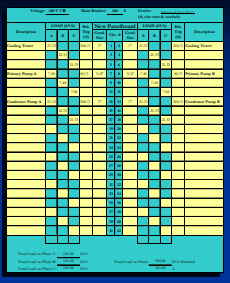

Electrical Breadth

- **Purpose: Provide electrical service to the equipment selected in the most cost-effective mechanical design alternative (on site centrifugal chilling).**
- **(2) Chillers wired directly to main distribution panel**
- **All other associated equipment placed on a new panelboard**

Wire, Conduit, and Breaker Sizes for Panelboard Equipment				
Equipment	Full Load Current (A)	Wire Size	Conduit Size (inches)	Breaker Size (A)
Cooling Tower Cell A	77	#4 AWG	1	200
Cooling Tower Cell B	77	#4 AWG	1	200
Primary Pump A	27	#8 AWG	3/4	80
Primary Pump B	27	#8 AWG	3/4	80
Condenser Pump A	77	#4 AWG	1	200
Condenser Pump B	77	#4 AWG	1	200

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Original Main Distribution Panel

Resized Main Distribution Panel

Electrical Breadth

- **Switchgear F (the main distribution panel) needed to be resized in order to handle the new loads**
- **Main circuit breaker increased from 2000A to 5000A**

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Final Recommendation

Based on the design objective, it is the final recommendation of this report that on site centrifugal chilling, along with associated cooling towers and pumps, be installed at the Hilton Baltimore Convention Center Hotel.

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Questions ?