Feasibility of Ice Storage

1919 M St.

Washington D.C.

Darren Bruce

Penn State University

Architectural Engineering

Mechanical Option

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Presentation Outline

- Introduction & Background
- Existing Conditions
- Mechanical Redesign
- Electrical Redesign
- Structural Analysis
- Cost Analysis
- Conclusions

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Introduction & Background

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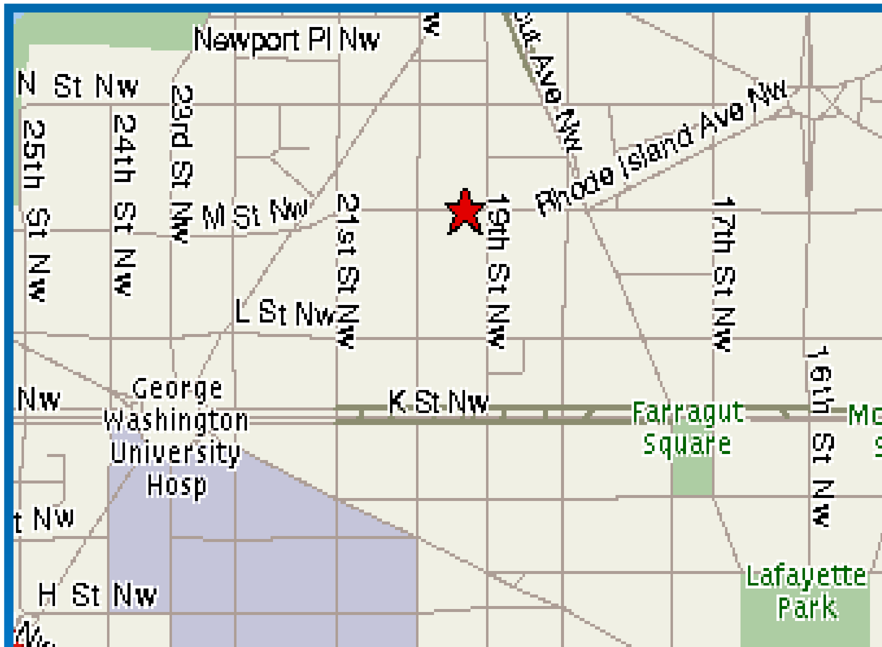
Location



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Project Team

Owner:	The Charles E. Smith Companies
Architect:	Weihle Design Group
Structural Engineer:	Robert Theobald Associates
MEP Engineer:	Girard Engineering
Abatement Consultant:	Consolidated Engineering Services
General Contractor:	Clark Construction Group
Mechanical Contractor:	PBM Mechanical, Inc
Electrical Contractor:	T.A. Beach

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Building History

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Building History

- 265,000 sq.ft. of tenant space
- 82,000 sq.ft. of garage levels
- Originally built in 1964 for the Federal Commerce Commission’s Headquarters
- $20,000,000 renovation took place in 1999
- The building was demolished down to the structural system and completely redesigned.
- Construction started in July of 1999 and was occupied by October of 2000

Building Occupants

- Conservational International (300 Employees)
- McKee Nelson, LLP (130 Employees)
- Grace Digital Media (51 Employees)
- Plus several smaller firms (~200 Employees)

- For a total of approximately 680 Employees

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Mechanical Redesign

Existing Conditions

Existing Conditions: Air Side

- 2 AHU's per floor (14 total)
- 196,000 CFM of SA provided to the entire building
- Fan Powered VAV boxes along perimeter spaces
- Shut Off VAV boxes in the interior spaces

Existing Conditions: Water Side

- (2) 320 Ton Centrifugal Chillers
- 44° CHWT
- 2400 gpm Cooling Tower

Proposed Changes

Design Goals

1. Lower Utility Costs
2. Decrease Equipment Size

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Ice Storage

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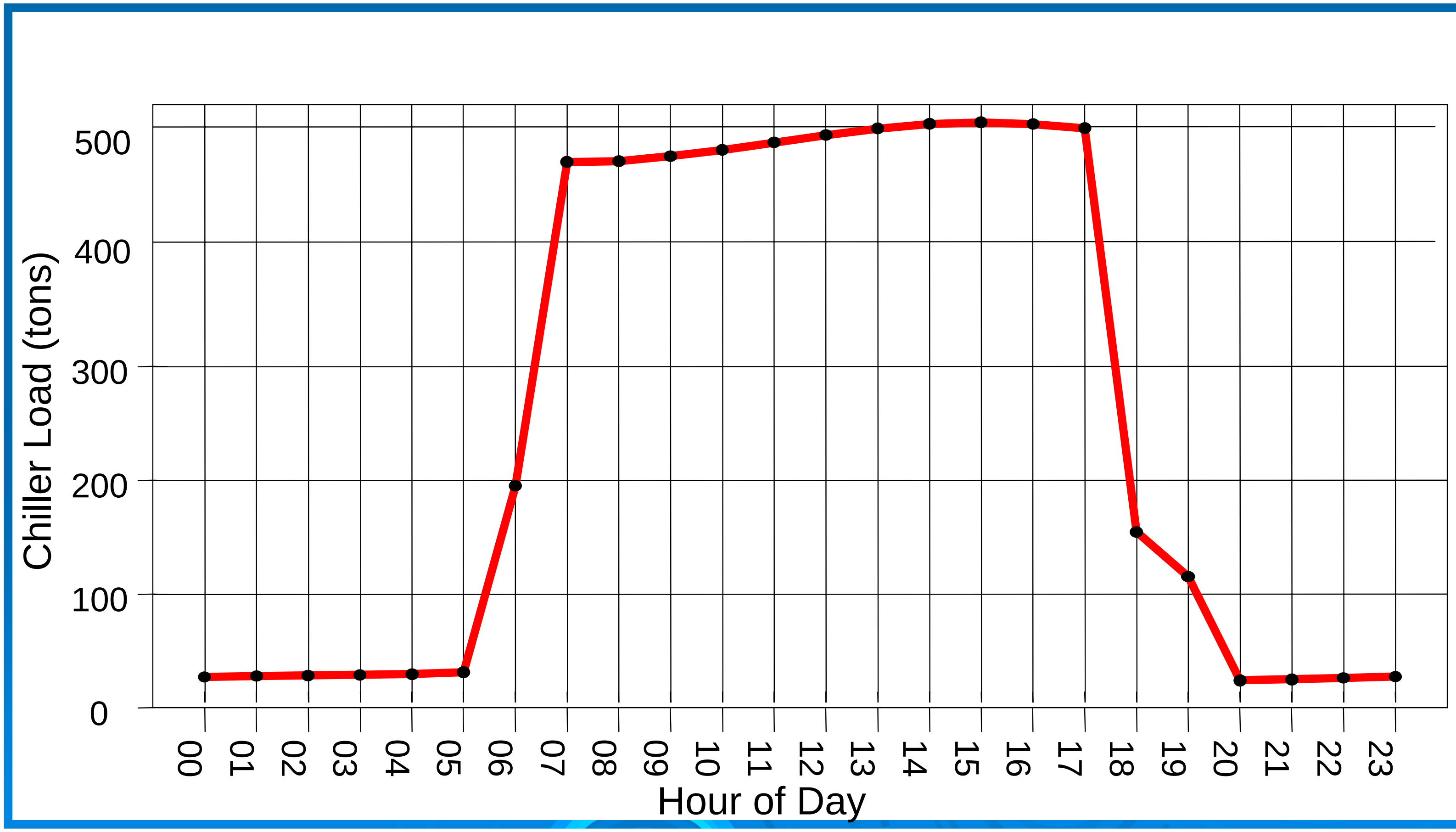
Existing Load Profile



PEPCO Rate Structure

	Billing Months of	
	June through October	November through May
Customer Charge	$19.25	$19.25
Demand Charge (per kW) - Peak	$18.59	$8.36
- Off-Peak	$8.36	$8.36
Consumption Charge (per kWhr)- Peak	$.0315	$.0306
- Off-Peak	$.0315	$.0306

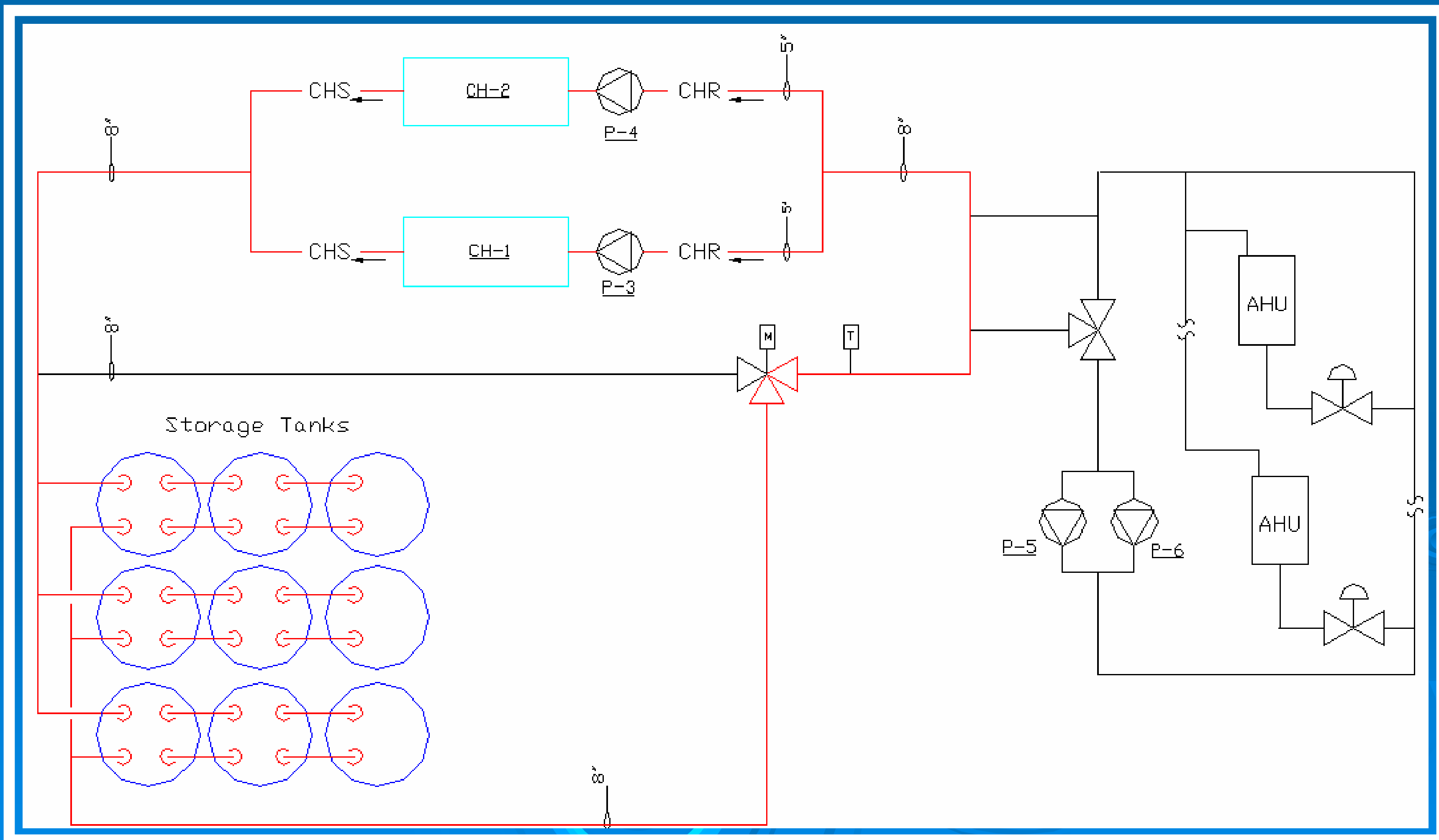
Operating Strategies

- **Load-Leveling, Partial Storage**
  - Chillers run all day at full capacity
  - Lower First Costs than Full Storage
- **Chiller Priority**
  - Chiller meets as much load as it can without relying on tanks
- **Chiller Upstream**
  - Chiller operates at a higher efficiency due to the higher entering temperatures

Ice Tank Flow Cycles

1. Charging Cycle
2. Discharging Cycle
3. Bypass Cycle

Charging Cycle Schematic



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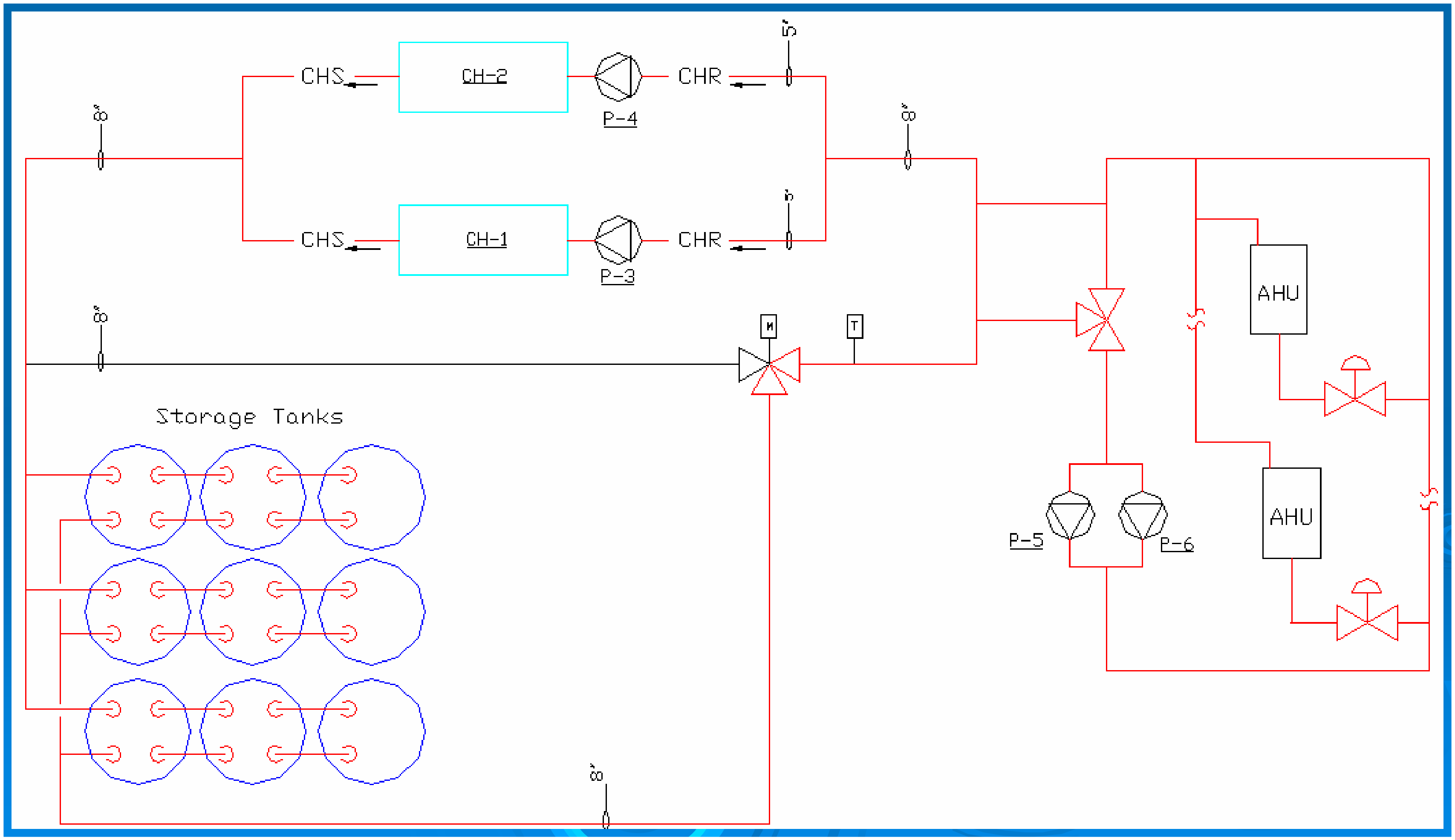
Discharging Cycle Schematic



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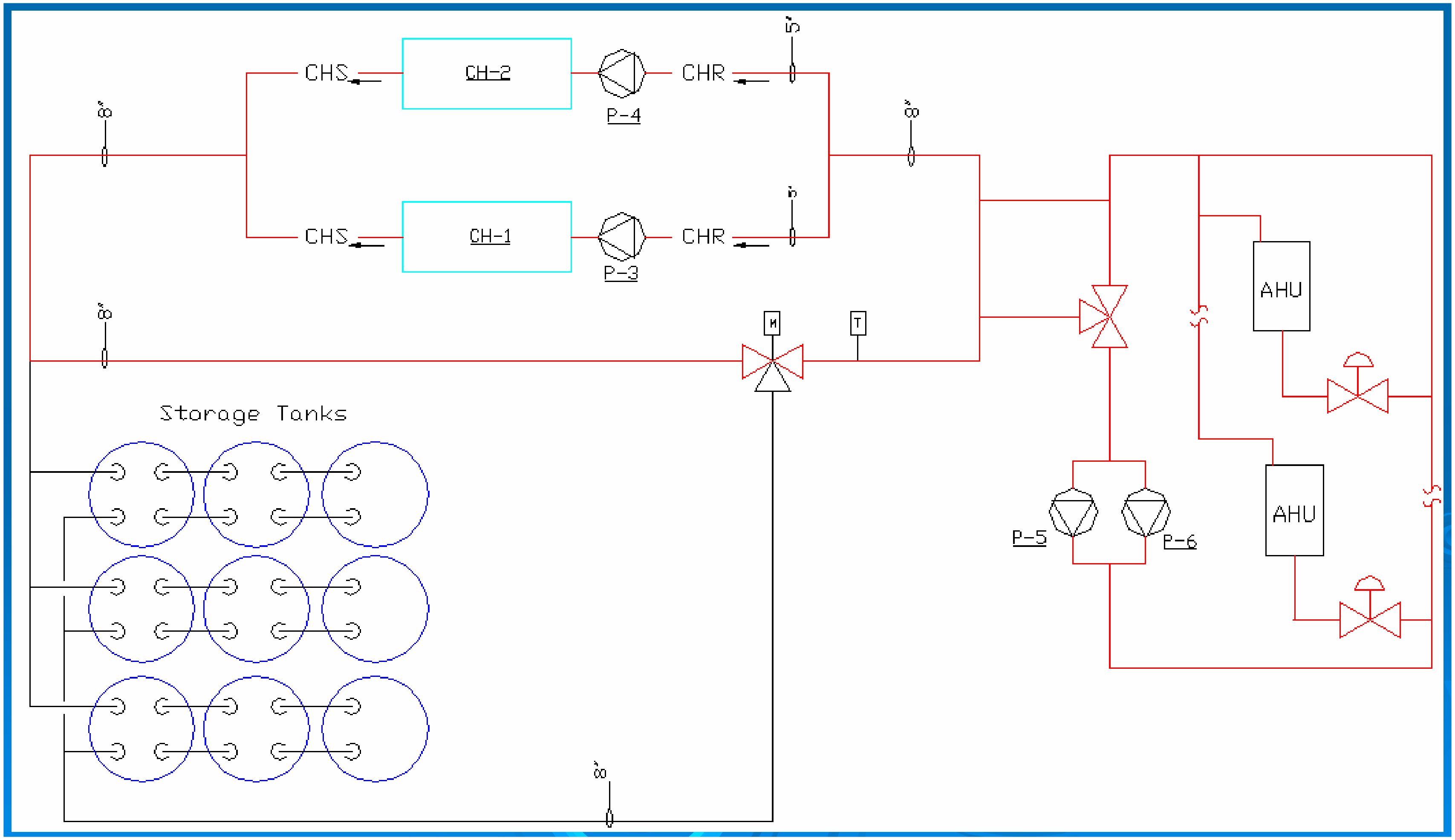
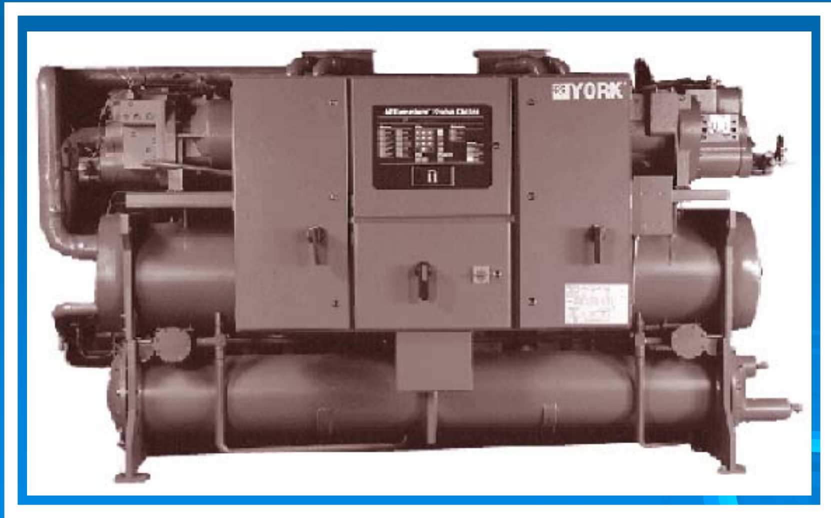
Bypass Cycle Schematic



System Components

- CALMAC 1500C Storage Tanks
  - 3 Tanks @ 420 Ton-Hours each
  - 25% Ethylene Glycol
  - 38^{o} Exiting Fluid Temperature



- (2) 150 Ton Screw Chillers
  - 425 gpm at 31^{o}/22^{o} F
  - Basis of Design: York

Low Temperature Air Distribution

- 38° Fluid temperature from tanks
- 44° Supply air into spaces
- HAP determined total airflow, coil load and fluid flow

HAP Outputs

2^{nd} through 7^{th} Floor AHU's

Total Coil Load = 35 tons

Fluid Flow = 57 gpm

8^{th} Floor AHU's

Total Coil Load = 39 tons

Fluid Flow = 62 gpm

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System Components

- Carrier – 39M Size 14 Double Walled AHU's
  - 6,300 cfm AHU (2nd-7th Floors)
  - 6,800 cfm AHU (8th Floor)

- 26 Gauge Metal Ducts
  - Existing System = 21,263 ft^2
  - New Design = 15,172 ft^2

Structural Redesign

Existing Conditions

Existing Conditions: Roof

- 5000 psi concrete
- 8”, Two-Way Concrete slab
- 24” Concrete columns @ 19’ O.C.
- Maximum Factored Load of 250 psf
- Live Load of 30 psf

Proposed Changes

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Structural Considerations

Ice Tanks Total Load:	**391 psf**
Roof Live Load:	**+ 30 psf**
Total Calculated Load:	**421 psf**

CRSI Handbook

5000 psi concrete

8" Slab

19' Span

500 psf Superimposed Load

5" Drop Panel 7.6' Wide with 19" Columns

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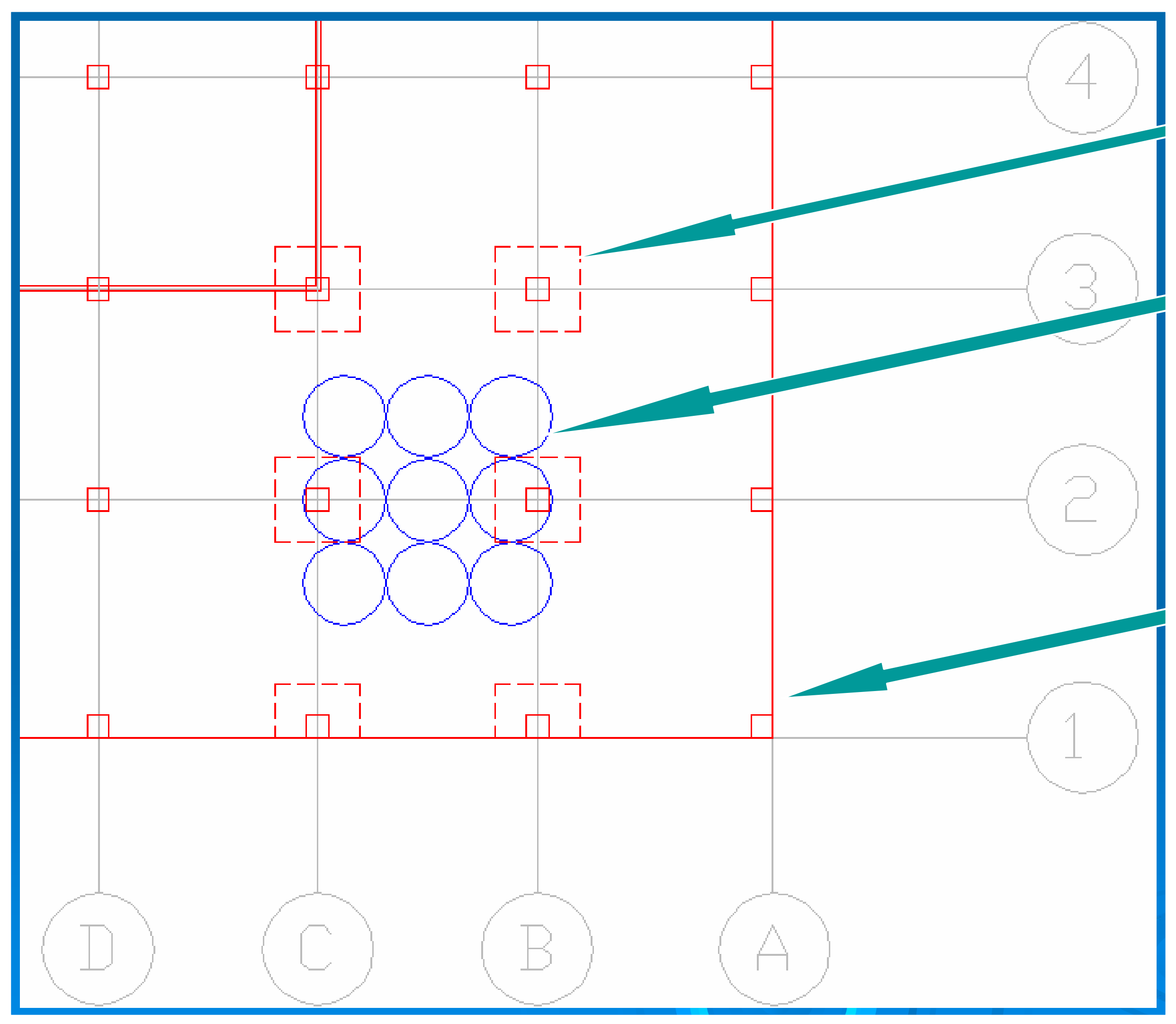

Drop Panels

Ice Tank Footprint

Building Footprint

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Electrical Redesign

Existing Conditions

Existing Electrical Supply

- Primary System
  277/480V, 3 Φ, 4 Wire,
  Y System

- Switchgear Units
  (2) 4000A and
  (1) 1200A

Existing Wire and Breaker Sizes

	Wire	Breaker
Condenser Pumps	3- #4 THW-1" C	70A
Chiller Pumps	3- #8 THW-3/4" C	35A
AHU Pumps	3- #6 THW-1" C	60A
AHU's	3- #4 THW-1" C	70A
Chillers	----	400A

Proposed Changes

Sizing Method

-AHU's 2nd-7th Floors

- From NEC Table 430.150
  460V and 10HP Motor
  → FLC=14A
- From NEC Table 430.152
  Over Current = 250% of FLC
  → 35A
- New Breaker Size = 35A
- From NEC Table 310.16
  → 3- #8 THW- ¾" C

Wire Size Reduction

	Existing Wire	New Wire
Condenser Pumps	3 - #4 THW-1” C	**3 - #8 THW-3/4” C**
Chiller Pumps	3 - #8 THW-3/4" C	**3 - #8 THW-3/4" C**
AHU Pumps	3 - #6 THW-1” C	**3 - #12 THW-1/2” C**
AHU’s (2nd-7th)	3 - #4 THW-1” C	**3 - #8 THW-3/4” C**
AHU’s (8th)	3 - #4 THW-1” C	**3 - #6 THW-1” C**
Chillers	----	**3 - 300 MCM 2 1/2” C**
Cooling Tower	----	**3 - #6 THW-1” C**

Breaker Size Reduction

	Existing Breaker	New Breaker
Condenser Pumps	70A	**35A**
Chiller Pumps	35A	**35A**
AHU Pumps	60A	**15A**
AHU's (2nd-7th)	70A	**35A**
AHU's (8th)	70A	**60A**
Chillers	400A	**250A**
Cooling Tower	----	**60A**

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Cost Analysis

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Utility Costs per Year

Ice Storage reduces utility costs by 38%

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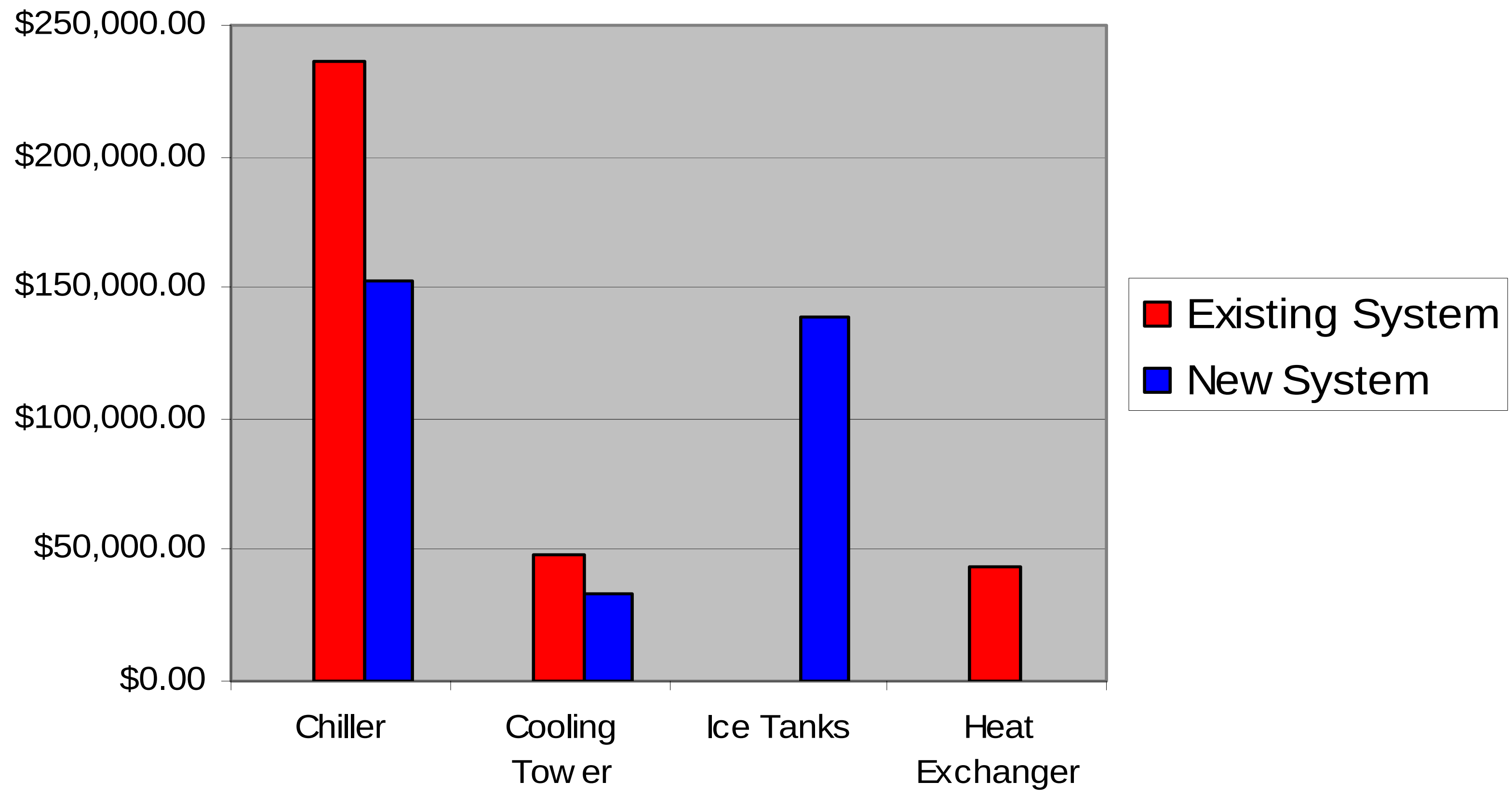
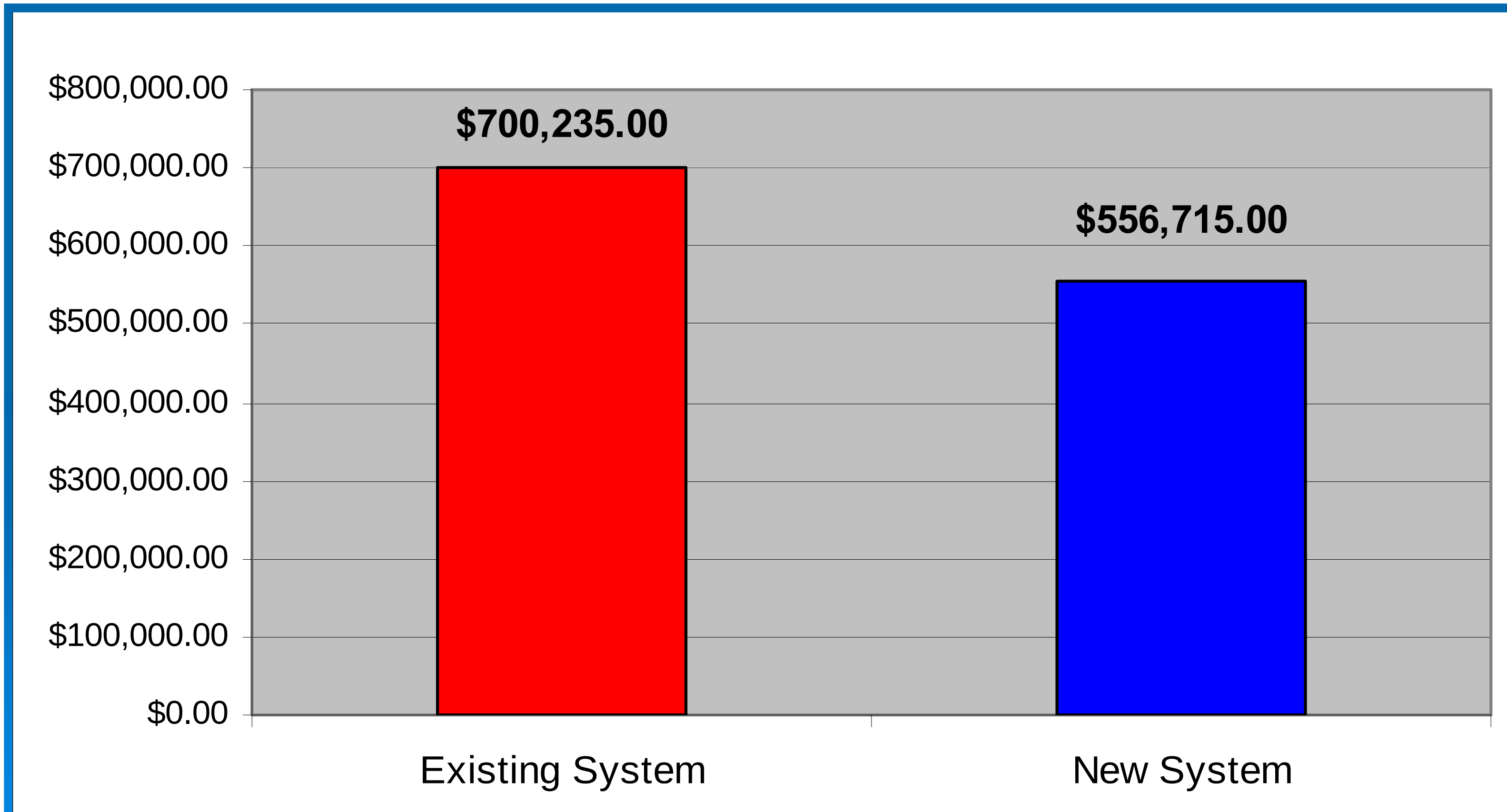
Mechanical Equipment Costs



Total Mechanical Costs



Total Structural Costs

Material	Quantity	Price
5000psi Concrete @ $89/Cu. Yd.	13.4 Cu.Yds.	$1,190
Grade 60 Re-Bar @ $1,225/ton	.121 tons	$149
Additional Form Work @ $.55/ ft^2	289 ft^2	$159
	Total:	**$1,498**

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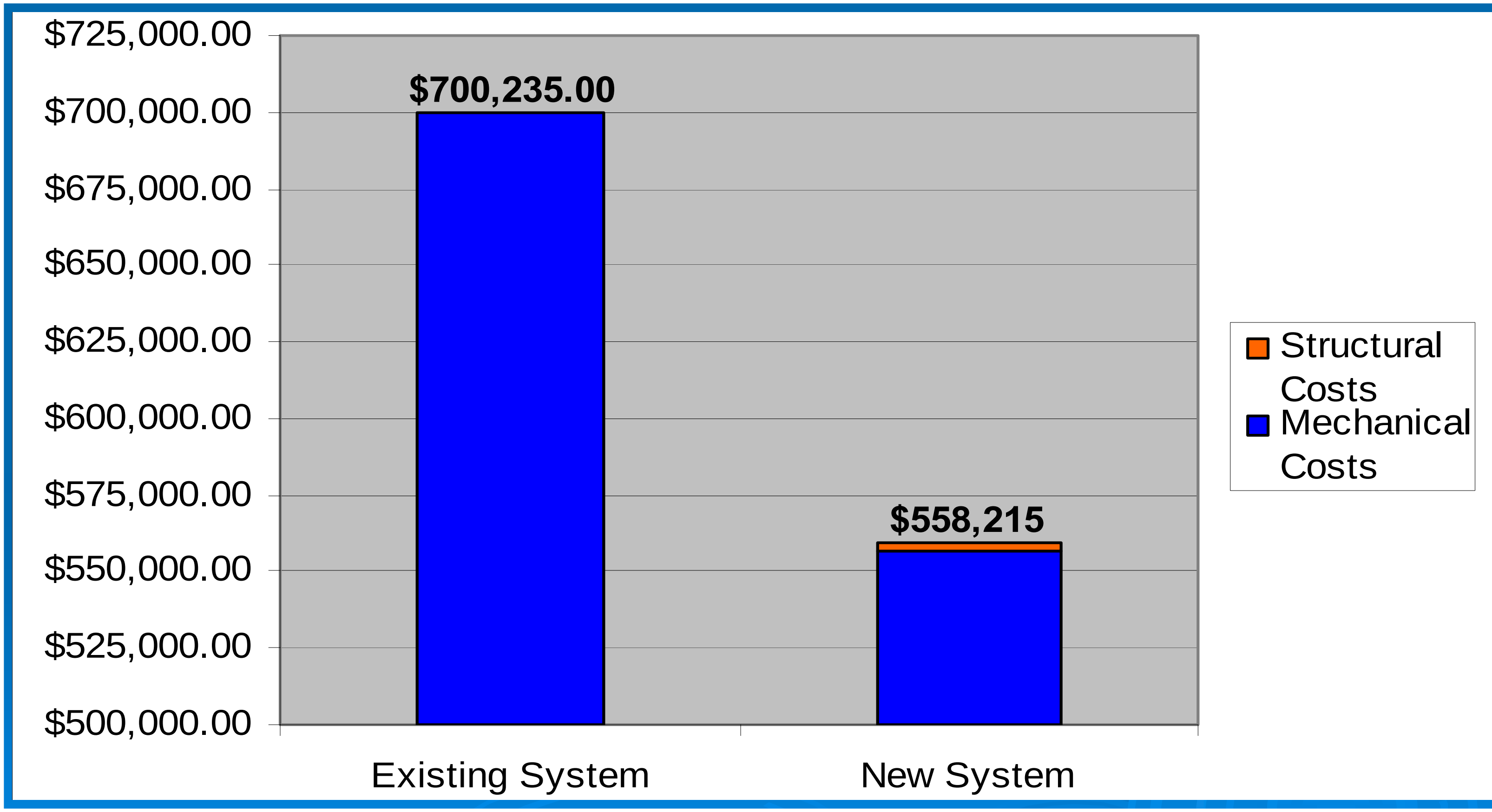
Total System Costs



Ice Storage and Low Temp Air reduce Total cost $141,500

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Conclusions

Recommendation

- Install Load-Leveling, Partial Storage Ice System
  - Saves considerable amounts in utility costs
  - Minimal First Costs
- Take advantage of the capability to use Low Temp Air
  - Decrease size of mechanical equipment and save on first costs

Design Goals

1. Lower Utility Costs

   Saved $180,050 per year

2. Decrease Equipment Size

   Chillers Decreased from (2) 320 ton to (2) 150 ton

   AHU's decreased from ~13,000 cfm to ~6,500 cfm

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Thanks!

- Penn State Faculty
  - Dr. Bahnfleth
  - Dr. Mumma
- Consolidated Engineering
- My Friends and Family
- My fellow AE's

Questions??

Room Conditions: 74^{o} and 40% RH → 48^{o} Dew Point

$T_o = T_{dp} - dT_{fan} - dT_{duct} - dT_s$

T_o = Minimum Diffuser Outlet Temperature, ^{o}F
T_{dp} = Space Dew-Point Temperature, 48^{o}F
dT_{fan} = Fan Temperature Rise, 2^{o}F
dT_{duct} = Duct Temperature Rise, 2^{o}F
dT_s = Diffuser Surface and Supply Air Temperature Difference, 3^{o}F

$T_o = 48 - 2 - 2 - 3 = 41^{o}$F

Typical Outlet Temperature for a 44^{o} SA System is 48^{o} → OK

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2nd through 7th AHU Coils

Glycol

Construction

Tubing OD:	4
Wall Thickness:	0.017
Fin Material:	A
Fin Thickness:	0.006
Fin Treatment:	CR
Fins Per Inch:	14
Rows Deep:	8
Tube Height:	24
Finned Length:	60
Circuits:	30

Entering Conditions

Altitude (ft)	
CFM	3134
Ent air db (°f)	87
Ent air wb (°f)	68
Glycol Temp. (°f)	38
Gpm	30.92
Per gly (1-70)	25

Calculations

Btuh (Total)	219860.700
Btuh (Sens)	151175.100
Air PD (IN W.G.)	0.384
Scfm	3134.000
Air Velocity (SFPM)	250.720
LAT DB (°F)	42.841
LAT WB (°F)	42.841
Lvg Fl Temp (°F)	53.108
Glycol PD (FT H2O)	6.402
Glycol Vel (FPS)	1.786
Fin Height	30.000

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