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How Traditional Chiller Plant Design and Operation Reduces System Efficiency

Mike Flaherty, *General Manager of tekWorx*

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Chiller and Cooling Best Practices

Chilled Water Plant Optimization Case Study

Global Pharmaceutical R&D Campus

Presented by

Mike Flaherty

General Manager – tekWorx, LLC

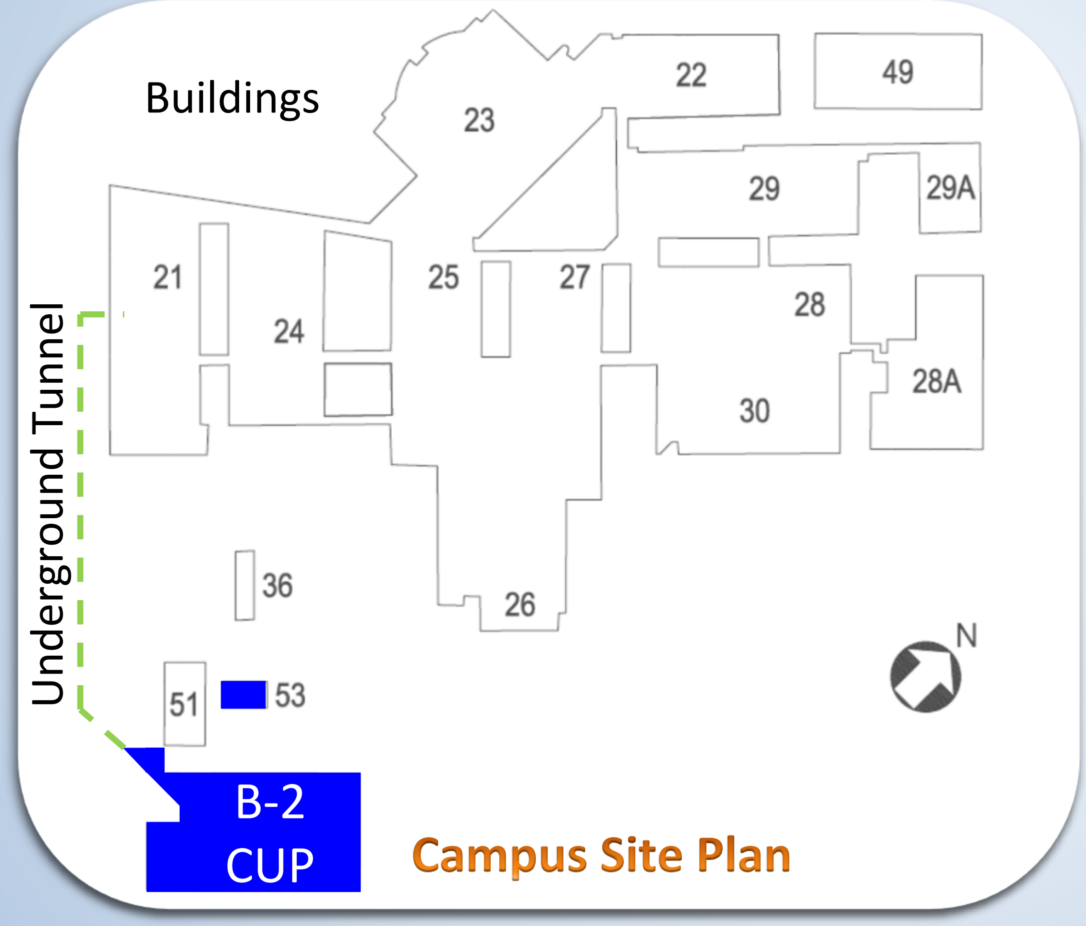
Optimization Case Study Outline

- Project Goals
- System Overview
- System Analysis
- Energy Conservation Measures
- Supporting Modifications
- Project Results
- Identifying Potential CHW Optimization Projects

Optimization Project Goals

1. Maintain Cooling Reliability.
2. Maintain Cooling Reliability.
3. Maintain Cooling Reliability.
4. Minimize Operation Disruption.
5. Optimize System Efficiency.
6. Meet payback requirements.

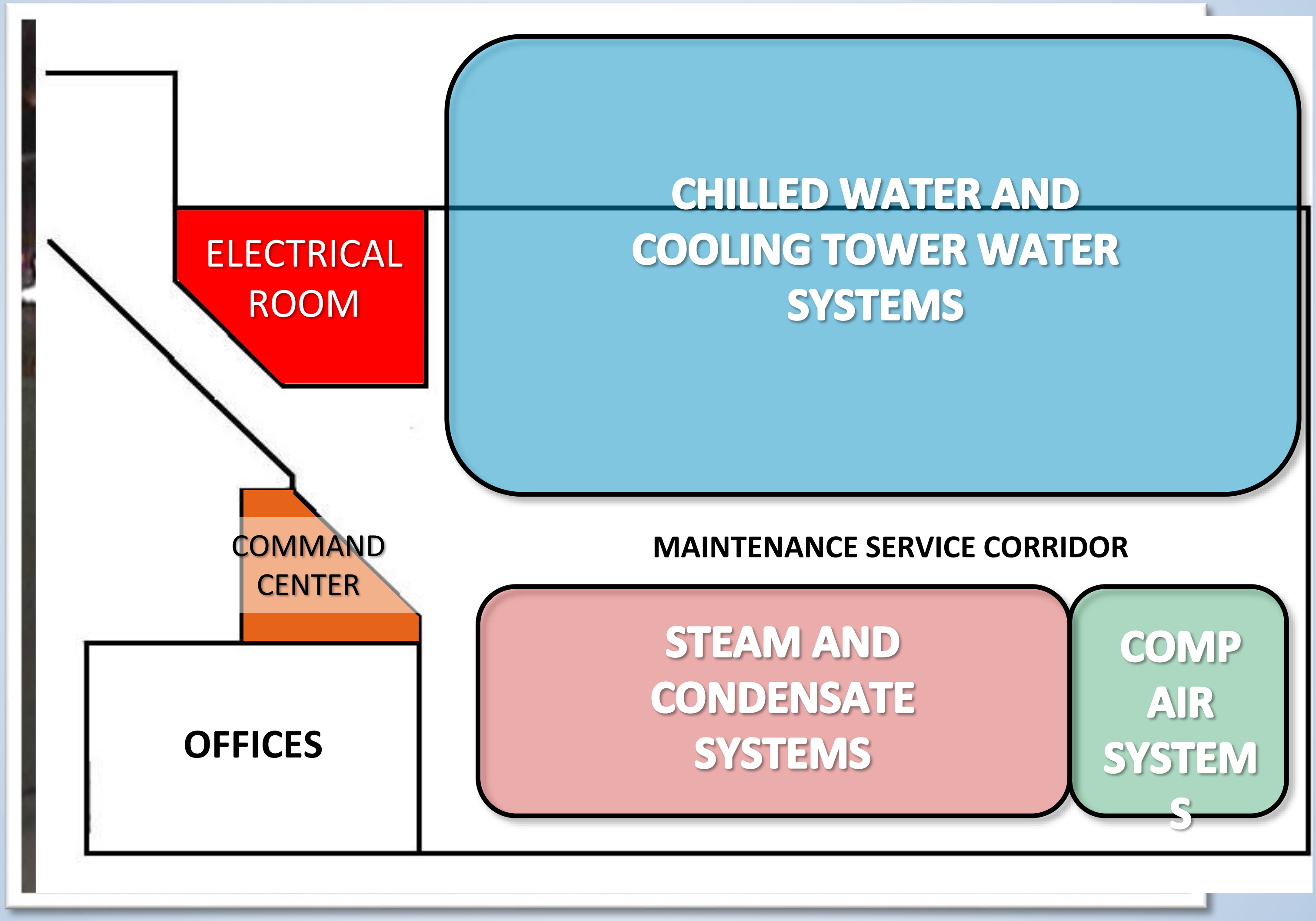
Campus Map / Distribution System



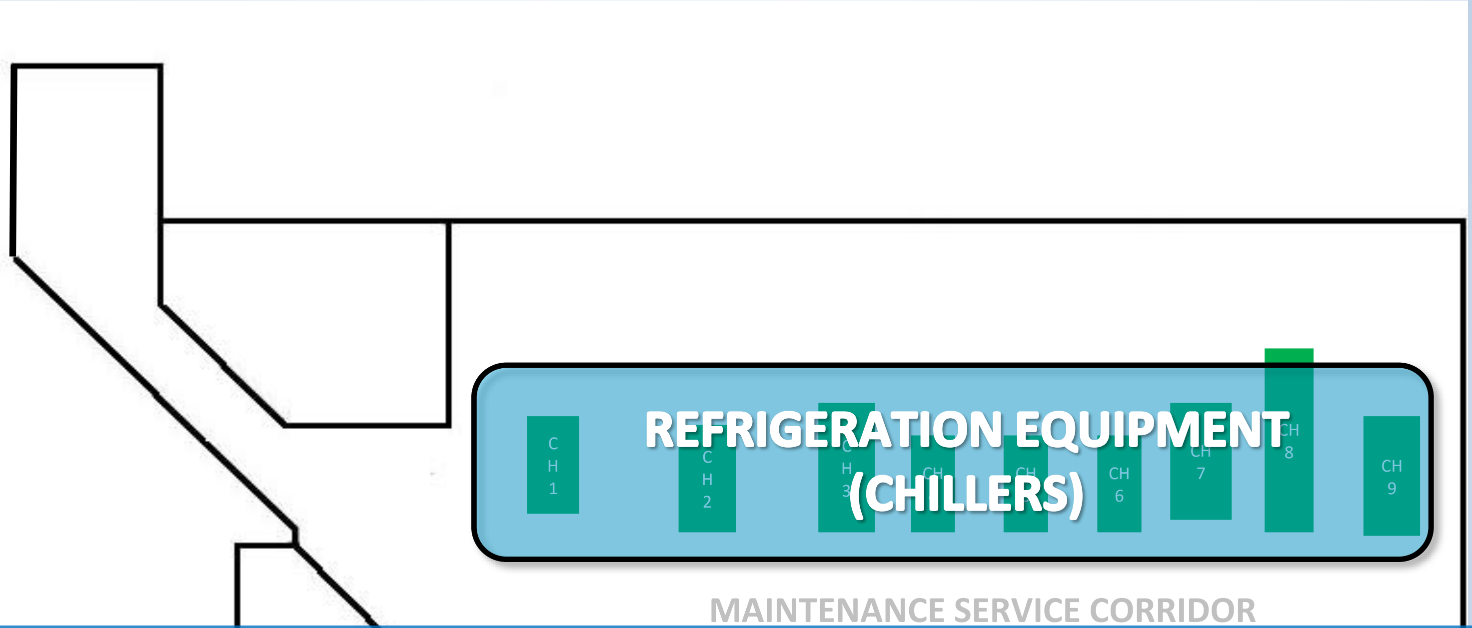
<u>Cooling to:</u>

- R&D Laboratories
- Datacenter
- Laboratory Animal Sciences (LAS)
- Sterile Suite
- Critical Manufacturing
- Offices

Central Utility Plant

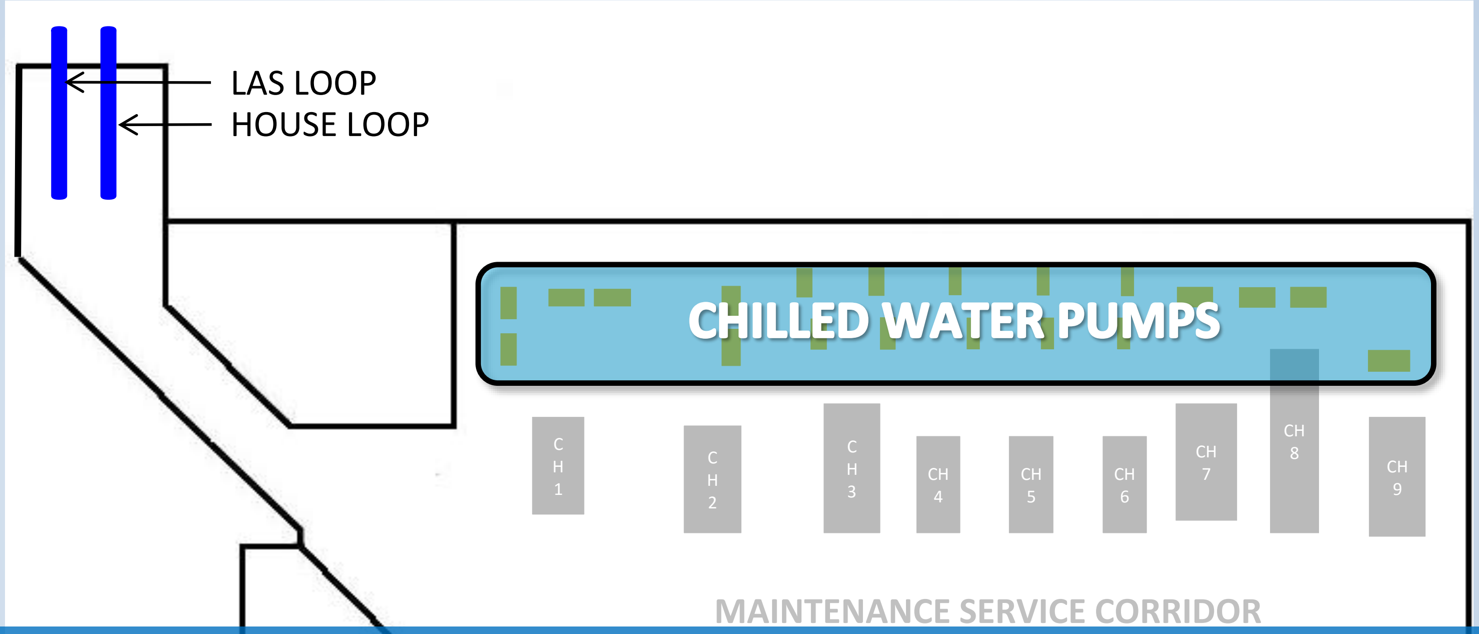


Previous CHW Generation Scheme



CHILLED WATER GENERATION		
Eight (8) Water-cooled Elect. Centrif. Chillers 950 TR TO 2,000 TR 4160V Constant Speed Motors	One (1) Low Pressure Steam Absorption	Chiller design $\Delta T = 16°F$

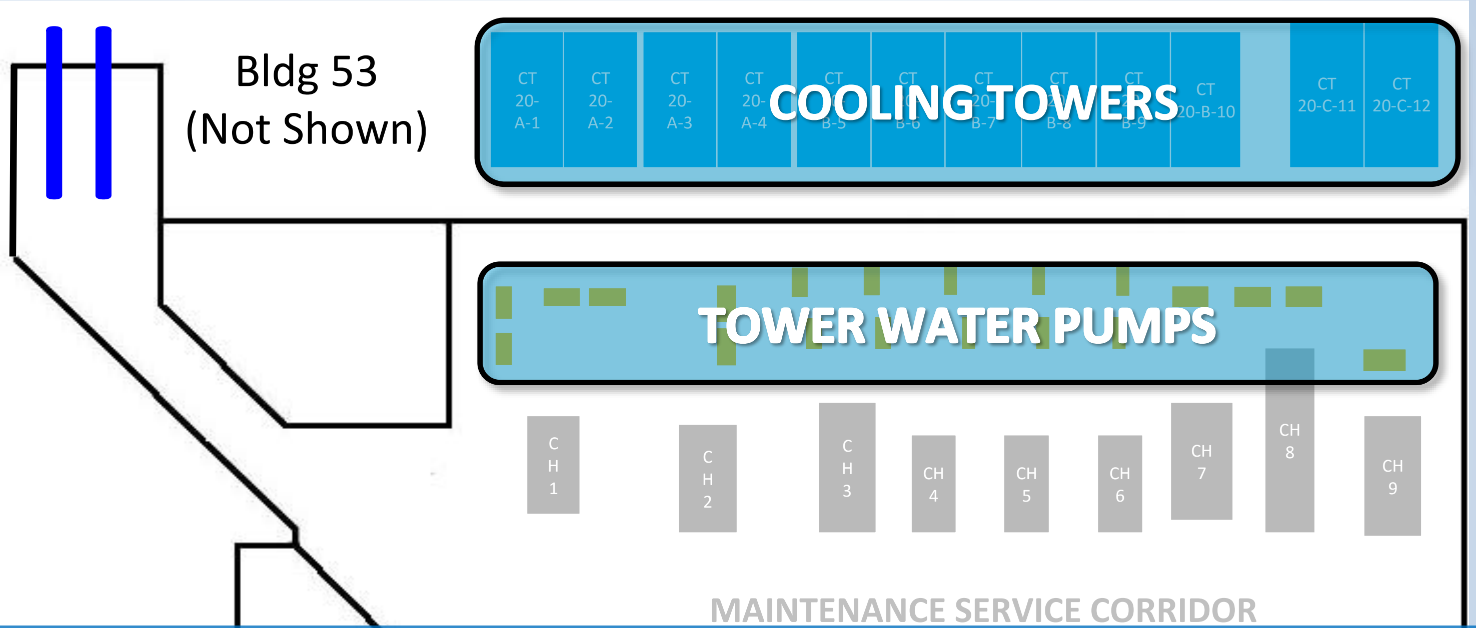
Previous CHW Distribution Scheme



CHILLED WATER DISTRIBUTION

Headered Primary Only Pumping Configuration	Ten (10) Centrifugal Pumps	Two (2) Interconnected Piping Loops LAS And House Loops

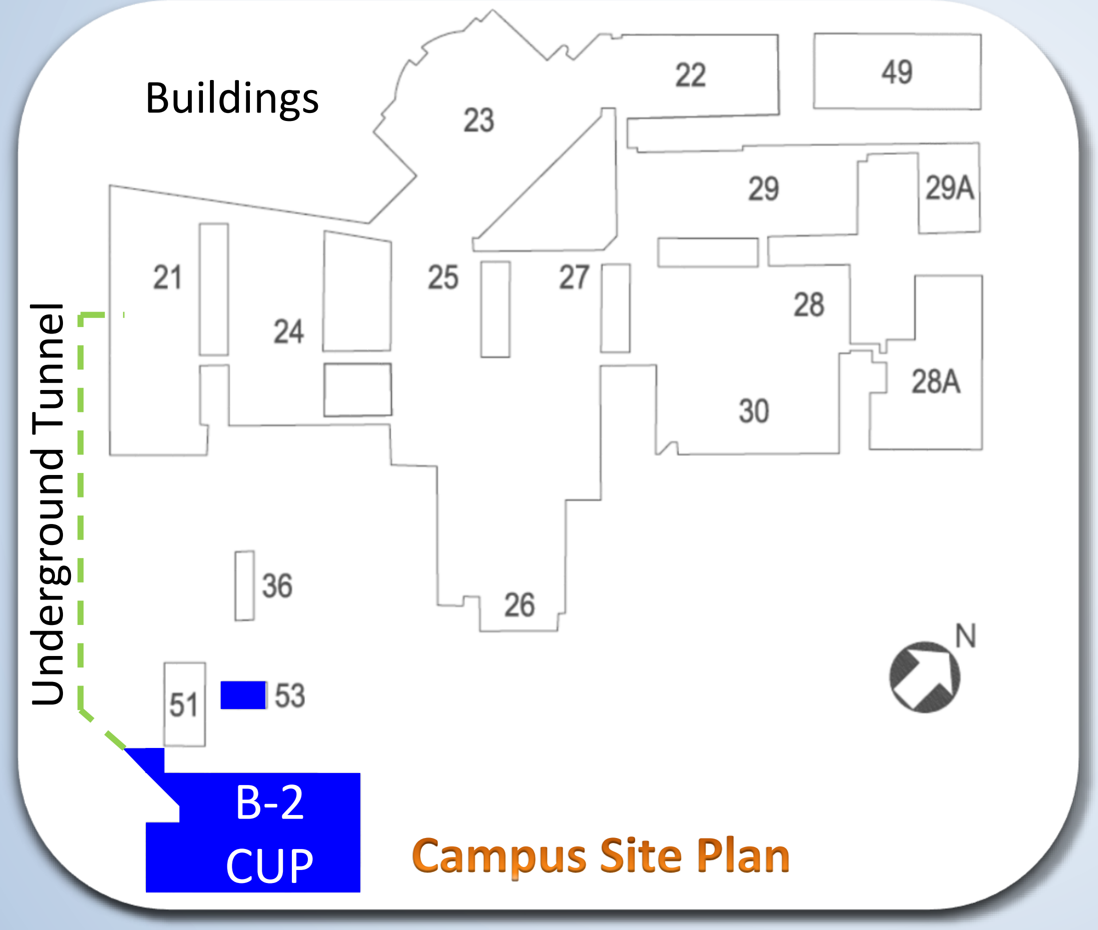
Previous Tower Water System Scheme



TOWER WATER SYSTEM

4 Towers / 15 Cells Induced Draft Crossflow Type	VFD's On Cooling Towers Fixed Condenser Water Supply Temperature	Headered Pump Config 12 Centrifugal Pumps Constant Speed

Chilled Water Demand And Usage

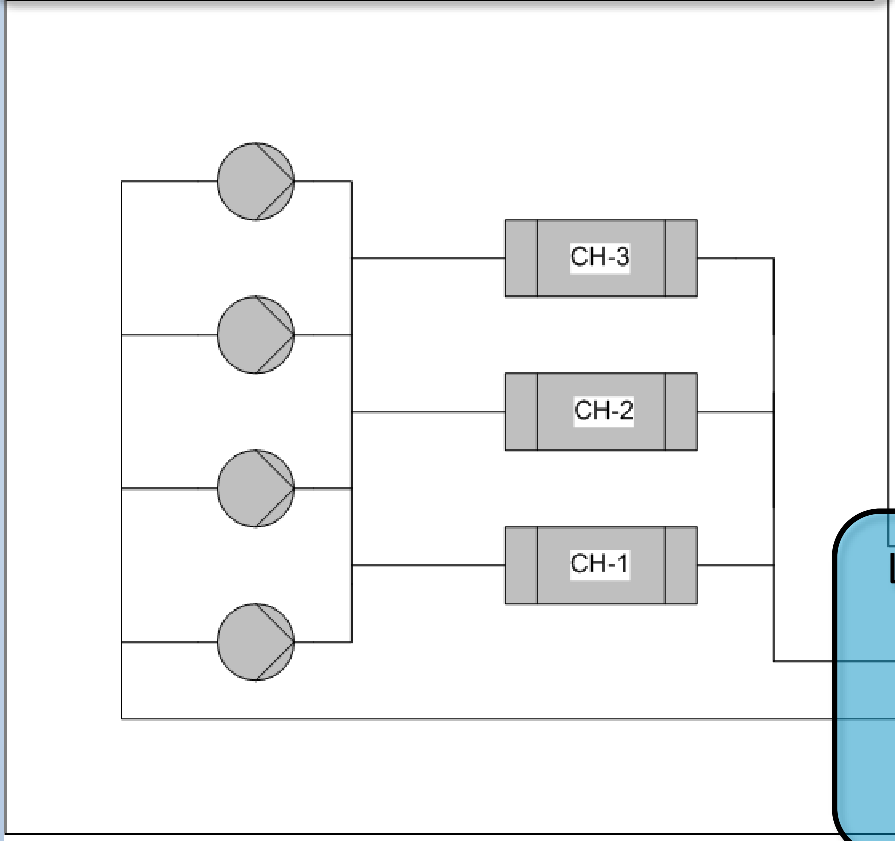


B-2 CHW SYSTEM DEMANDS
9,980 Tons

B-2 CHW SYSTEM CAPACITY
10,635 Tons

Previous CHW Plant Operation

ONE PUMP / ONE CHILLER / TWO CT CELLS
MANUAL VALVE OPERATION



Constant Flow Primary Pumping

Pressure Regulating / 2-Way / Flow Control Valves in Distribution

2 Independent Distribution Loops

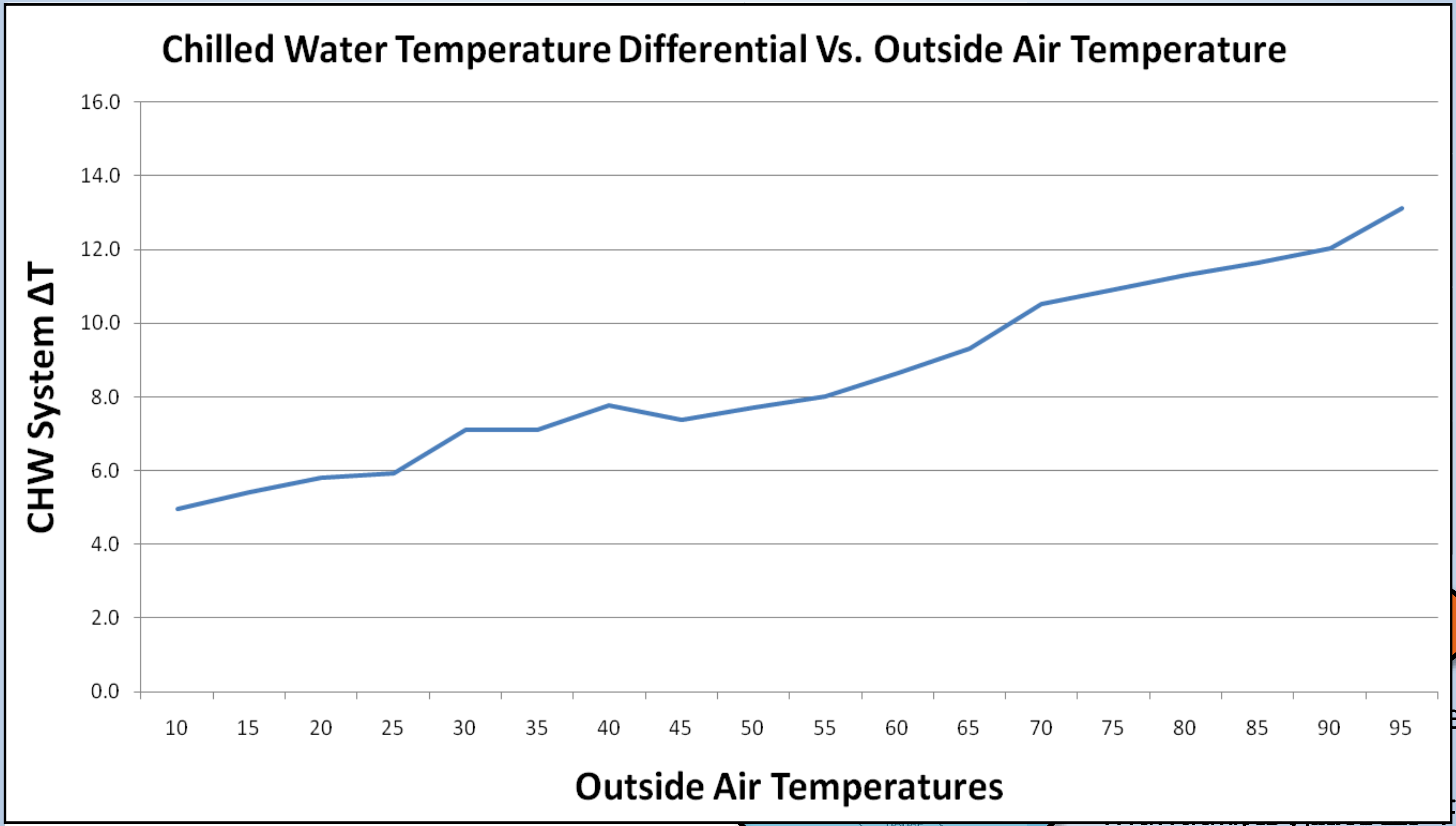
LAS (40°F) and House (44°F)

Manual Sequencing of Equipment

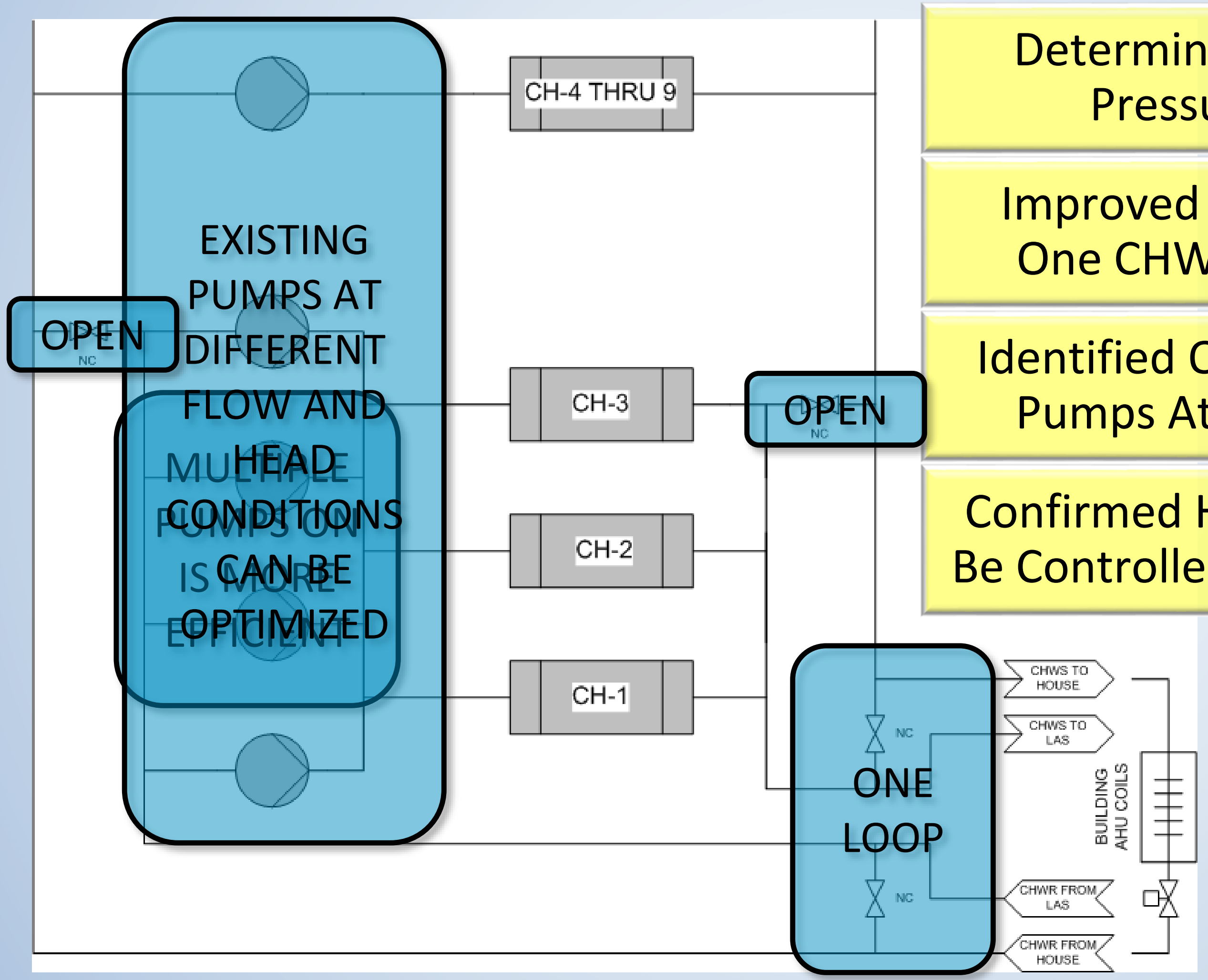
Limited CHW Plant Monitoring Capabilities to BASem

Maintain Supply Pressure
80-100 PSIG (ΔP = 30-50 PSID)

Previous Plant Performance Issues



System Hydraulic Evaluation Summary



Determined Minimum CHW Pressure Differential

Improved Pumping Efficiency One CHW Distribution Loop

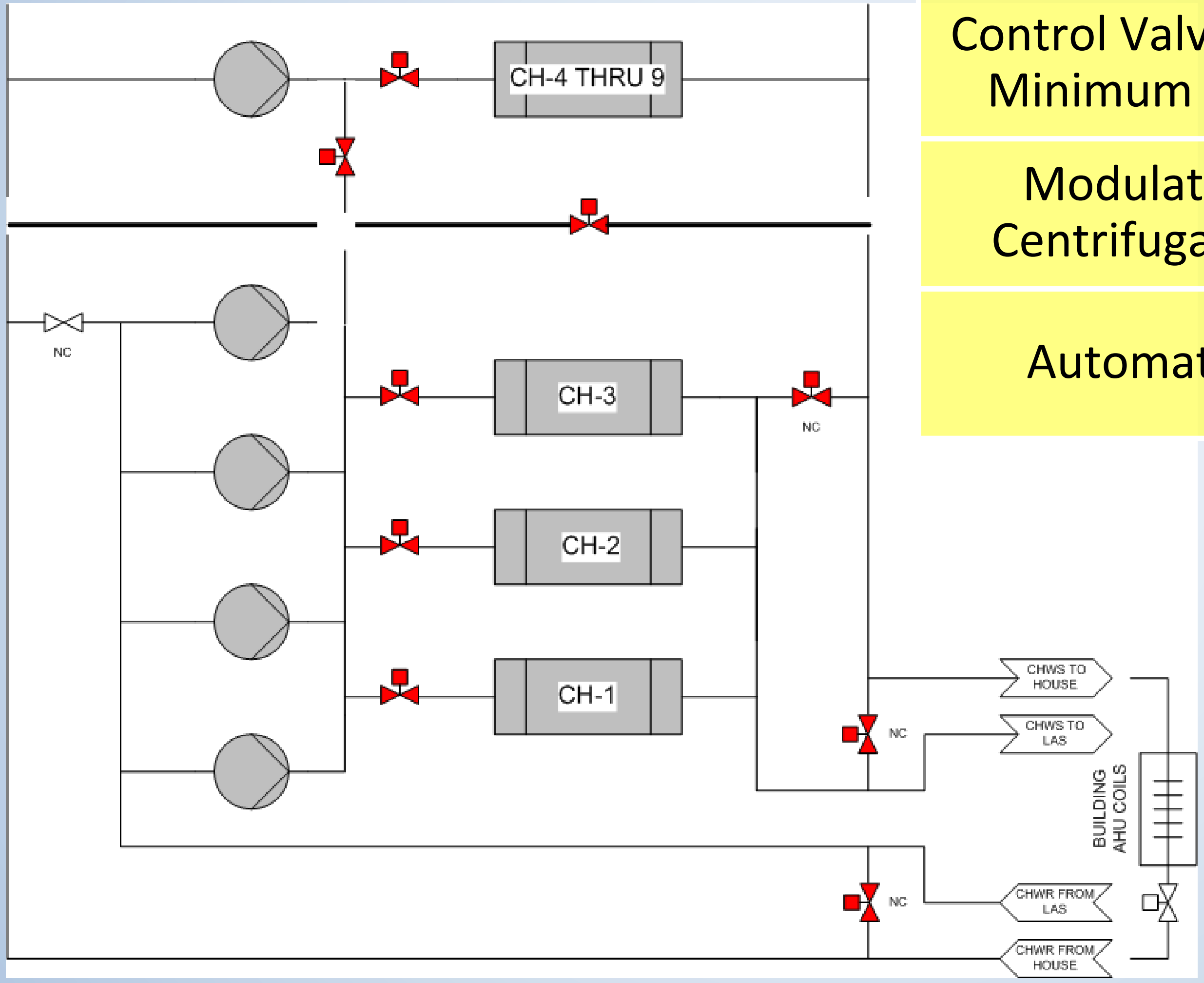
Identified Optimum Number Of Pumps At Varying Demands

Confirmed Headered Pumps Can Be Controlled Effectively on VFD's

P

System DP To Satisfy All Demands is approx. 5-35 PSID

Hydronic / Mechanical Modifications

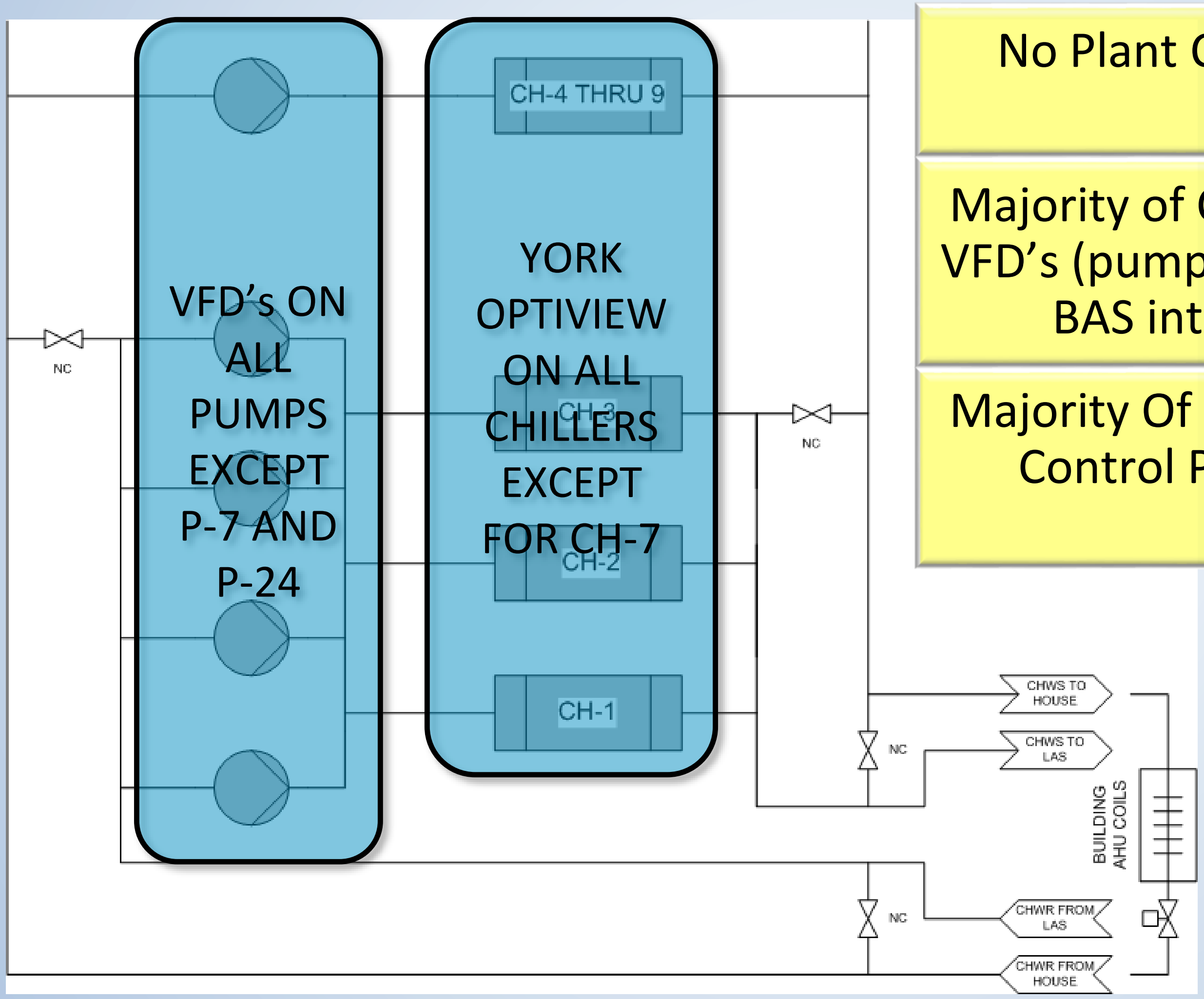


Control Valve Bypass To Maintain Minimum Flow At The Chillers

Modulating Valves At Each Centrifugal Chiller Evaporator

Automatic Isolation valves

Previous Control System Evaluation

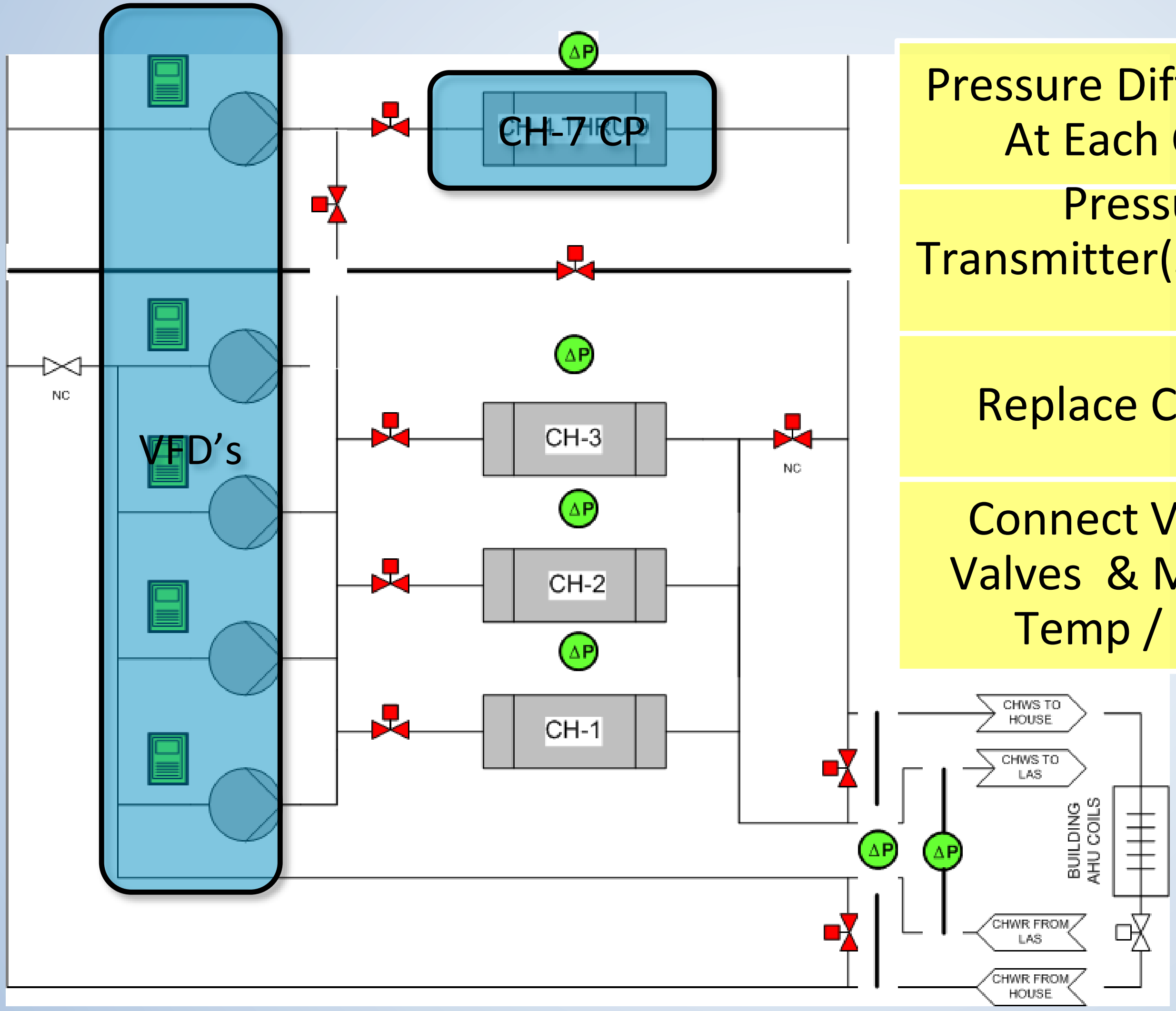


No Plant Control Automation Installed

Majority of CHW equipment have VFD's (pumps and towers) with no BAS interface or control

Majority Of Chillers Have Modern Control Panels with no BAS interface

Instrument & Field Device Modifications



Pressure Differential Transmitters At Each Chiller Evaporator

Pressure Differential Transmitter(s) In CHW Distribution Loops

Replace Chiller Control Panel

Connect VFD's, Chiller Panels, Valves & Miscellaneous Press / Temp / Flow Instruments

BYPASS PT
CHW S AND R TT's
DPS, HOA, S CV POSITIONS

Summary: Issues & Recommendations

Issue	Recommendation
Low ΔT's, High CHW Flows, Chillers Operating when Not Required	Convert To Variable Primary Flow (VPF) operation
Inefficient Operation with Two CHW Distribution Loops	Operate With Only One CHW Distribution Loop
Inefficient Operation of Equipment/Plant – Manual Mode	Fully Automate Operation

Automatic Operation ≠ Optimized Operation

Solution: Control Based Optimization

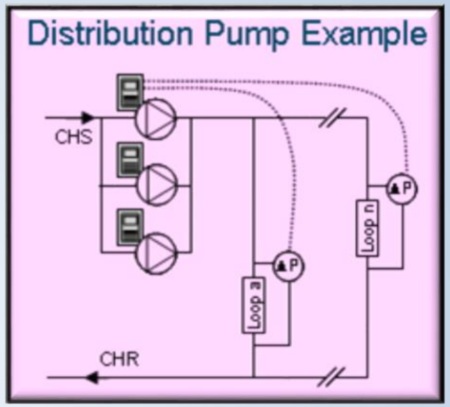
Integrated Local Control and Optimization

Control Based Optimization

- Standard Control System Design Goal: auto control to make enough cold water on a design day.
- Control Based Optimization Design Goal: control to meet demand *every* day at the lowest kW/ton.
- Utilize real-time values to control operation *and* maximize energy efficiency: flow / ΔT / ΔP / ***kW***.
- Automatic, incremental adjustments to equipment operation in real-time to minimize kW/ton.

Control Based Optimization: Distribution Pumps

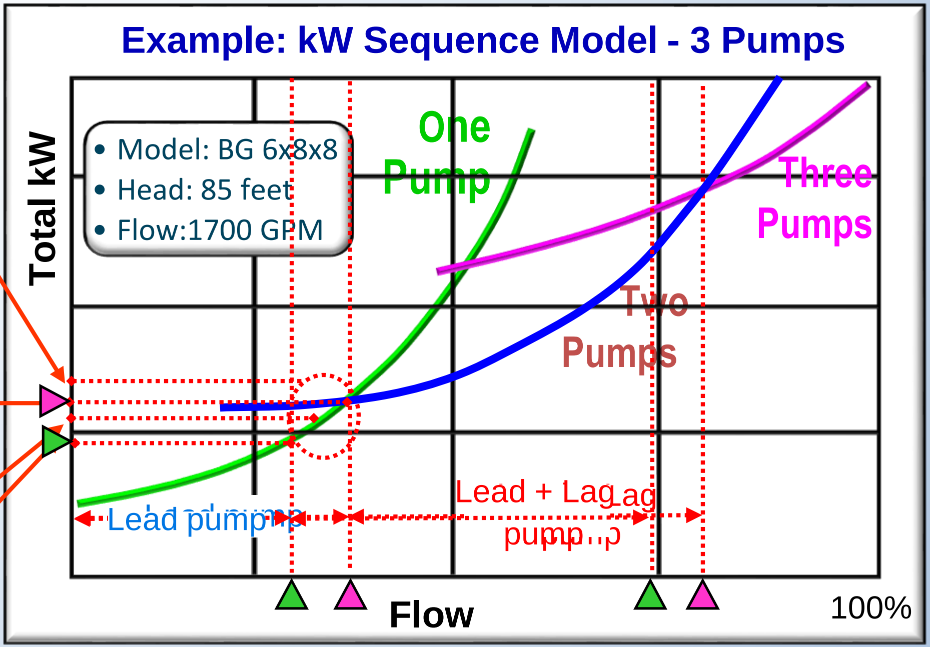
- Pump speed regulated to demand (remote DP.)
- # of pumps to run for lowest pump power?
- *Pump kW Sequence Model* – based on specific hydronic system and affinity laws.
- Adaptive algorithm auto resets setpoint to minimize pump power.



kW evaluated after each lag pump sequence operation

ON setpoint for 1st sequence operation using model

ON setpoint for next operation using adaptive algorithm



Energy/Cost Savings Projections

Baseline	
Annual Production:	19,875,000 ton-hours
Plant Average Low Load:	435 Tons @ 4.5 °F ΔT
Plant Average High Load:	6,725 Tons @ 11.7 °F ΔT

Projected Savings	
Efficiency Improvement:	0.23 kW / ton
Reduced Power Usage:	4,600,000 kWh
Cost Savings:	$410,000

Actual Project Energy/Cost Savings

Project Payback	
Total Project Cost	• $2,175,000
Utility Rebate	• $385,000
Annual Projected Savings	• $402,000 (blended average 9¢/kWh)
Simple Payback	• Without rebate: 5.3 years • With rebate: 4.3 years

Identifying Optimization Opportunities

System Size: Cooling Production is Key

- 3,000,000 ton-hrs annually, based 10¢/kWh
- Usually > 800 tons installed capacity

Observable Problems / Conditions

- Unable to meet demand/redundancy.
- Add chillers for flow rather than cooling.

Identifying Optimization Opportunities

Hydronic issues / symptoms

- ΔT more than 3° below design.
- Primary/secondary or CS w/ 3-way valves.
- Excess flow / bypassing.
- Leaky/broken coil control valves.
- Balance valves on constant speed pumps.

Control Issues

- Manual control / frequent intervention.
- Make-it-work sequence of operation.
- Failed / non-calibrated instrumentation.

Typical Results / Expectations / Example

- Savings: .1 to .4 kW per ton, or ~ 20% - 50%.

Cl er Plant Upgrac Vorksheet EXAMPLE

- Primary / Secondary
- Typical BAS Control
- Make-it-work sequence
- Reasonable oversight
- Current control system

- Constant speed / 3 way
- Manual operation
- No automatic sequence
- Nobody paying attention
- Old / obsolete control

Typical Results / Expectations / Example

Chiller Plant Upgrade Worksheet EXAMPLE

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Pharmaceutical

Chiller Plant Optimization Case Study

Questions and Discussion

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Q&A

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