SISTEMAS DE ÁGUA GELADA

PROGRAMA BRASILEIRO DE ELIMINAÇÃO DOS HCFCs

Projeto para o Gerenciamento de Chillers

Projeto Demonstrativo para o Gerenciamento Integrado no Setor de Chillers

Primary Heating / Cooling Plant Strategies & How to Maximize the Energy Savings

Jim Vallort– ESD / ASHRAE

25/02/2016 - Rio de Janeiro

Execução

SOMAR

Implementação

PNUD

Empoderando vidas. Fortalecendo nações.

Realização

Ministério do Meio Ambiente

GOVERNO FEDERAL BRASIL PÁTRIA EDUCADORA

Agenda

- Overview and Rationale of Central Plants
- Cooling Plant Strategies
  - Building (Shell) and System Type/Configurations
- Distribution Systems
- System Parameters
- Commissioning (Cx) Overview – Process and Benefits
- Plant Case Review
- Q & A

Rationale for Central Plant

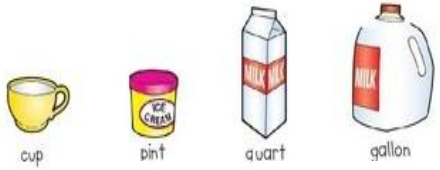
Operations

Capital Investment

Increase Efficiency

Reduce Maintenance

Centralize Noise and Vibration

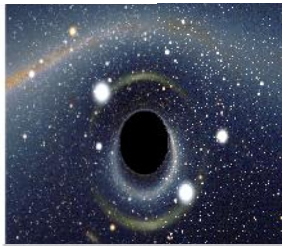


Reduce Installed Capacity

Increase Plant Safety

Improve Flexibility

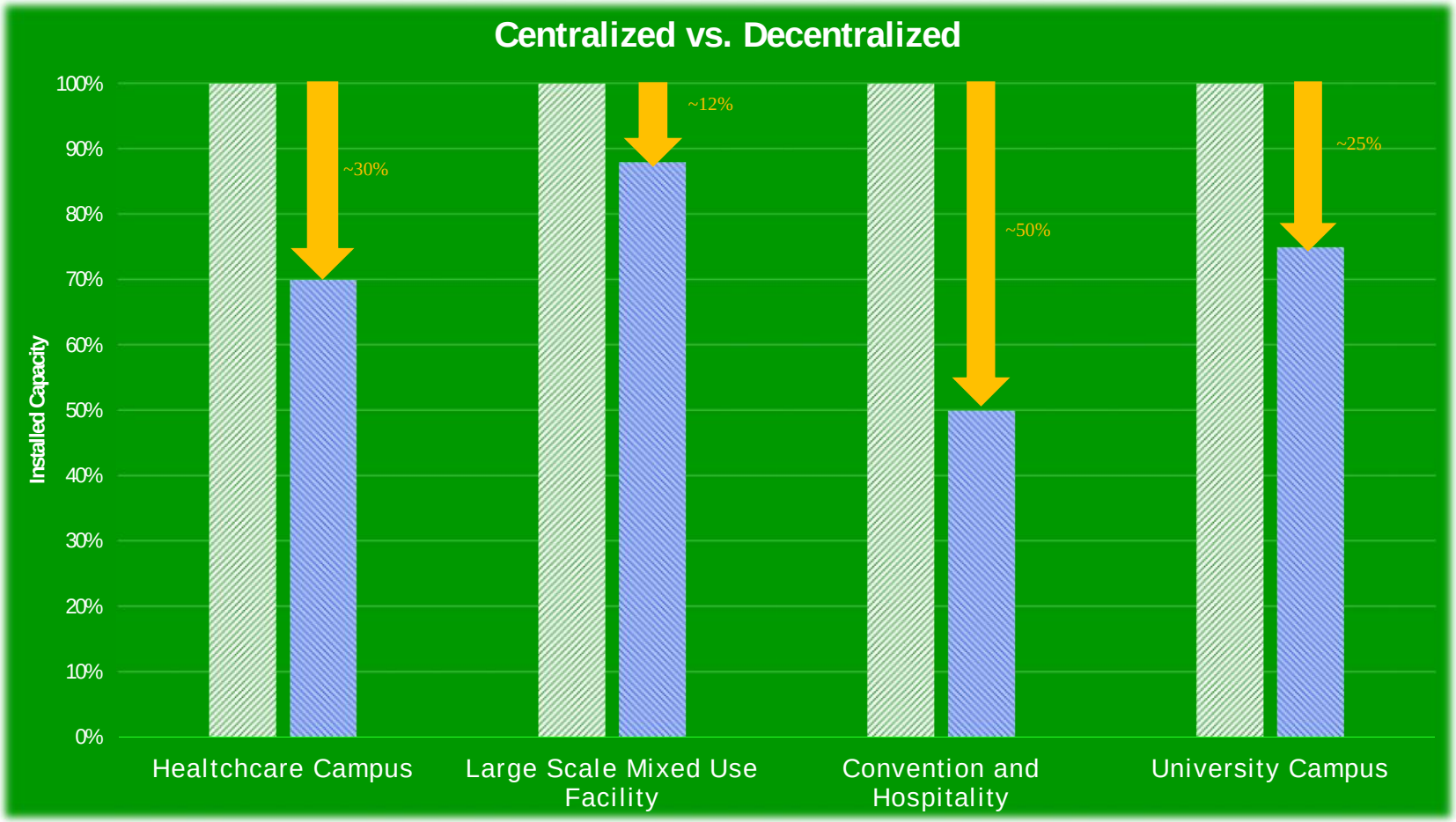
Increase Reliability



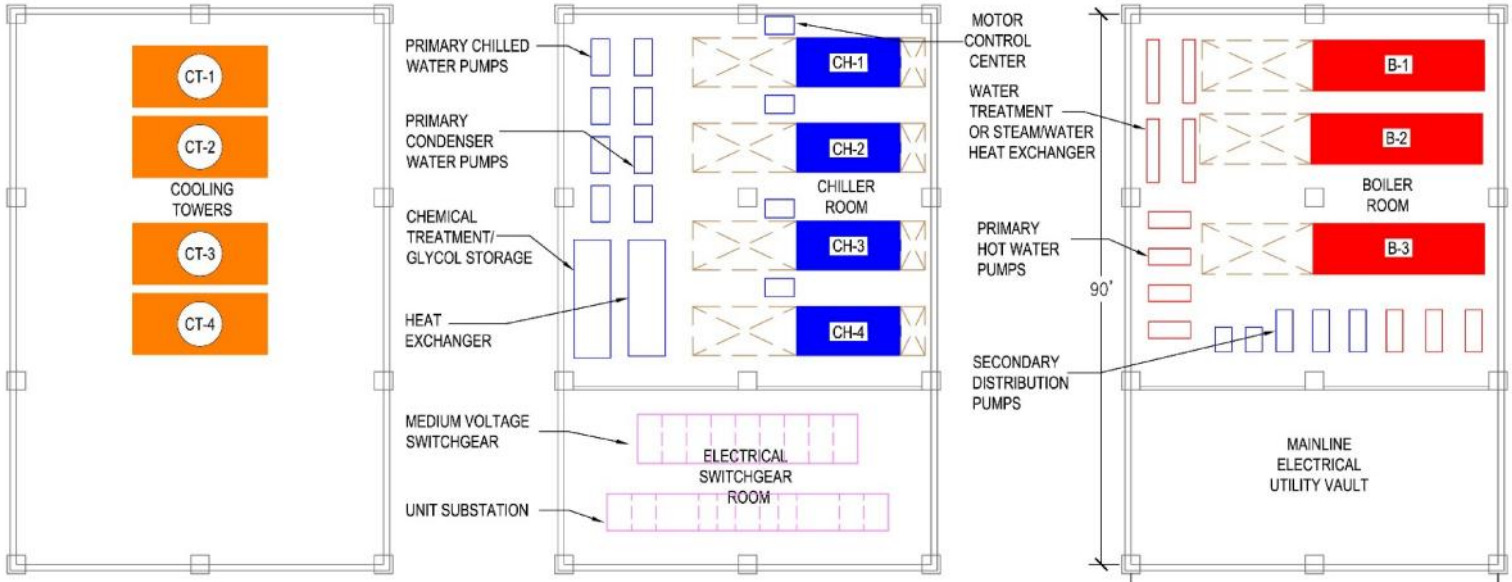
Reduce Space

Reduce Fuel Consumption

Centralized vs. Decentralized – Plant Capacity



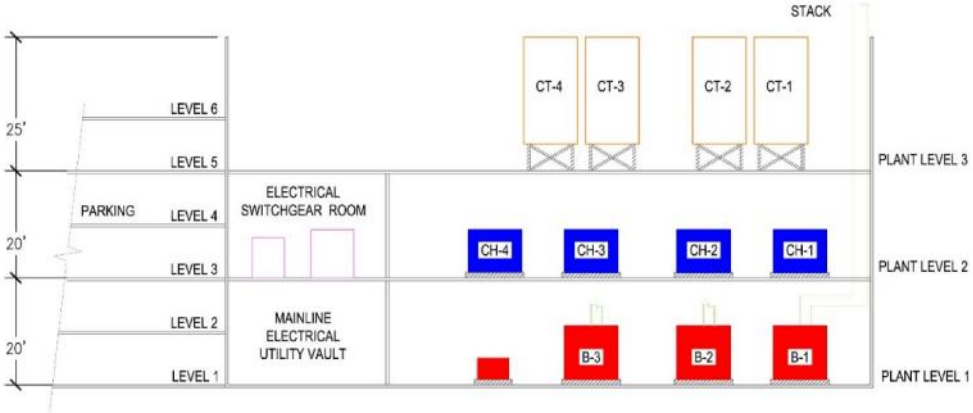
Typical Central Heating/Cooling Plant



3 CENTRAL PLANT CONCEPT - LEVEL 3
NOT TO SCALE

2 CENTRAL PLANT CONCEPT - LEVEL 2
NOT TO SCALE

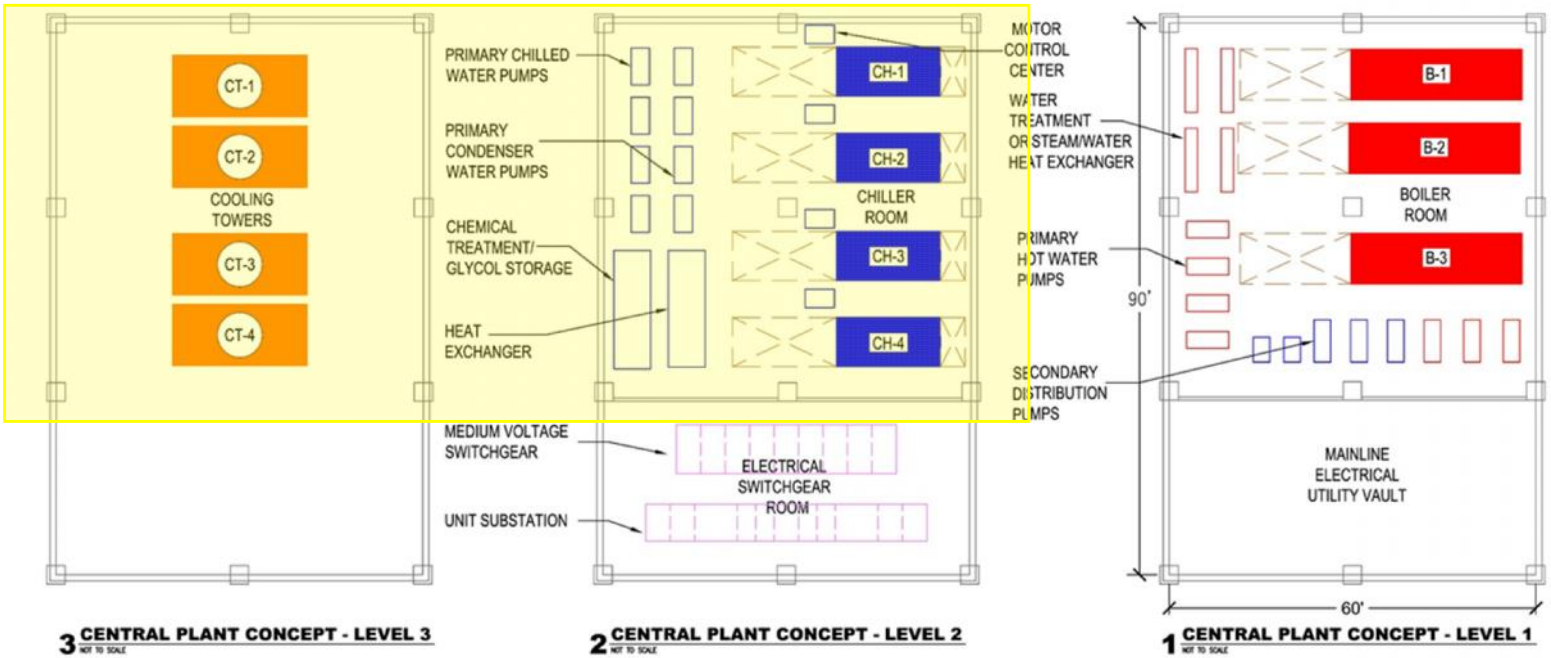
1 CENTRAL PLANT CONCEPT - LEVEL 1
NOT TO SCALE



1 CENTRAL PLANT CONCEPT - LEVEL 1-3 ELEVATION
NOT TO SCALE

Cooling Plant

Base System: Standard Chillers and Cooling Towers
Option 1: Low Temperature Chillers
Option 2: Heat Recovery Chillers
Option 3: Low Temperature chillers with Thermal Storage (Ice)



Base Scheme - Standard Chillers and Cooling Towers

System:
Central chilled water plant consisting of multiple electric centrifugal chillers. Condenser pumping loop rejects heat to open-cell cooling towers. Chilled water at 5.5ºC (42ºF) is distributed to meet all cooling loads via a primary/secondary distribution system. DT: 8.5ºC (15°F)

Equipment:

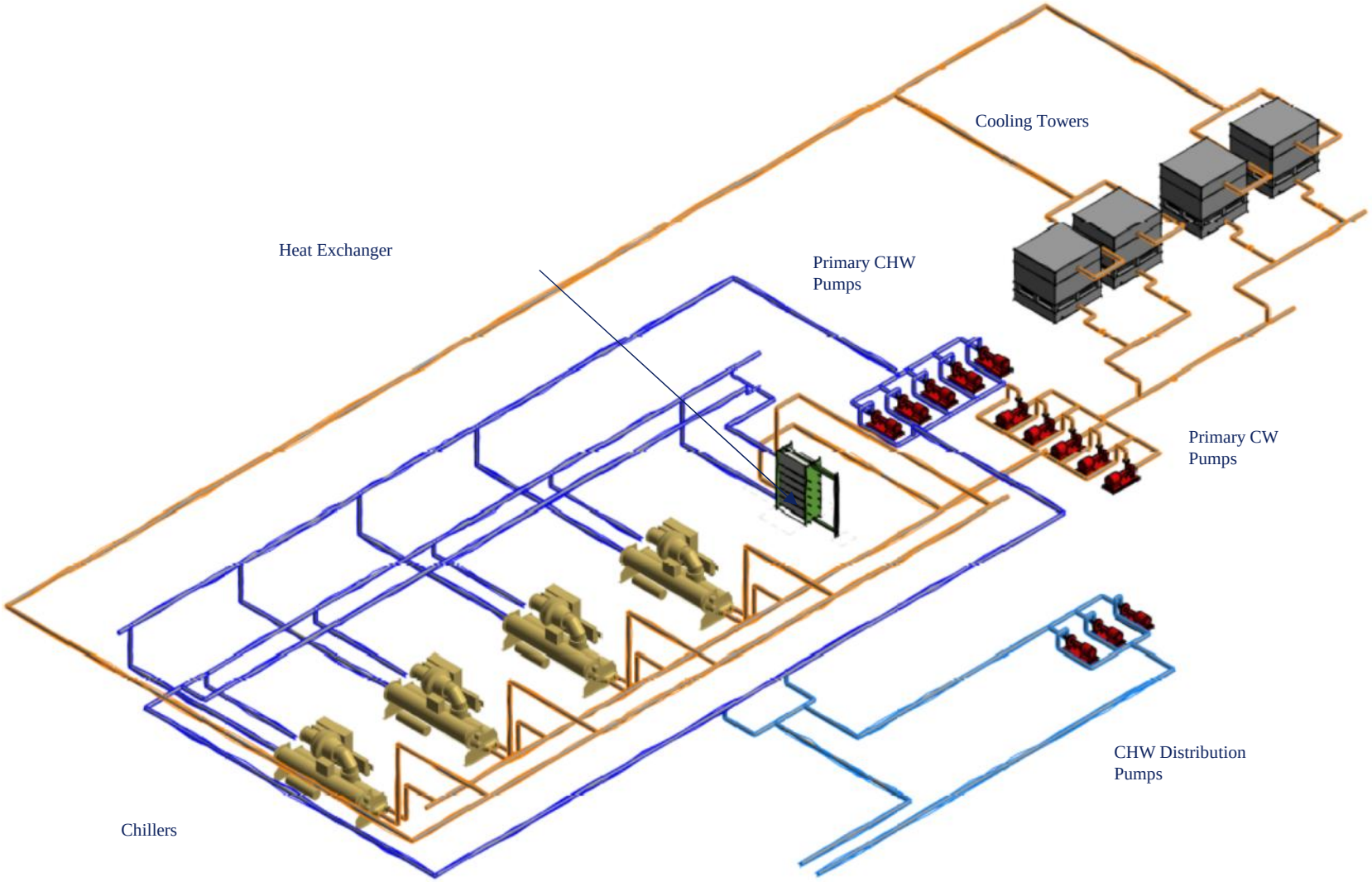
- 4 centrifugal chillers each sized at 30% of total building cooling load

- 4 primary pumps (+1 standby) operating in parallel and common header

- Multiple variable speed secondary pumps circulating chilled water to building systems

- Accessories: Strainers, control valves, expansion tanks, chemical feeders, make-up water stations, freeze protection

Base Scheme - Standard Chillers and Cooling Towers



Facility Chilled Water Supply/Return

Base Scheme - Standard Chillers and Cooling Towers

Pro's:

- Operational simplicity
- Good part-load efficiency
- Reliability
- Operational safety
- Long life expectancy
- Centralized maintenance
- Standard application

Con's:

- Space requirement
- Large pipe distribution
- High pumping energy

Option 1 – Low Temperature Chilled Water

System:
A dedicated central chilled water plant consisting of multiple electric centrifugal chillers. Condenser pumping loop rejects heat to open-cell cooling towers. Chilled water at 3.3ºC (38ºF) is distributed to meet cooling loads via a primary/secondary distribution system. Δ T10.6°C (19°F)

Equipment:

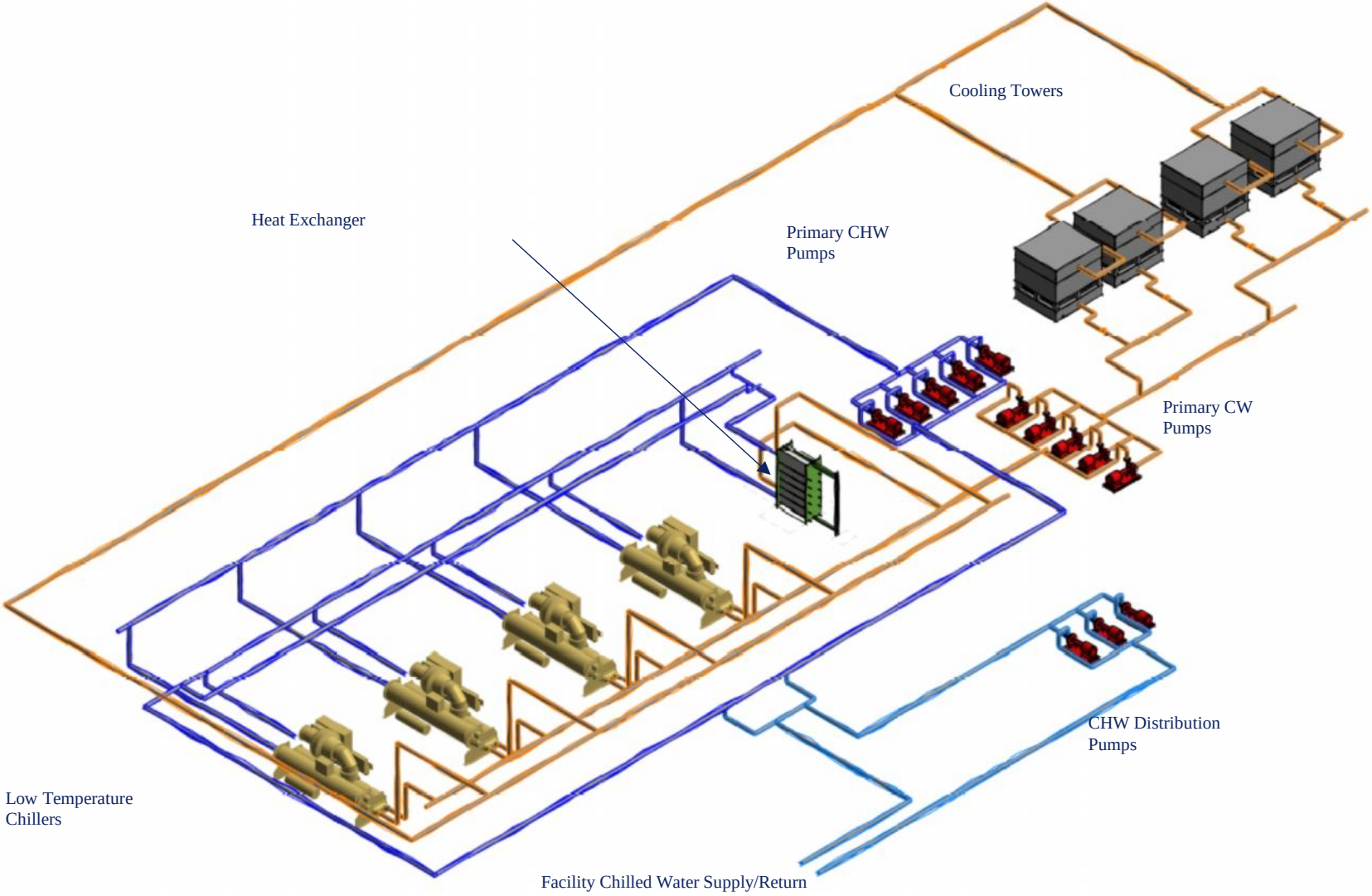
- 4 centrifugal chillers each sized at 30% of total building cooling load

- 4 primary pumps (+1 standby) operating in parallel and common header

- Multiple variable speed secondary pumps circulating chilled water to building systems

- Accessories: Strainers, control valves, expansion tanks, chemical feeders, make-up water stations, freeze protection

Option 1 – Low Temperature Chilled Water



Option 1 – Low Temperature Chilled Water

Pro's:

- High overall system efficiency
- Low overall system cost
- Low chilled water pumping energy
- Better dehumidification capability
- Good part-load efficiency
- Reliability
- Operational safety
- Long life expectancy
- Centralized maintenance

Con's:

- Space requirement
- Higher chiller power
- More complex operation

Option 2 – Heat Recovery Chiller

System:
Standard chiller and cooling tower arrangement as described in base system. One chiller is replaced by a heat recovery chiller to recover building heat and supplement the primary heating system.

Equipment:

- 3 centrifugal chillers each sized at 30% of total building cooling load

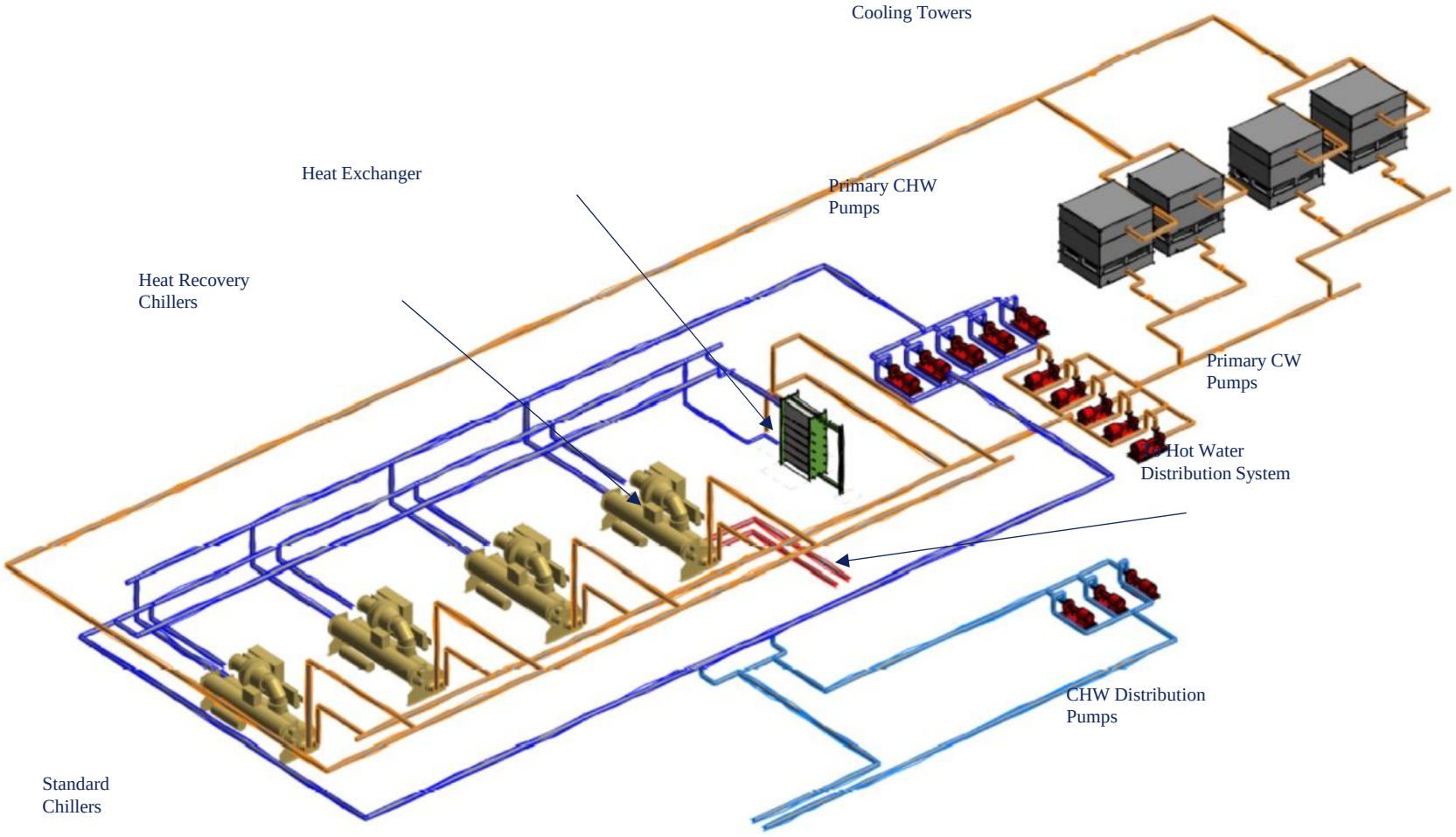
- 1 double bundle heat recovery chiller sized at 30% of total building cooling load

- 4 primary pumps (+1 standby) operating in parallel serving common header

- Multiple variable speed secondary pumps circulating chilled water to building systems

- Accessories: Strainers, control valves, expansion tanks, chemical feeders, make-up water stations, freeze protection

Option 2 – Heat Recovery Chiller



Facility Chilled Water Supply/Return

Option 2 – Heat Recovery Chiller

Pro's:

- High system efficiency
- Energy recovery (from internal building heat gains)
- Good part-load efficiency
- Reliability
- Operational safety
- Long life expectancy
- Centralized maintenance

Con's:

- High initial cost
- Space requirement
- Large pipe distribution
- Higher pumping energy

Option 3 – Low Temperature Chiller & Thermal Storage

System:
Standard chiller and cooling tower arrangement as described in base system. One or more chillers with capability to make low temperature chilled water at 3.3ºC (30ºF). Low temperature chilled water (glycol mix) is used to create ice at off-peak hours to offset daily peak electrical loads.

Equipment:

- Minimum of 3 centrifugal chillers sized for 120% of total system cooling load

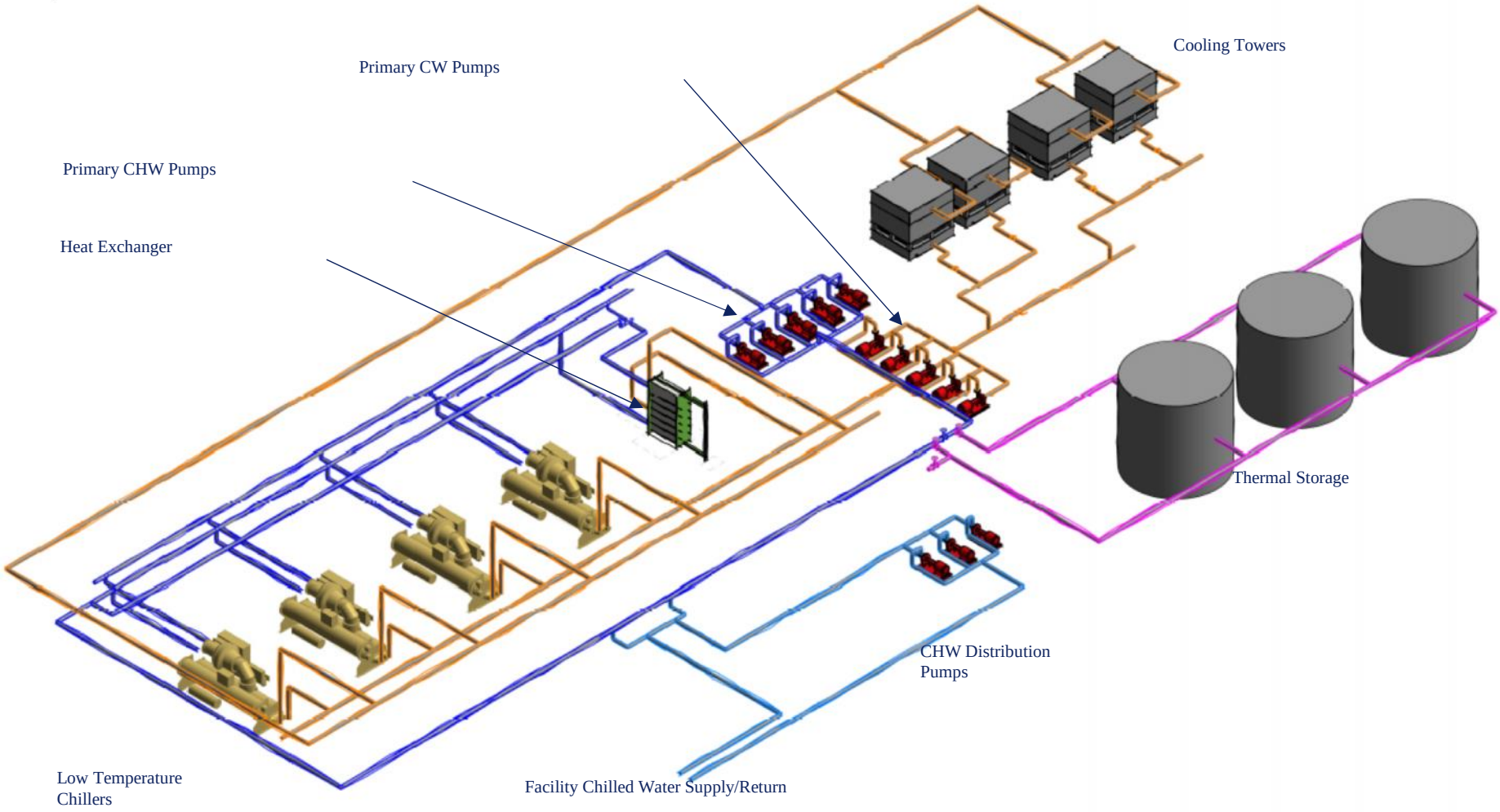
- Primary pumps (+1 standby) operating in parallel serving common header

- Multiple variable speed secondary pumps circulating chilled water to building systems

- Ice storage units sized to meet 30% of total building cooling load on design day

- Accessories: Strainers, control valves, expansion tanks, chemical feeders, make-up water stations, freeze protection, heat exchanger

Option 3 – Low Temperature Chillers & Thermal Storage



Option 3 – Low Temperature Chiller & Thermal Storage

Pro's:

- Reduces utility demand charge
- Lower installed chiller capacity
- Low chilled water pumping energy
- Better dehumidification capability
- Good part-load efficiency
- Reliability
- Long life expectancy
- Centralized maintenance

Con's:

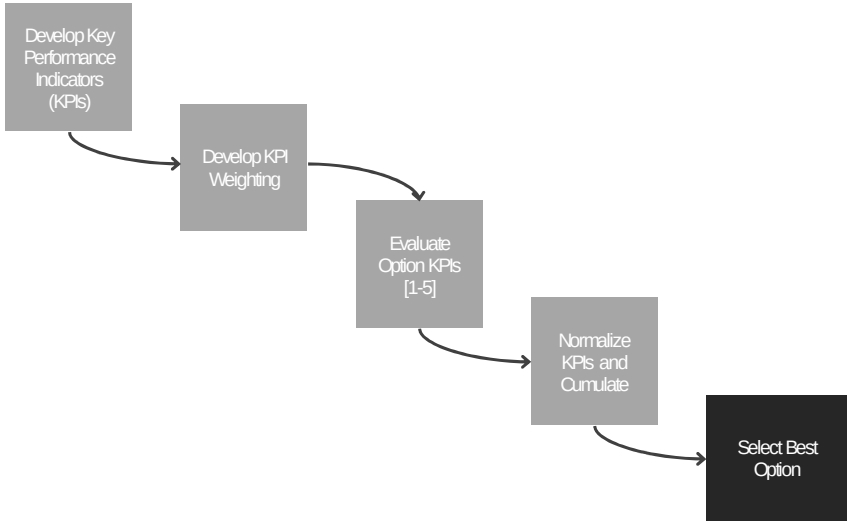
- Large space requirement
- Higher chiller power
- Higher maintenance
- Complex operation
- Savings based on utility structure that may change

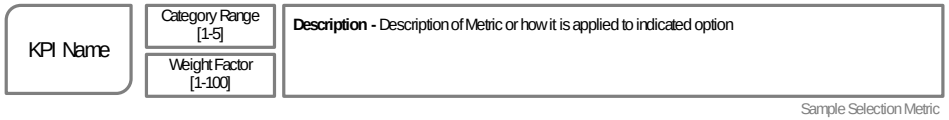
Decision Analysis

EVALUATION CRITERIA	%TOTAL	% TOTAL
Energy Conservation		10
Cost		10
Life Cycle Cost	20	
First Cost	30	
Energy Cost	30	
Maintenance Cost	20	
Sub-Total	100	
Operational Issues	10	
Special Training	5	
Operating Simplicity	10	
Noise & Vibration	15	
Capacity Control	15	
Part Load Efficiency	10	
Control Stability	10	
Operational Stability	5	
Flexibility	15	
Reliability	15	
Sub-Total	100	
Maintenance Issues		15
System Safe for Operating Personnel	30	
Availability of Repair Contractors	20	
Minimal Failure Potential	15	
Ease of Maintenance	35	
Sub-Total	100	
Environmental Impacts		10
Global Warming Potential	40	
Ozone Depletion	40	
Corrosion of Building Elements	20	
Sub-Total	100	
Architectural Impacts		10
Construction Impacts		15
Procurement		10
Regulatory Requirements		10
TOTAL		100

Comparison Workflow

Double Weighted Comparison





Sample Selection Metric

	Weight Factor	Option 1	Option 2
Criterion 1	X	1 1*X/5	2 2*X/5
Criterion 2	Y	3 3*X/5	4 4*X/5

Sample Weighting Summary Matrix

1	Significant Negative Affect
2	
3	Neutral
4	
5	Significant Positive Affect

Scale

Summary – Decision Analysis

Summary Matrix	Weight Factor	Option 1	Option 2	Option 3
Enhancement to Operations	20	5	4	5
		20	16	20
Ability to Meet Near Future Requirements	20	5	4	3
		20	16	12
Cost (calculated from Cost Matrix)	10	3	4	3
		6	8	6
Operational Issues (calculated from Operations Matrix)	20	5	4	4
		20	16	16
Maintenance Issues (calculated from Maintenance Matrix)	15	4	4	4
		12	12	12
Masterplan Coordination	15	5	3	3
		15	9	9
Total	100	93	77	75

Distribution System

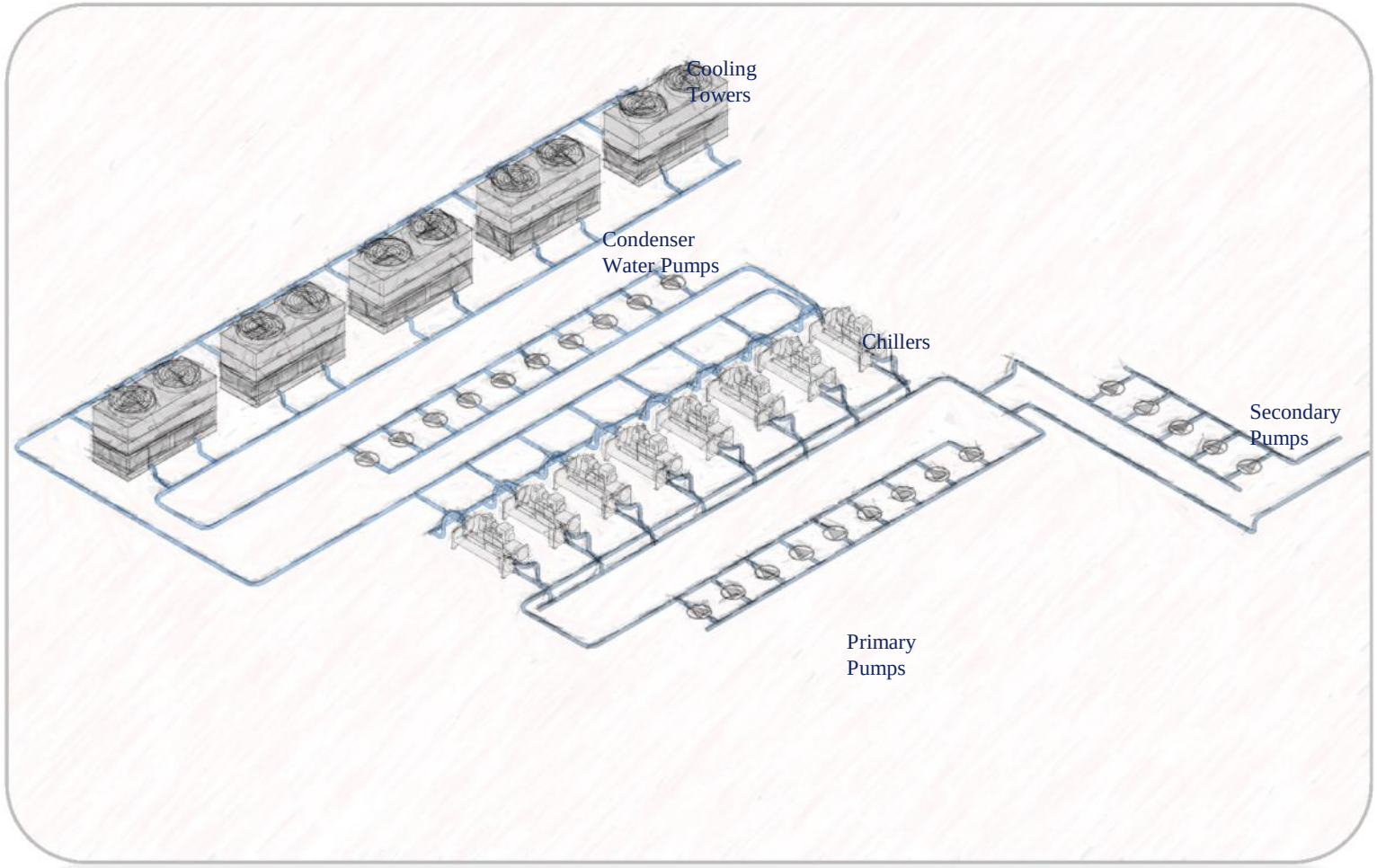
Two Major Principles

- Constant flow
- Variable flow

Challenges

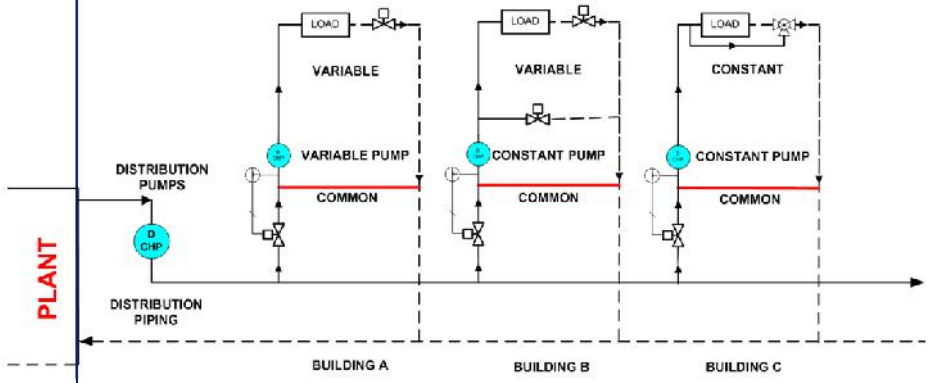
- Incompatible principles
- Should not be incorporated into the same system
- Typical problem across campuses

Typical Central/District Cooling Plant

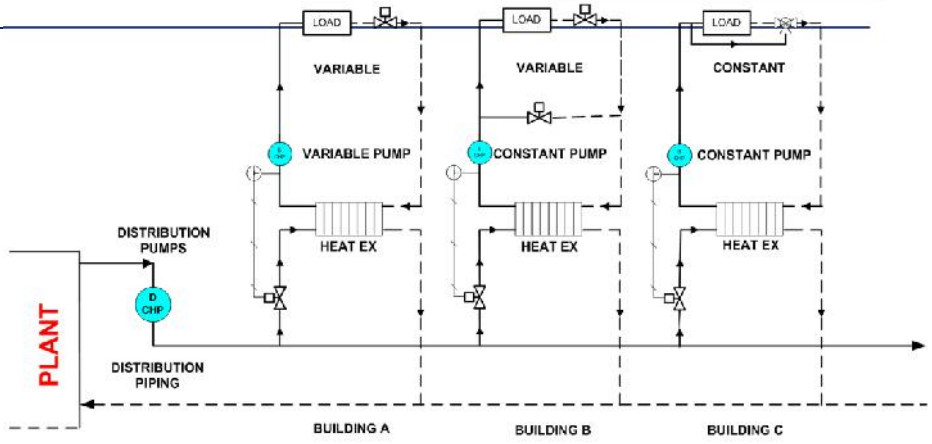


Chilled Water Distribution

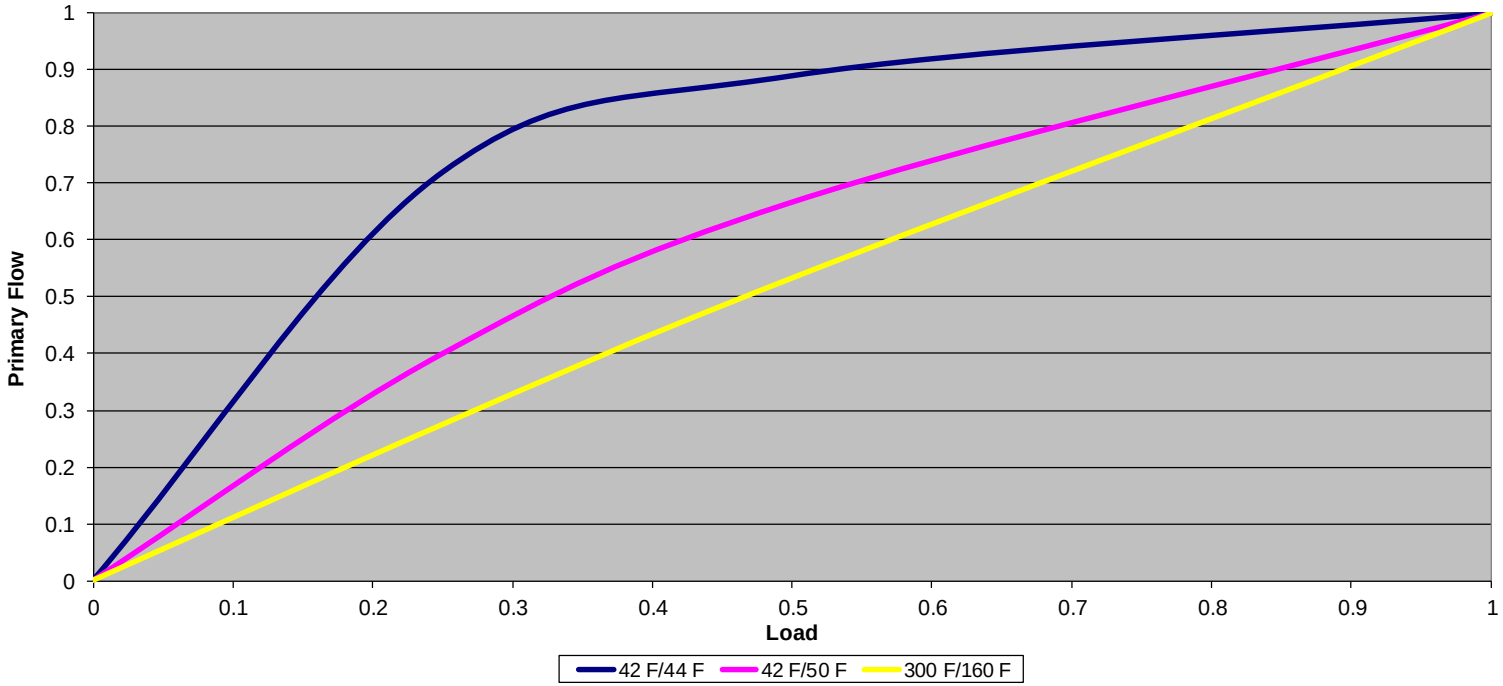
INTEGRAL PRIMARY-SECONDARY PIPING



HEAT EXCHANGER PRIMARY-SECONDARY PIPING

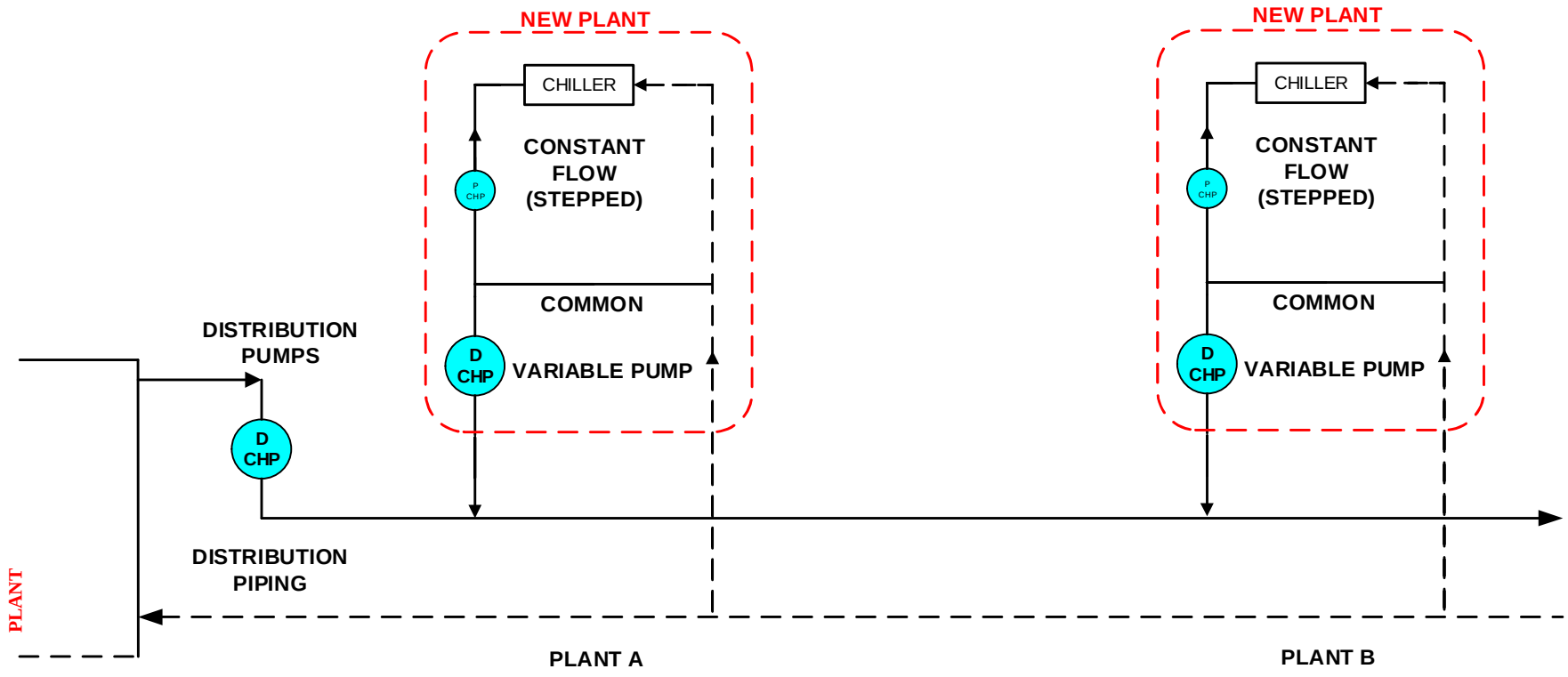


Primary System Flow vs. Load

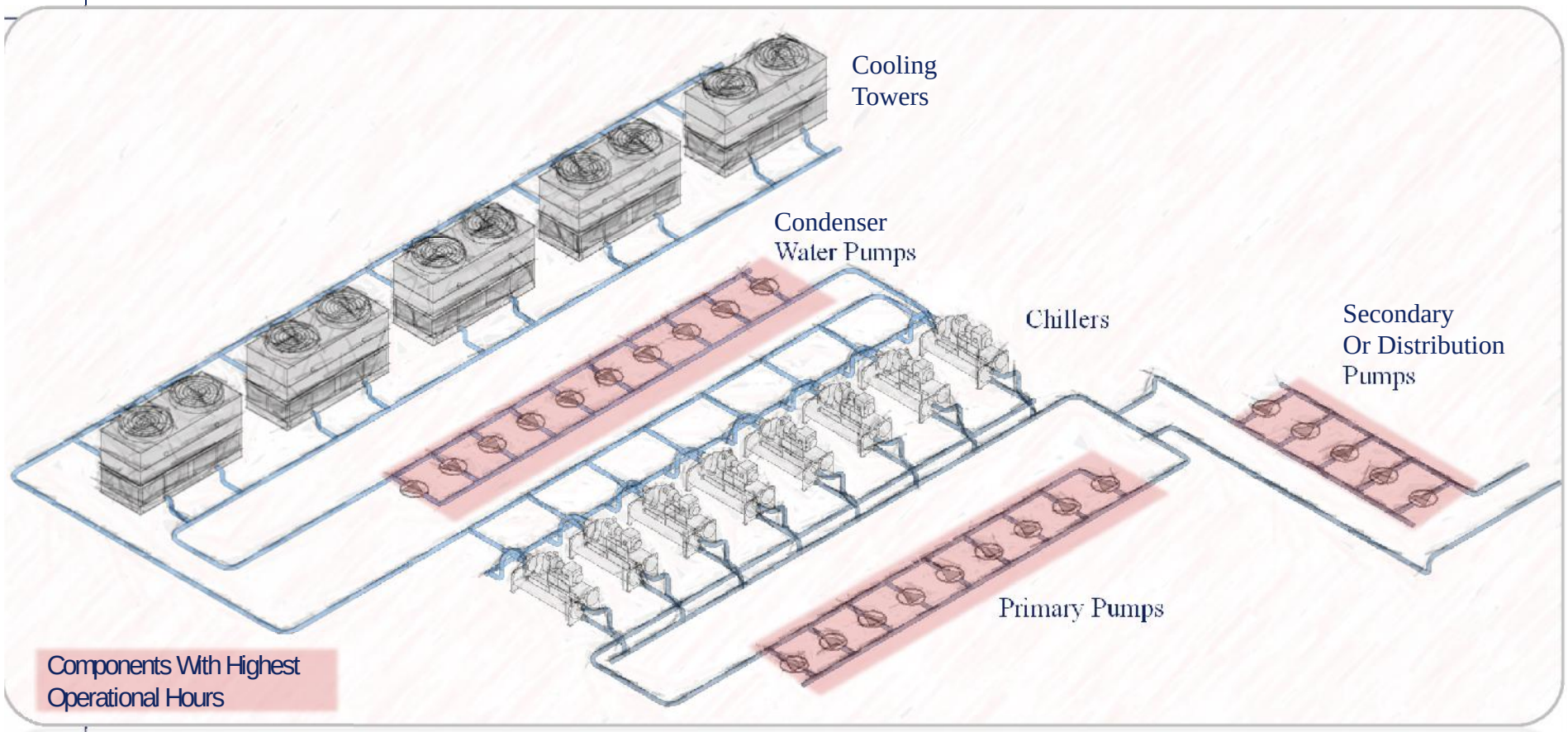


Integration of Future Cooling Plants

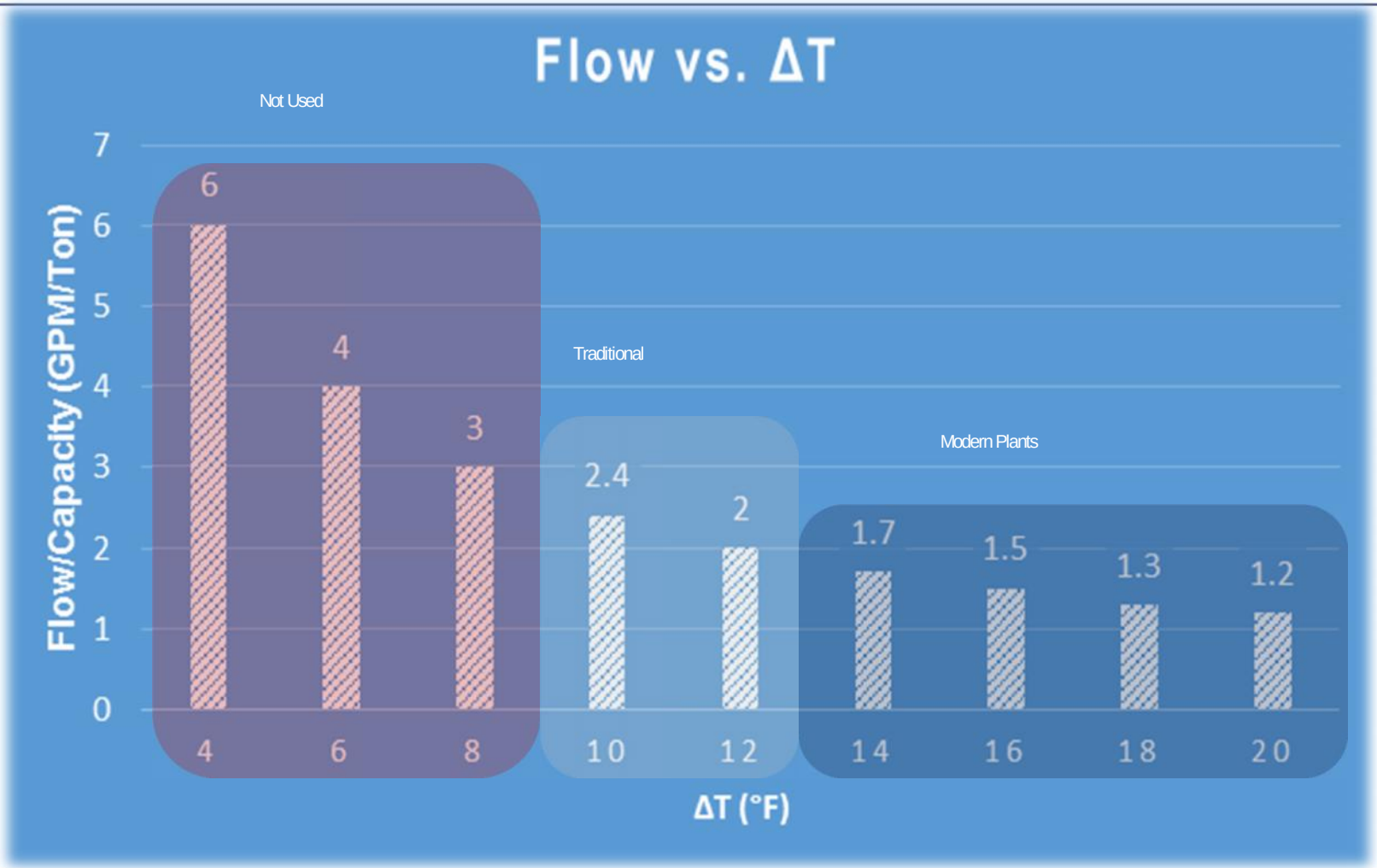
PRIMARY COOLING PLANT – FUTURE ADDITIONS/EXPANSIONS



Typical Central/District Cooling Plant



Central Plant Hydronic Flow

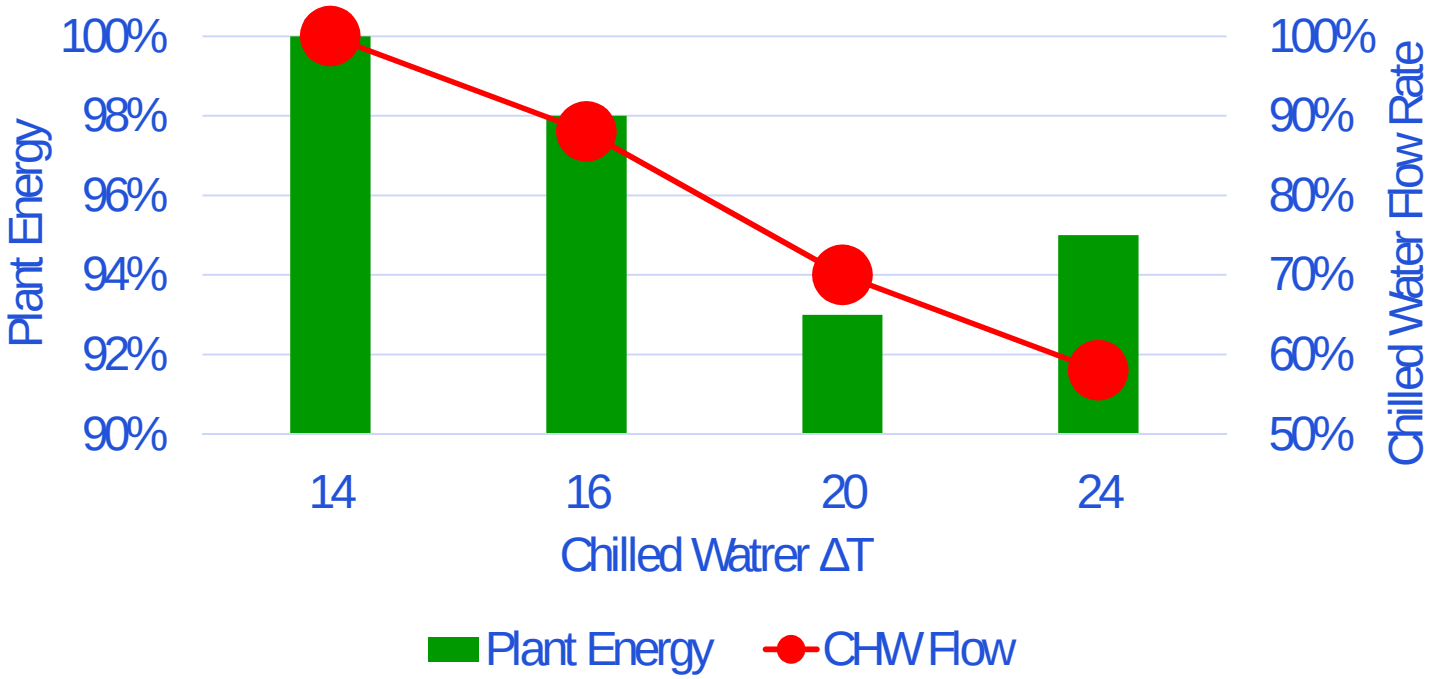


Comparative Plant Parameters – 800 Ton Capacity

	Traditional	Efficient	
Chilled Water Supply	44ºF	41ºF	
Cooling Coil WTR	10ºF (2.4 gpm/ton)	16ºF (1.5 gpm/ton)	37.6% Flow Reduction
Cooling Tower Range	10ºF (3.0 gpm/ton)	15ºF (2.0 gpm/ton)	33.3% Flow Reduction
Chiller Power	0.580 kw/ton	0.651 kw/ton	+0.071 kw/ton
Chilled Water Pump Power	0.065 kw/ton	0.020 kw/ton	-0.045 kw/ton
Cooling Tower Power	0.040 kw/ton	0.030 kw/ton	-0.010 kw/ton
Condenser Water Pump Power	0.054 kw/ton	0.019 kw/ton	-0.035 kw/ton
Plant Power	0.739 kw/ton	0.720 kw/ton	-0.019 kw/ton

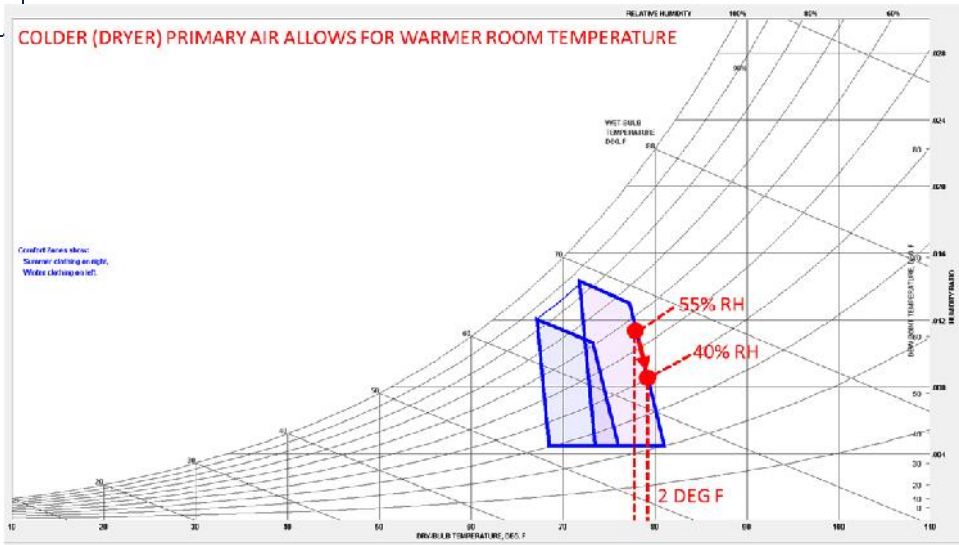


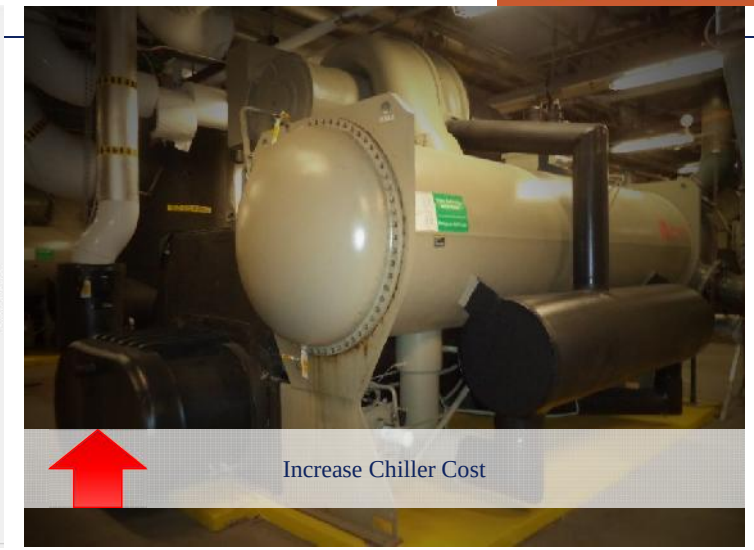

Plant Energy and Systems Chilled Water Flow





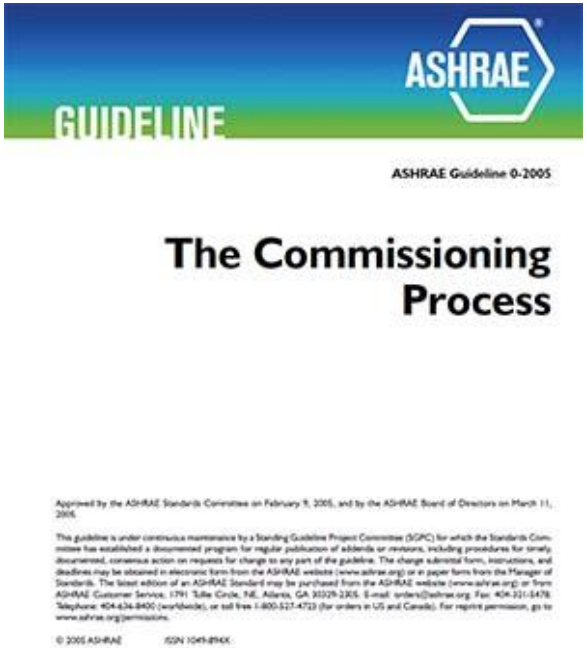

Overall System Impact – Low Temp Air





Cx Overview – New Construction

- Commissioning Overview
- Initial Commissioning Phase
  - Design and Contractor Construction Review
  - Commissioning Specifications
  - Commissioning Design Review Log
- Construction Phase Commissioning
  - Final Commissioning Plan and Schedule for Activities
  - Controls meetings
  - System Readiness Checklists (SRC)
  - Functional Performance Tests Prepared (FPT)
  - Construction Observation Site Visits
- Acceptance Phase Commissioning
  - Systems Functional Performance Testing
  - O&M and Systems Manuals
  - Training
  - Final Commissioning Report and Lessons Learned
- Open Forum
  - Q & A


ASHRAE

GUIDELINE

ASHRAE Guideline 0-2005

The Commissioning Process

Approved by the ASHRAE Standards Committee on February 9, 2005, and by the ASHRAE Board of Directors on March 11, 2005.

This guideline is under continuous maintenance by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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Commissioning Overview

Definition of Commissioning:

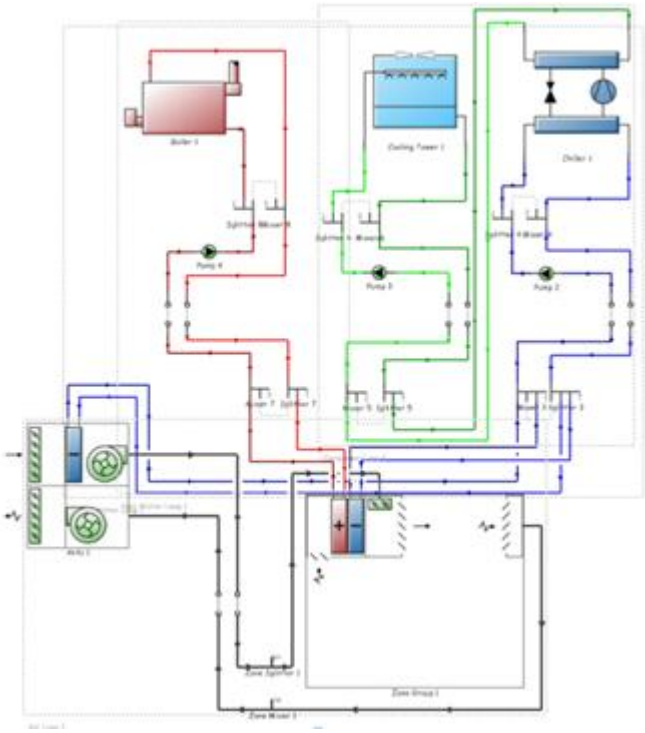
- **Commissioning is a programmed series of design and construction documentation and testing activities that are performed specifically to ensure that the finished facility operates as intended (defined by The Building Commissioning Handbook)**

Primary Goal of Commissioning:

- **Provide functional buildings and systems that meet both the design intent and the owner's operational needs**

Initial Commissioning Phase

- **Design Review:**
  - Not a peer review
  - Based on the BOD and OPR
  - Focus on Commissioning facilitation
  - Conformance with standard engineering and construction practices
- **Contractor Construction Plans Review**
  - General Contractor Construction Plans
  - Addresses Owner's Project Requirements (OPR)

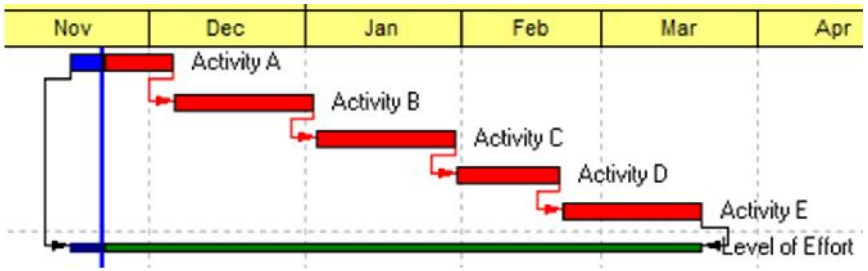


Initial Commissioning Phase

- Commissioning Specifications
  - Commissioning Tasks with specific Roles and Responsibilities outlined.
- Commissioning Design Review Log
  - Maintain a Commissioning Design Review Log to document commissioning issues identified during commissioning design reviews.

Construction Phase Commissioning

- Final Commissioning Plan
  - Update Preliminary Commissioning Plan
  - Sample System Readiness Checklists and Functional Test Plans
- Schedule for Activities
  - Schedule to show the duration, predecessors and successors for commissioning activities.
    - Integrated into master schedule
    - Virtually all tasks are dependent upon completion of start-up and system readiness for testing.



Construction Phase Commissioning

- **Submittal and Shop Drawing Review**
  - **Review of selected submittals and shop drawings to support commissioning process.**
    - **<u>Focus on commissionability</u>.**
  - **Allows for development of SRCs and FTPs.**
- **Controls Meetings**
  - **Meeting to review Controls Submittal**
  - **Verification of systems operation with Owner's requirements**

Construction Phase Commissioning

- **System Readiness Checklists (SRC)**
  - **Based on Design Documents and Submittals**
  - **Purpose is to: Confirm no more work will be performed and <u>Everything</u> is complete.**
- **Functional Performance Tests (FPT)**
  - **Occur After Completion of SRC**
  - **Dynamic Testing Under Load**
  - **Recommended Participation of Operating Staff**

Functional Performance Tests

- **Systems Functional Performance Testing**
  - **CxA to direct, facilitate, and document all FPT testing.**
  - **Performed by the contractors.**
  - **Functional Performance Testing will be completed prior to, or shortly after substantial completion of construction activities.**
  - **The goal is to have no construction activity related to a system after completion of the FPT**

Acceptance Phase Commissioning

- **Operation and Maintenance Manuals**
  - Review Operations and Maintenance Manuals submitted by contractors for general conformance with specifications and owner's requirements.
- **Training Plan Review**
  - Review contractor and manufacturer training plans and agendas for general conformance with specs & OPR.
    - Will focus on:
      - Review of system design, capacity, and equipment selection
      - Review of system operating sequences
      - Review of interconnection with other systems
      - Review of Emergency operating procedures
      - Evaluation forms

Acceptance Phase Commissioning

- **Final Commissioning Report**
- **Lessons Learned**
- **Project Closeout**

Primary Benefit of Cx; To the Owner and the Occupants

- **The non-Textbook answer**

- **You get what you want!**
- **You get a means and method to maintain what you have.**
- **Eliminate surprises when seasons changes or problems occur**

Central Plant Cx: The Best Bang for Your Buck

- **Value for time and money spent**

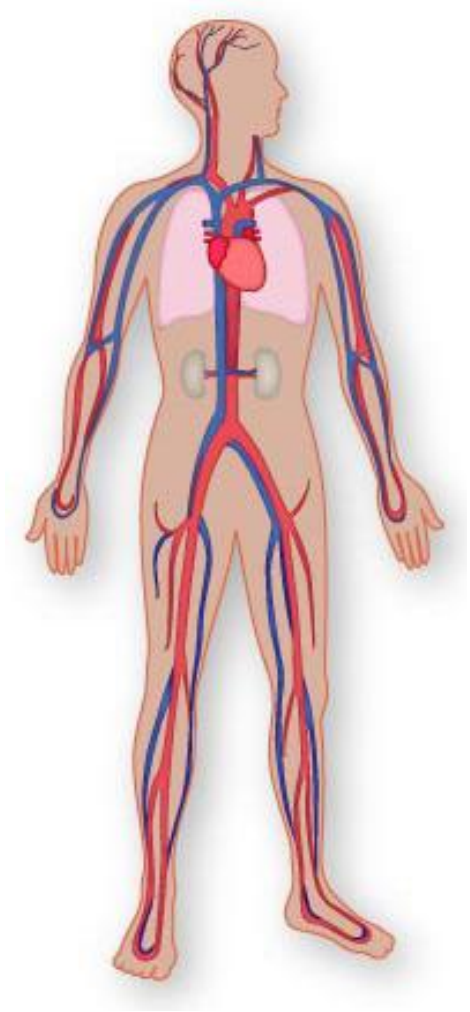
- **The Central plant consumes as much as half of you HVAC energy**
- **The central plant often has only 20 percent of the points in a building wide automation system**

Why is the Central Plant Often overlooked

- The “space” is visible and can be heard by occupants
- The larger pieces of equipment often come with start-up services
- How to test the central plant before the building is done

Central plant Cx overview & benefits: New construction

- Largest core energy use for your building
  - The heart of the living building
- If central plant is failing no other system can help
- Huge energy savings potential
- Easiest to commission ☺!



Tips & tricks to Cx a central plants without active loads

- Maybe not the easiest to commission …
- How do you test a heart without a body
- Focus on modular approach
  - Logic simulations
  - Monitoring verification
  - Fake “body”
  - Fake “treadmill”
- Define future tests or observation
  - No surprises!!!!!

Central plant Cx overview & benefits: Undergoing expansion

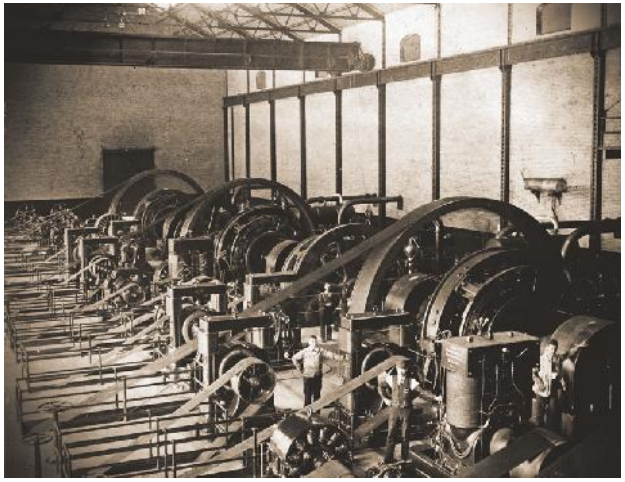
- Expanding your plant – Free EBCx
  - Well almost free
- You must test the complete system
- Again, modular approach
  - Test all new pieces
  - Test interconnection point
  - Test load shed and ramp up
  - Failure scenerios
- TAB scope for old and new!

Central Plant Cx overview & benefits: Undergoing expansion

- **What if I have two different generations of equipment and controls?**

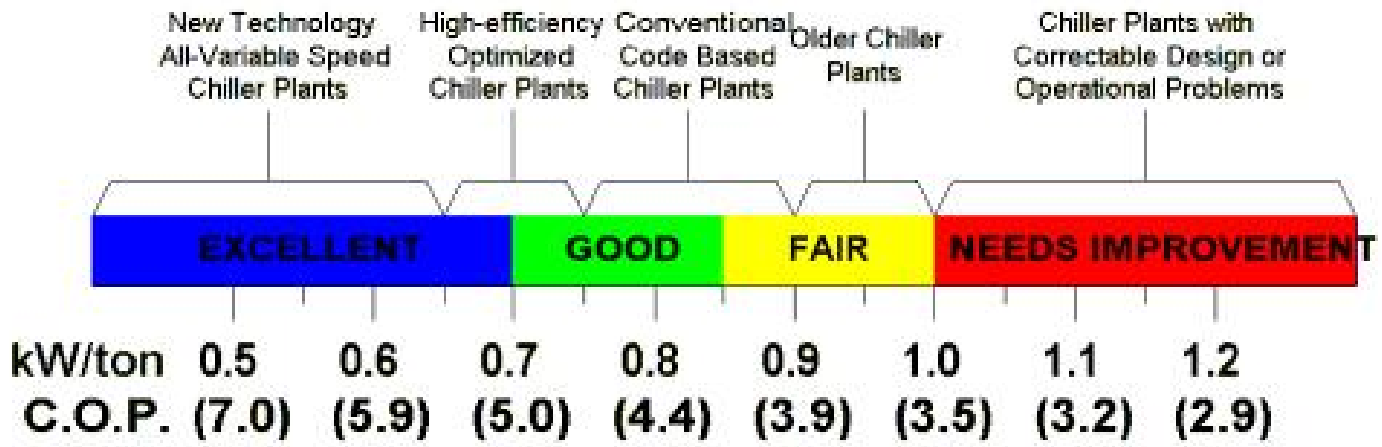
- **Focus on:**
  - **Life safety**
  - **Individual unit control**
  - **Downstream system feedback**

  - **Ask for an automation upgrade in the next capital plan!**



Central plant Cx overview & benefits: Existing system

- **Maybe your not adding anything but just want to be better?**

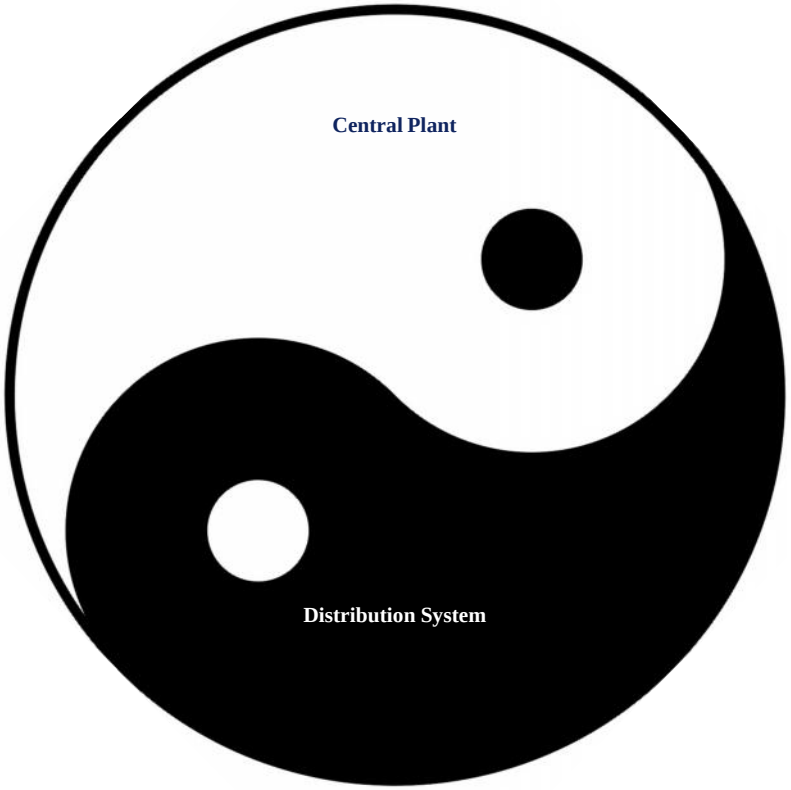


AVERAGE ANNUAL CHILLER PLANT EFFICIENCY IN KW/TON (C.O.P.)
(Input energy includes chillers, condenser pumps and tower fans)

Based on electrically driven centrifugal chiller plants in comfort conditioning applications with 42F (5.6C) nominal chilled water supply temperature and open cooling towers sized for 85F (29.4C) maximum entering condenser water temperature. Local Climate adjustment for North American climates is +/- 0.05 kW/ton

Central plant Cx overview & benefits: Existing system

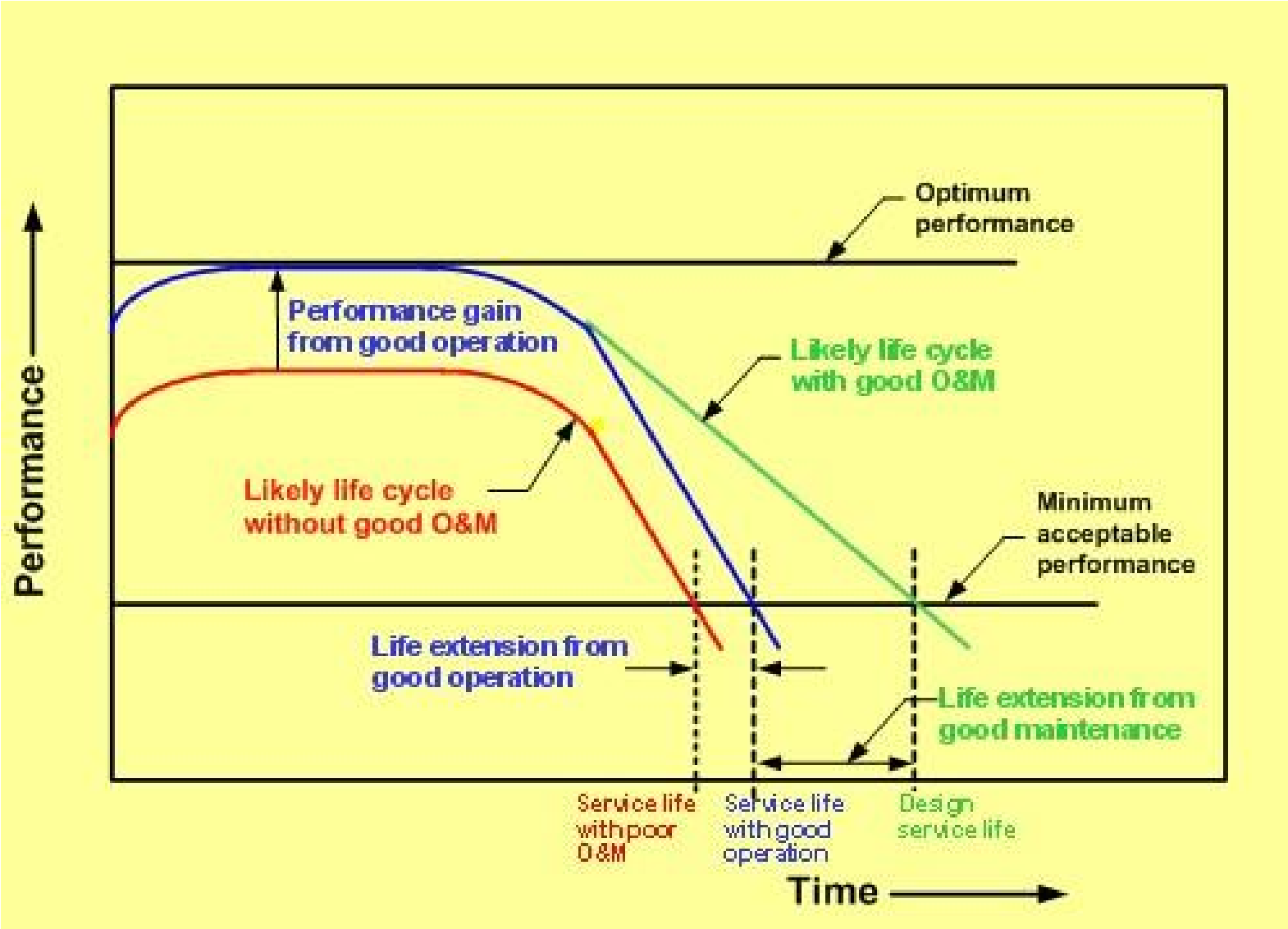
- Focus on all aspects of central plant
  - Pumping is 1st place to look
  - Part load operating strategy and control
  - Next look at the end use consumption
    - Delta T at each building – Anything stand out
    - Required supply condition at only one spot!
    - Steam: Check the return and traps



Automation & Monitoring to Run Your Building

- Automation is needed to run your building – step one
- Focus on system operations at turn-over
- What does the operator see?
  - Macro system graphics
  - Detailed components
  - Trend data
  - Prioritized alarms
- These are all needed to run a building

What the edge means to you – $ and time



Plant Case Review - McCormick Place


300-4,500 person Theaters


Nations Largest Convention Center

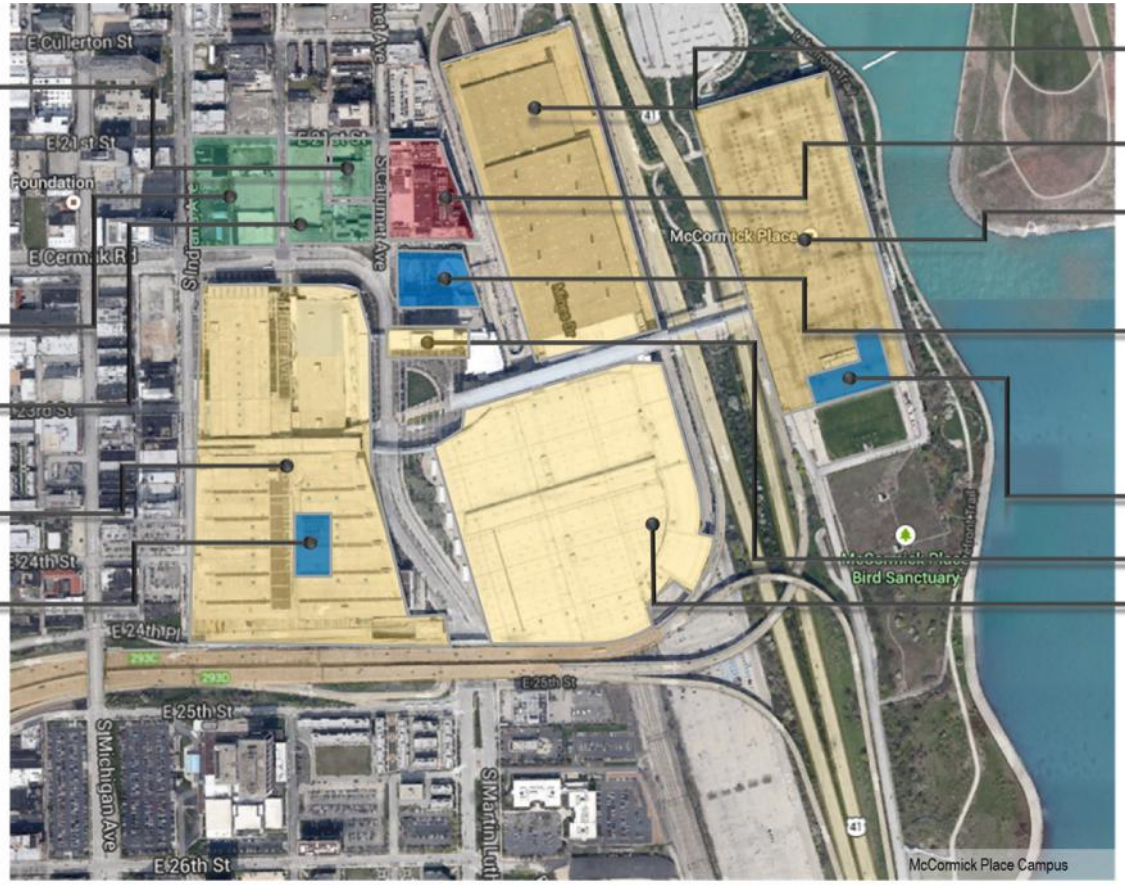

1,200 Room Hyatt Hotel


Multiple Ballrooms


600,000sf of Meeting Rooms


40,000sf Grand Concourse

Explore the Campus



Plant Exploration

West Plant

- 8,400 Tons Capacity
- Low Temperature (27°F) LWT
- Newest Plant

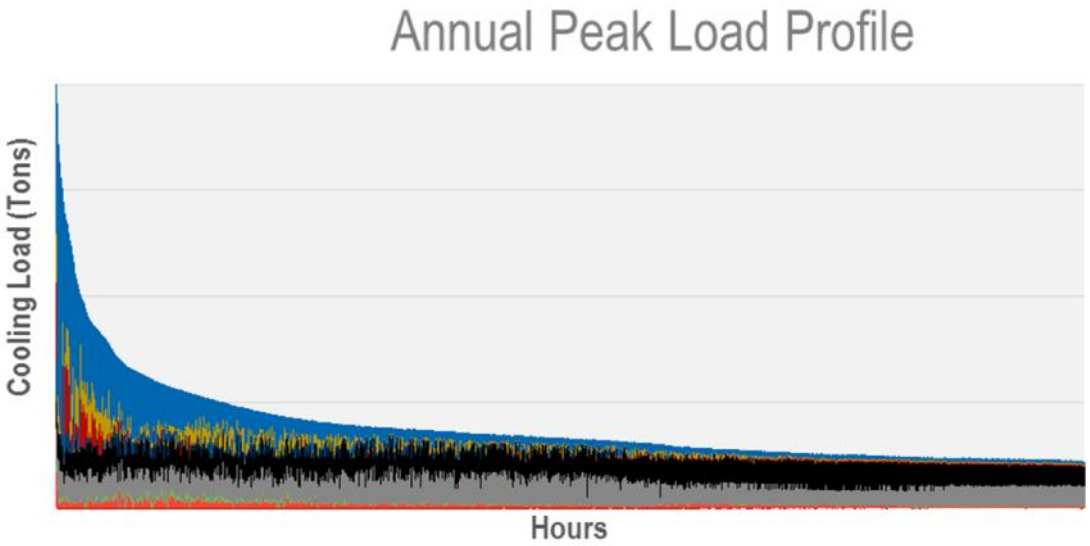
Energy Center

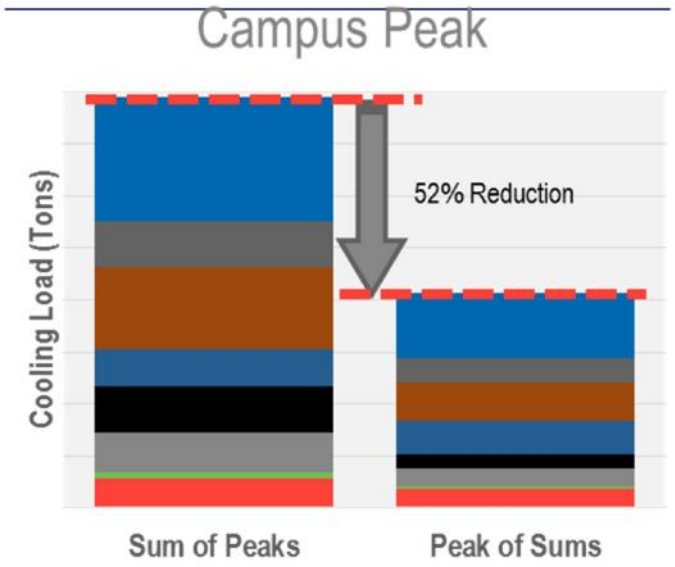
- (3) Ammonia Screw Compressors coupled with turbine generators
- 20,000 Tons Capacity
- 8.5million gallon TES Tank, 133,000 Ton-hrs
- 80,000pph HRSG

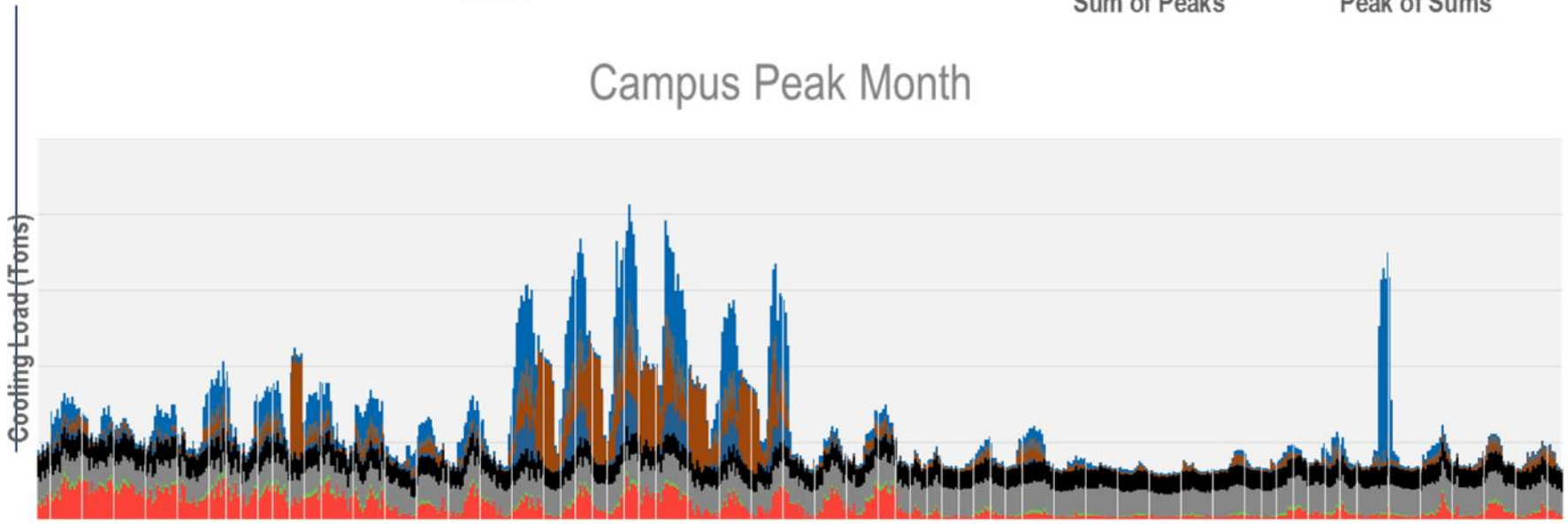
East Plant

- 10,000 Tons Capacity
- Connected to Lake Michigan
- Oldest Plant

Cooling Load







Design Parameters

Chilled Water

- 27°F Primary Chilled Water Supply
- 56°F Chilled Water Return
- 22% Ethylene Glycol
- Over 100 miles of Hydronic Piping

Building Distribution

- Decoupling with Heat Exchangers
- 34°F Secondary Chilled Water Supply
- 58°F Chilled Water Return

Air Distribution

- 45°F Supply Air
- Induction diffusers
- Over 50 miles of Duct Distribution

The Final Destination

1 Million CFM of Airflow Reduced

Over $3 Million of Equipment Savings

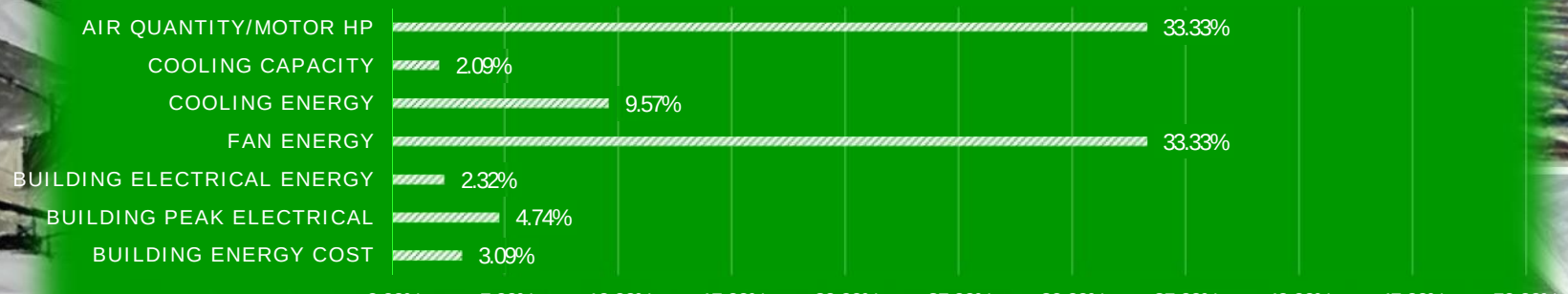
Reduced Maintenance

Reduced flow by over 30,000 GPM

Increased Efficiency

50% Reduction in Piping

System Savings



Thank You

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SISTEMAS DE ÁGUA GELADA

PROGRAMA BRASILEIRO DE ELIMINAÇÃO DOS HCFCs
Projeto para o Gerenciamento de Chillers

Apoio Institucional:

ASHRAE Brasil Chapter

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GREEN BUILDING COUNCIL BRASIL
GBC BRASIL

BCxA Building Commissioning Association
BRASIL CHAPTER

SINDRATAR-RJ

Execução

SOMAR

Implementação

PNUD
Empoderando vidas. Fortalecendo nações.

Realização

Ministério do Meio Ambiente

GOVERNO FEDERAL
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