



5 Energy Treasure Hunts for Chilled Water

Presented by Mike Flaherty, *tekWorx*

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All materials presented are educational. Each system is unique and must be evaluated on its own merits.



5 Energy Treasure Hunts for Chilled Water

Introduction by Rod Smith, Publisher,
Chiller & Cooling Best Practices[®] Magazine

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About the Speaker



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Chiller and Cooling Best Practices



5 Ways the *Energy Treasure Hunt* can Reduce Chilled Water System Cost



Presented by

Mike Flaherty

General Manager – tekWorx, LLC

Energy Treasure Hunt (ETH) Outline

- Energy Treasure Hunt (ETH) Introduction
 - Process / Goals / Tips /
 - Schedule / Reporting
- Chilled Water System Treasures
 - Mechanical
 - Controls
 - Operations
- Actual ETH Results: Ireland Pharma Plant

What is an Energy Treasure Hunt?



Energy Treasure Hunt Opportunities

Where are the Opportunities

Electricity	lighting, motors, VFD, PF, generation, distribution, rate, load sharing
Natural gas	hedging, boilers, heating, test
Water	treatment, processing, sewer
Compressed air	pressure, leaks, dryers, demand
Steam	Condensate, leaks, traps, -pre heat, insulation, blowdown chemistry
Chilled water	Generation, insulation, distribution, chemistry, towers, demand, setpoint
Heat recovery	Processes, testing

Measure the Waste - Examples

- Lighting
 - Foot-candles, spacing, height of fixture, wattage of lamp, technology. Hours of operation
- Motors
 - nameplate data – HP, volts, amps, phase, efficiency. Measured amps where needed. Hours of operation
- HVAC
 - Space temperature, type, economizer, minimum outside air? Hours of operation

Energy Treasure Hunt Participants

- Site Staff:

- Operations
- Maintenance
- Quality



- Subject matter experts:

- Corporate staff: Regulatory/ Energy
- Key Vendors: equipment, systems
- Experienced (local) contractors



Energy Treasure Hunt Schedule

Goal: study site in active and downtime conditions

Sunday 8:00 to 5:00 – Non Operation

It's not a Witch Hunt....

... it's a Treasure Hunt



ETH Teams Assembled by Category

Team 1 - Lighting



Team 2 – Motors /
Electrical Distribution



Team 3 – Steam Dist



Team 4 – Bldg 800



Team 5 – Bldg 818



Facilitator/ Site Leader



Team 6 – Bldgs 820,
819, 814, 815, 821



Team 7 – Bldg 80Y



Team 8 – Bldgs
80W,80T,80M,80N



Team 9- Bldgs
80,80L,80K



Team 10- Bldgs 801,802,803



Energy Treasure Hunt Schedule

Goal: study site in active and downtime conditions

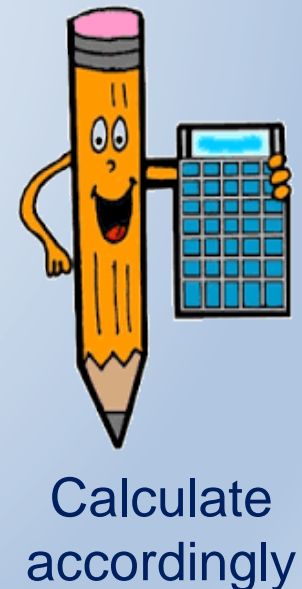
Sunday 8:00 to 5:00 – Non Operation

- Site orientation / safety rules / limits
- ETH Process & Tips
 - Goals: 2 prospects / team member
 - Rely on common sense experience.
 - Go and see, don't assume.
 - Five “Whys?” to get to the root cause
- Teams investigate assigned areas.
- Group summary meeting / progress report

Energy Treasure Hunt Schedule

Monday 8:00 to 5:00 – Full Operation

- Drill down on details of top 3 prospects:
 - Implementation, requirements, limitations
 - Practical issues and assumptions
- Initial calculations on savings and cost
 - Actual data vs. required assumptions.
 - Be practical: estimate +/- 25%



Energy Treasure Hunt Schedule

Gensuite® ETH Prospector: Demo, Demonstration Site >> ETH Prospector - Microsoft Internet Explorer provided by Merck & Co., Inc

Address: https://eth.gensuite.com/home/#/nth/eth/index.cfm?Business=economagination%20Treasure%20Hunts&Orname=Demo&Location=Demonstration%20Site&gso=1

McAfee SiteAdvisor

Gensuite Recent Applications Suite Help Me!

ETH Prospector
Click to return to Gensuite Home...

Tom Pagliuco
Demonstration Site / Demo
Event: ETH 2010

ecomagination

Setup Wizard Object Inventory Reports Report-Outs Quick Start New Prospect

Site-Wide Performance Summary

Team:

ETH Prospects Generated	81
ETH Prospects Quantified	55
Total Quantified Energy Reduction (MMBtu)	48,936
Total Quantified CO ₂ Reduction (MT CO ₂)	9,429
Total Quantified Cost Savings (\$)	2,744,648

Physical Areas	42
Functional Orgs / Depts	8
Processes	4
Products	1
# Teams	9

Team Summary

My ETH Task List

Team Name	Prospects	Energy Reduction	CO ₂ Reduction	Cost Savings
Boilers & Steam	0	0	0	0
Building Management	4	1,309	95	25,576
Conference Rooms	2	2	1	142
Electricity	13	1,200	248	69,873
HVAC	6	3,662	758	210,310
Lighting	23	4,428	916	282,477
Motors	27	34,958	7,232	2,110,120
Power Plant	3	3,375	179	47,350
Water Management	3	0	0	0

Site-Wide Energy Baseline

Energy Usage by MMBtu
Note: Total excludes Compressed Air

Resource	Annualized Usage (MMBtu)
A Electricity Usage	57,904
B Natural Gas Usage	30,005
C Steam	172,838

Reduction Prospects

Prospects by Resource (top 5)

Resource	# Prospects
A Electricity	85
B Water	13
C Natural Gas	10
D Compressed Air	8
E Steam	6

Prospect Comparisons

Energy Savings by MMBtu (top 5)

Prospects	Energy Savings (MMBtu)
A Add VFDs to re-pump stati...	12,042
B Motors test	11,540
C A/C Unit Efficiency	2,863
D Motors in Bldg A	1,883
E Lighting in the Record Ro...	1,842

Done

start

Microsoft PowerPoint ... Gensuite® ETH Prosp...


Search Desktop

100%

10:27 AM Thursday 12/2/2010

ETH Chilled Water Opportunities

Common sense / Obvious / Time / Cost / ROI

- 
1. Maintenance & Equipment
 2. Operating Methods
 3. Breaking Old Habits
 4. Mechanical Design / Hydronics
 5. Control System / Strategy

Complex / Longer term / Higher cost / ROI

Energy Treasure Hunt Prospects

Obvious, Common Sense “Low Hanging Fruit”

- Maintenance & Equipment
 - Old / inefficient / failed equipment.
 - Broken / non-operating valves.
 - Instrument calibration.
 - Missing insulation.
 - Clogged filters.
 - Dirty clogged coils / chiller tubes / CT fill.
 - Loose CT fan belts.



ETH Prospects: Operating Methods

- Operating Methods



ARE YOU KIDDING ME



ETH Prospects: Piping/Hydronics

- Piping/Hydronics:
 - Excess CHW flow wastes energy
 - Wastes pump energy
 - Degrades system differential temperature - ΔT
 - Requires extra chiller sets (chiller/pumps/fan.)
 - Sources
 - Open or uncontrolled bypass/de-coupler.
 - Three-way valves
 - Improper valve operation/installation
 - Flow thru non-operating chillers.

1 Cause: Mechanical system design

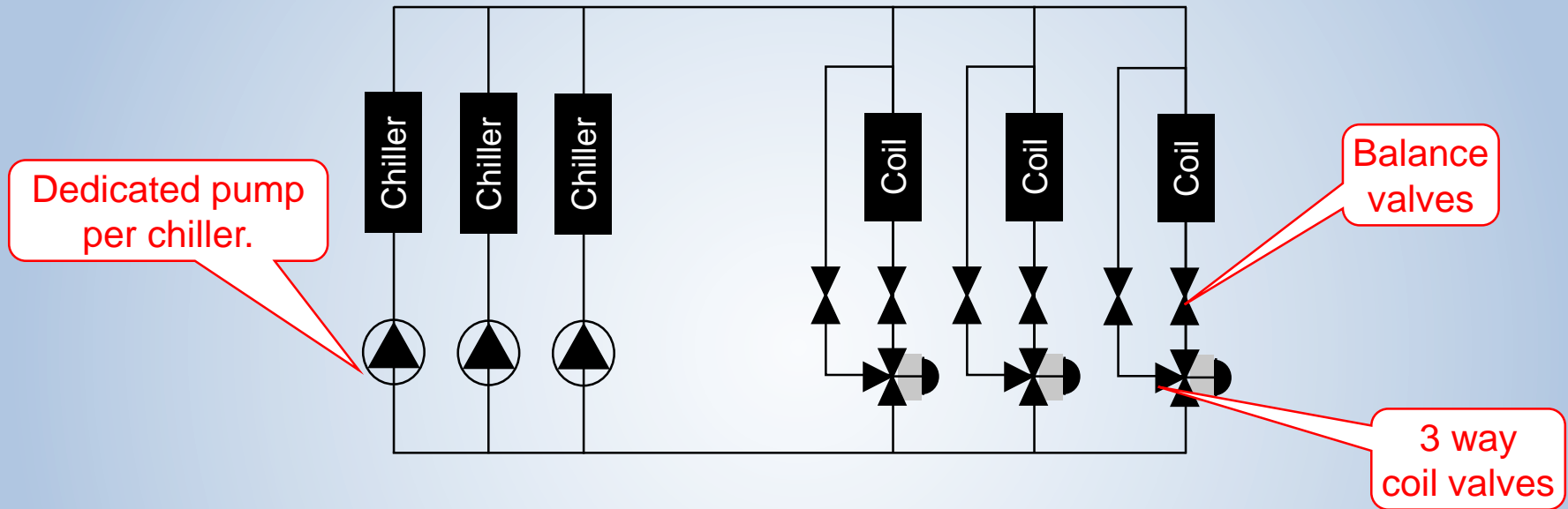
ETH Prospects: Mechanical Design

- Outdated or Inefficient Design and Practices
 - Constant speed/volume w/ 3 way valves (CV/3)
 - Primary /secondary with de-coupler (P/S)
 - Oversized Equipment / Capacity
 - Duty/ standby pump operation
 - Free cooling aka “Economizing”



ETH Prospect: Outdated System Design

Constant Volume – 3 way valve design

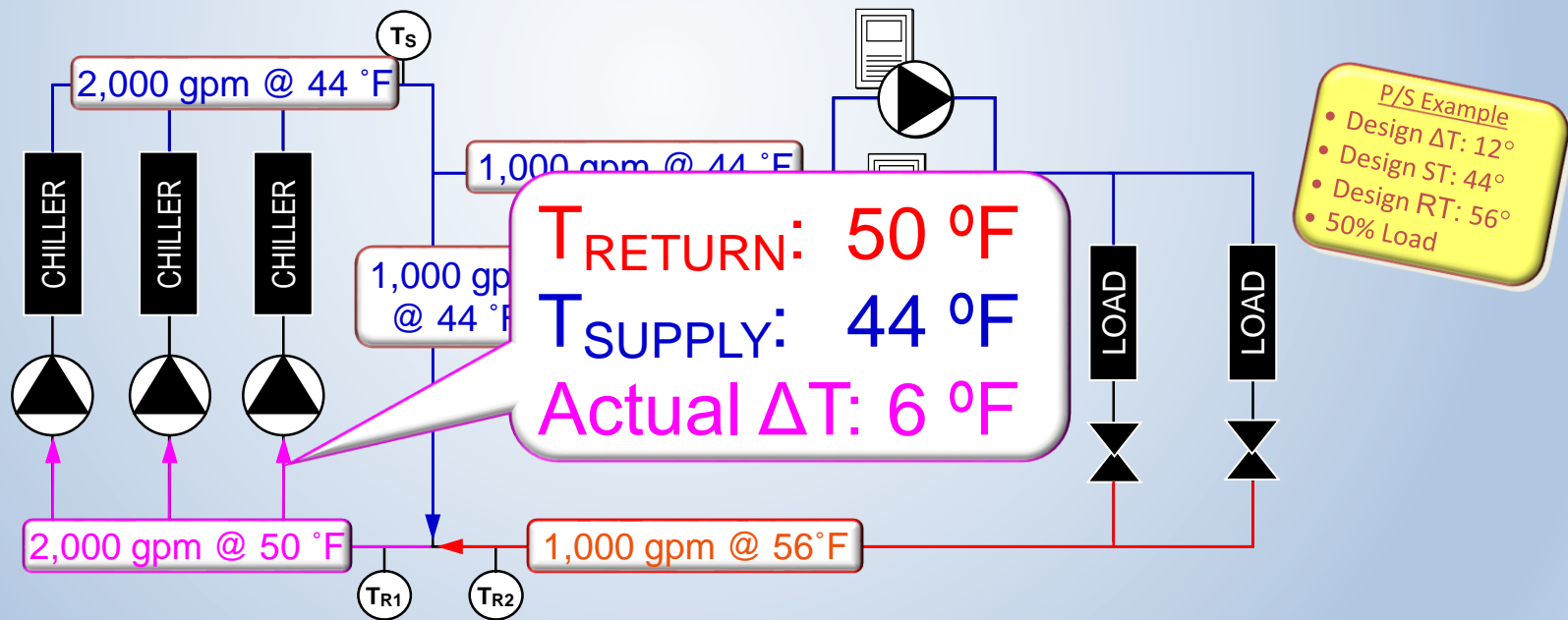


- Limited ability to modulate plant operation.
- Constant system flow regardless of load.
- Chiller staging often requires manual re-balancing so chillers often run continuously.

ETH Prospect: Outdated System Design

Primary/Secondary System: Excess Flow/ Low ΔT

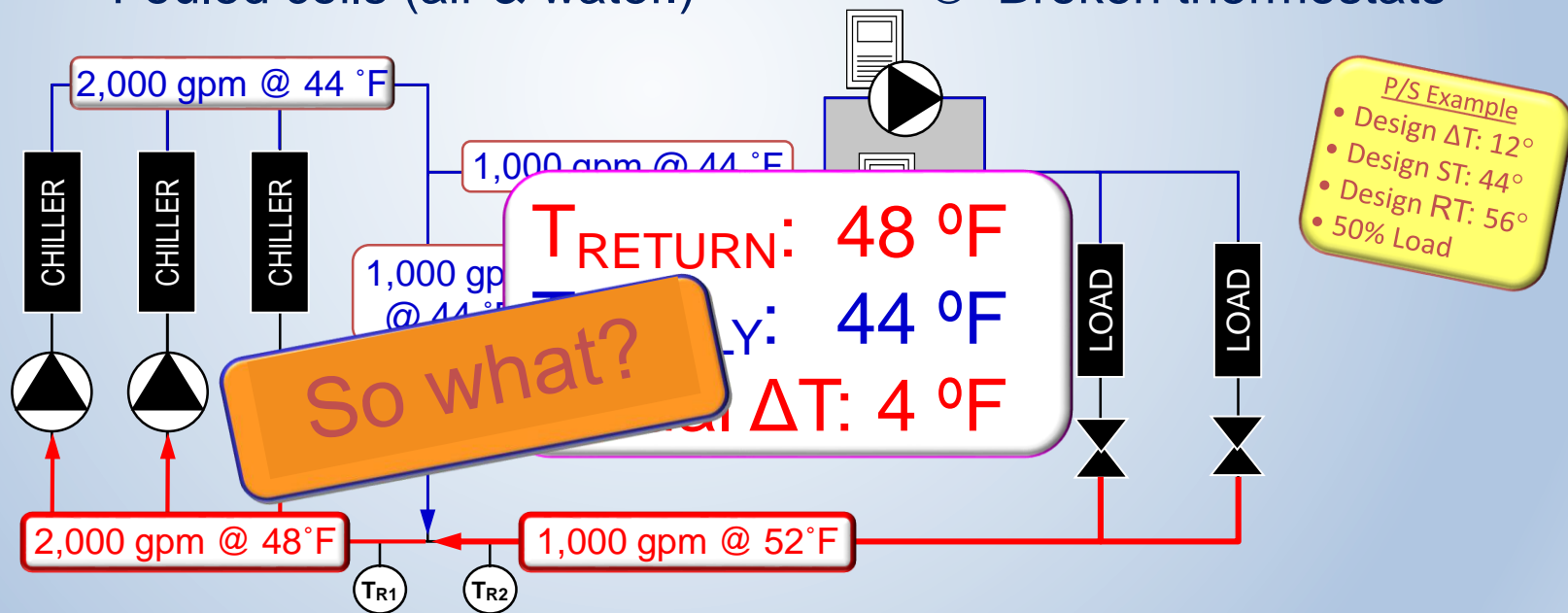
- Chilled water bypassed through decoupler line and blends with warm return water.



ETH Prospect: Outdated System Design

Primary/Secondary System: Excess Flow/ Low ΔT

- Chilled water bypassed through decoupler line and blends with warm return water.
- Equipment/conditions prevent proper heat transfer.
 - Leaking / low quality control valves \otimes Undersized coils
 - Fouled coils (air & water.) \otimes Broken thermostats



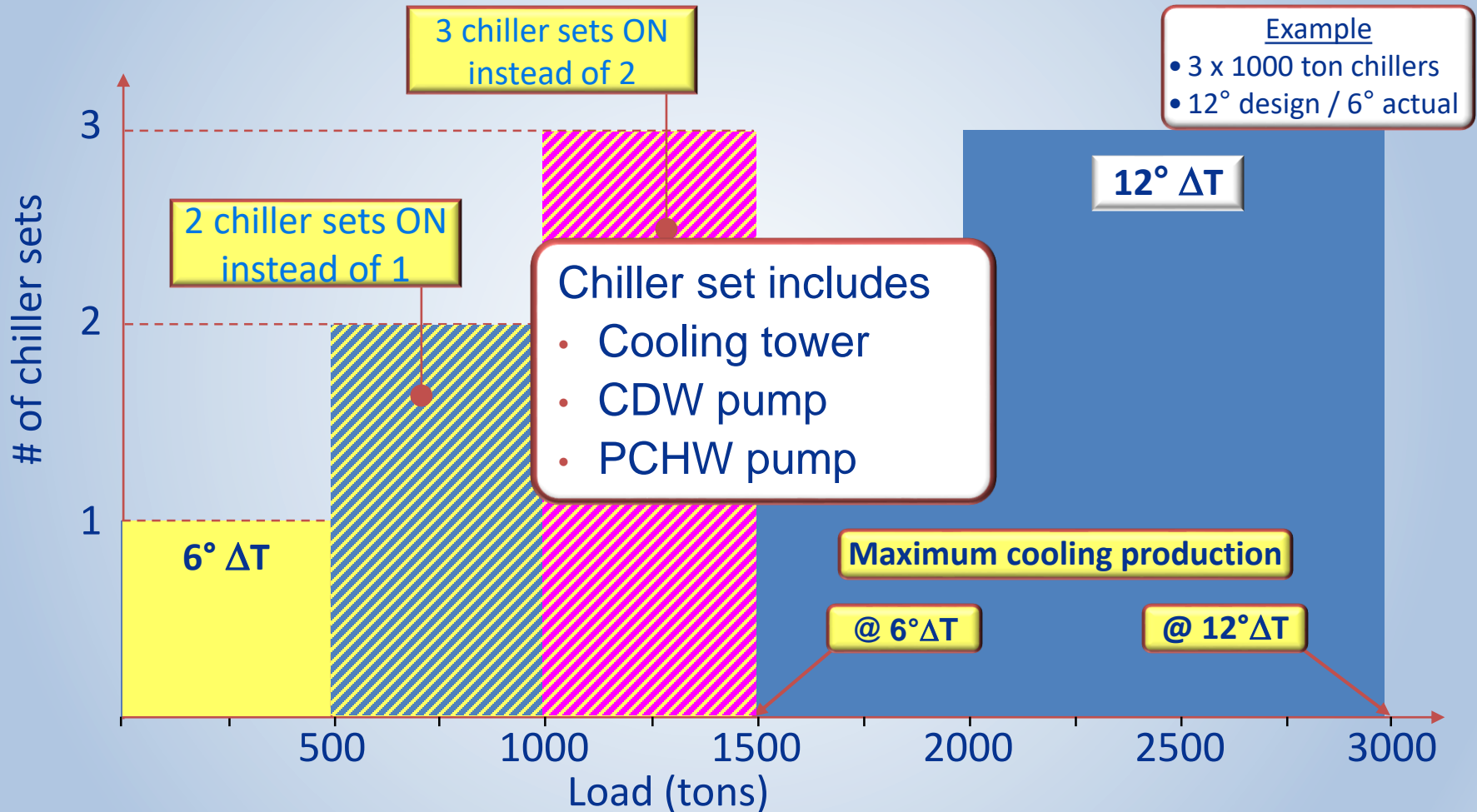
ETH Prospect: Outdated Mechanical Design

ΔT Effect on Pumping Energy

- ✓ CHW flow (gpm/ton) = $24 / \Delta T$ ($^{\circ}\text{F}$)
 - 12 $^{\circ}\text{F}$ Design $\Delta T \Rightarrow 2$ gpm/ton
 - 6 $^{\circ}\text{F}$ Actual $\Delta T \Rightarrow 4$ gpm/ton
- ✓ Affinity law: Pump power proportional to flow³.
 - 12 $^{\circ}\text{F}$ Design $\Delta T \Rightarrow 2$ gpm/ton $\Rightarrow n$ kW
 - 6 $^{\circ}\text{F}$ Actual $\Delta T \Rightarrow 4$ gpm/ton $\Rightarrow 8n$ kW
- ✓ $\frac{1}{2} \Delta T \Rightarrow 8$ x pump power

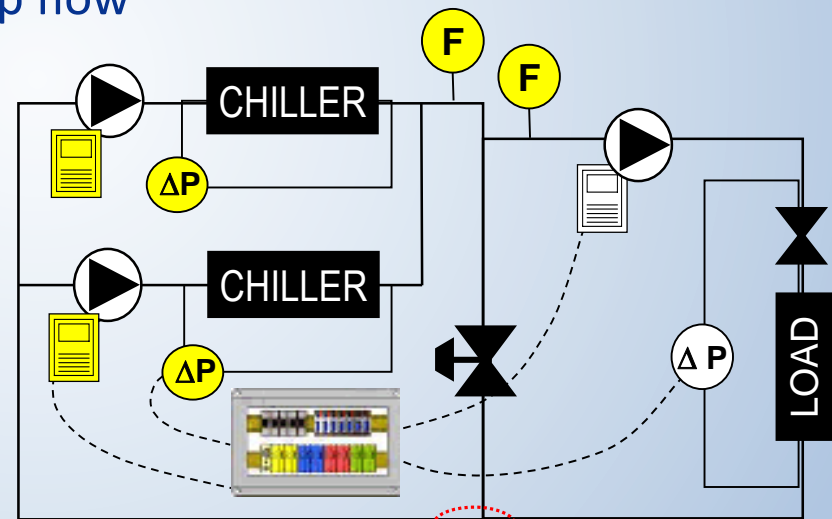
Primary/Secondary System with Low ΔT

Effect on Chiller Loading and Capacity



ETH Prospect: Integrated Primary/Secondary[®]

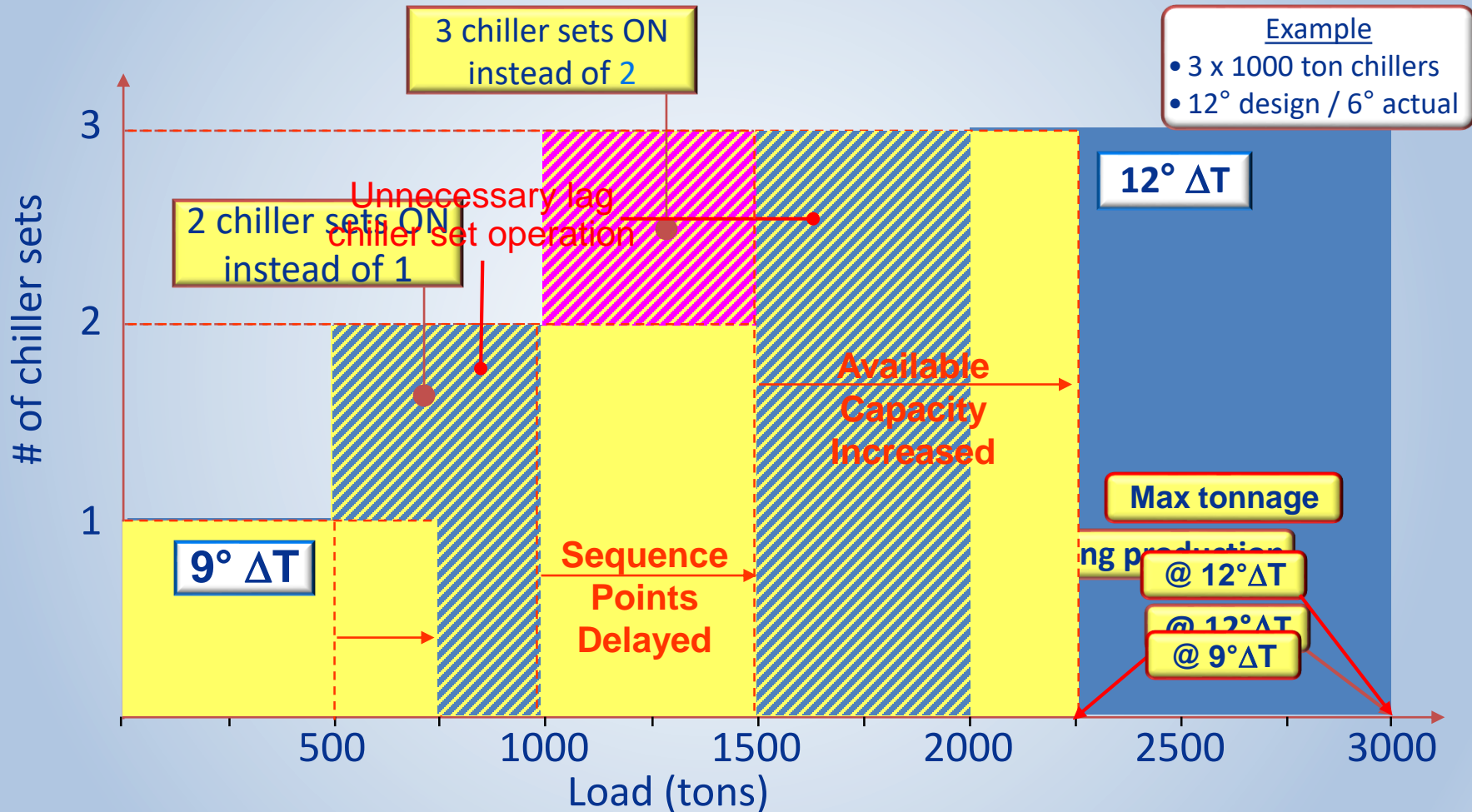
- Goal: Minimize bypass flow, improve system control.
- Standard solution: control valve to eliminate bypass flow.
- Valve installation may require shutdown.
- Alternate Solution if not possible:
 - Match primary & secondary loop flow to minimize bypass flow.
 - ✓ VFDs on primary pumps.
 - ✓ DPTs for evaporator flow (limited straight pipe)
 - ✓ PLC for control logic and optimization algorithms.



Reduce flow & blending,
increase ΔT

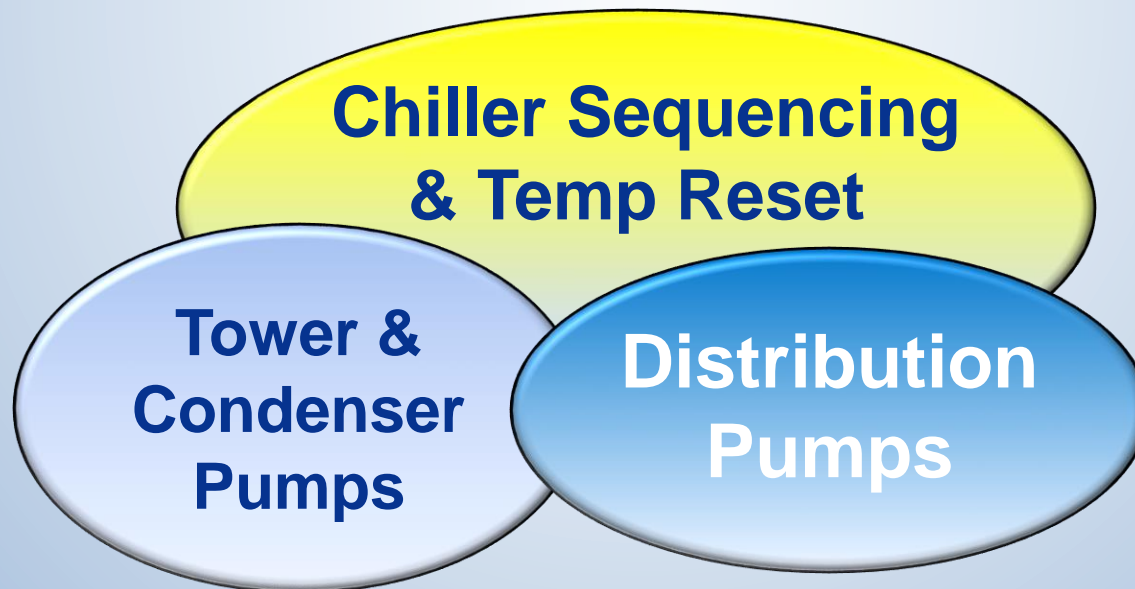
Primary/Secondary System with Low ΔT

3° ΔT Effect on Chiller Loading and Capacity



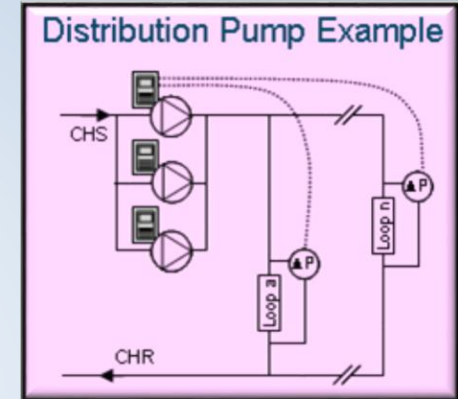
ETH Prospect: Control Strategy

- ~~Energy Coach~~ make enough at the lowest kW per ton day.
- Algorithms utilize real-time values of variables that affect both operation and efficiency: flow, ΔT , DP, kW, etc.
- Automatic, real-time adjustments to optimize kW per ton.



ETH Prospect: Adaptive Pump Control

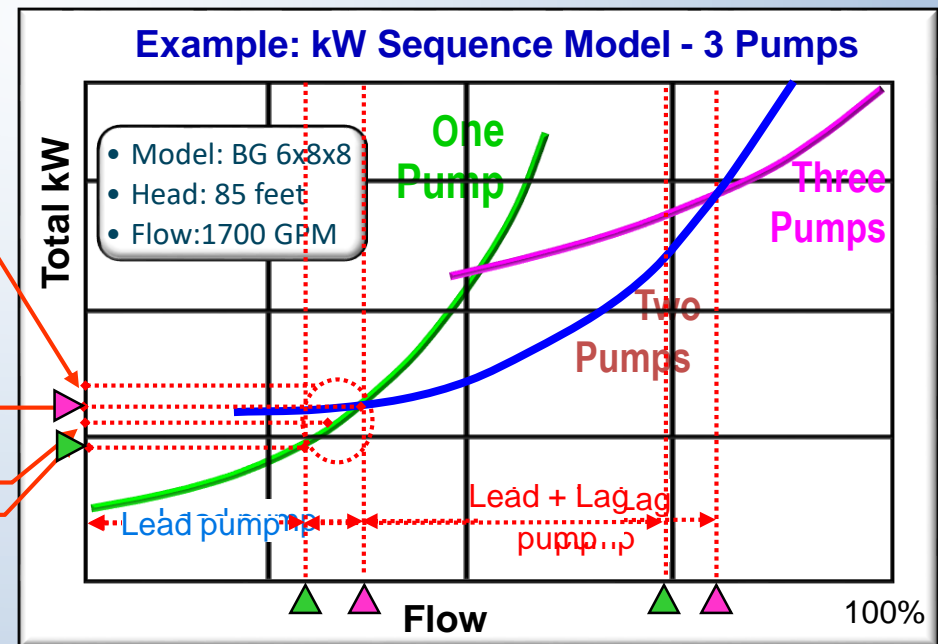
- Pump speed regulated to demand (remote DP.)
- # of pumps to run for lowest pump power?
- *Pump kW Sequence Model* – based on specific hydronic system and affinity laws.
- Adaptive algorithm auto resets setpoint to minimize pump power.



kW evaluated after each lag pump sequence operation

ON setpoint for 1st sequence operation using model

ON setpoint for next operation using adaptive algorithm



Recent Energy Treasure Hunt Example

Pharma manufacturing site - Ireland

- 2 x ~ 500 ton CHW plants – not validated
- Prospects Identified were “usual suspects”
 - No free cooling
 - Inefficient chiller for a once/month operation.
 - CHW temp setpoints lower than required.
 - Frequent (ineffective) manual override.
 - Duty / standby constant speed pump sets with throttling valves

Recent Energy Treasure Hunt Example

Pharma manufacturing site - Ireland

- Recommended measures
 - Add free cooling HX, use below $\sim 50^{\circ}\text{F}$ OAT
 - Use more efficient chiller for the monthly operation.
 - Raise CHW setpoints though “trial & error”
 - Reduce manual override:
 - Short term: guidelines procedures
 - Longer term: fully automated adaptive control.

Recent Energy Treasure Hunt Experience

Pharma manufacturing site - Ireland

- Recommended CHW measures
 - VFDs on duty/standby constant speed pump sets:
 - one pump at 100% speed vs. two pumps at 50% speed.
 - Savings calculations using affinity laws:
 - 100% speed = 24 kW (design)
 - 50% speed = $50\% ^3$ power = 12.5% of design = 3 kW/pump
 - 2 pumps x 3 kW/pump = 6 kW total/pump set
 - 6 kW after vs. 24 kW before = 18 kW / 75% reduction.
 - 18 kW x 8760 hours x \$0.11 /kwh = \$17,344 annual savings !!

Recent Energy Treasure Hunt Experience

Pharma manufacturing site - Ireland

- Energy Treasure Hunt Overall results:
 - Identified 20%+ total site spend reduction
 - Average overall payback: 1.8 years

Energy Treasure Hunt

Resources and Reference:

www.energystar.gov/treasurehunt

Thanks to Bruce Bremer – Bremer Energy

www.bremerenergy.com

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