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5 Energy Treasure Hunts for Chilled Water

Presented by Mike Flaherty, *tekWorx*

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

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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

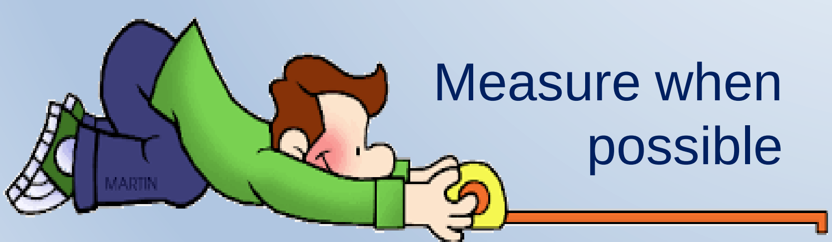
Sunday 8:00 to 5:00 – Non Operation

- 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

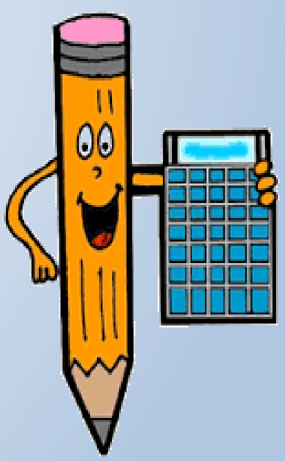
Monday 8:00 to 5:00 – Full Operation

- 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%



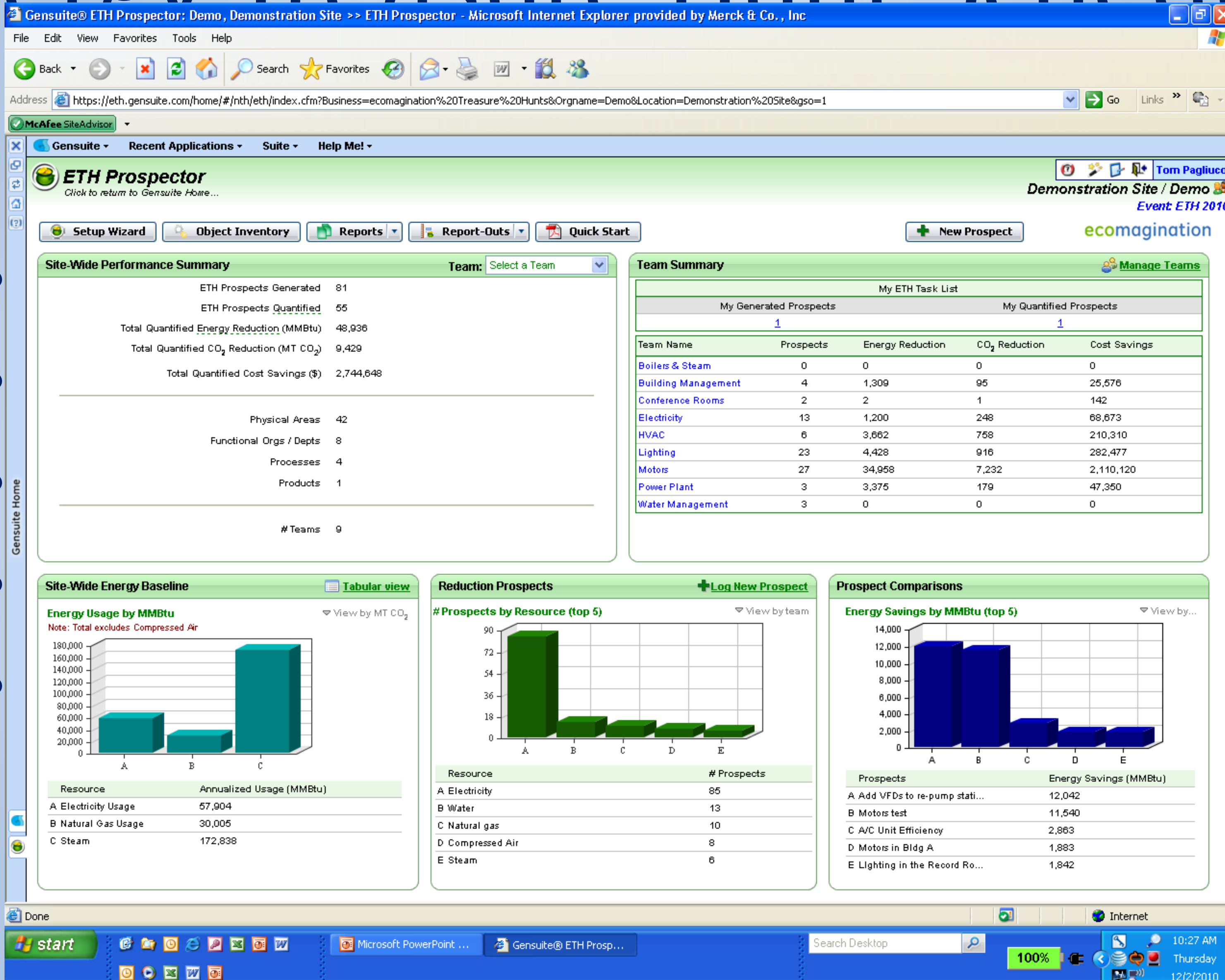
Measure when possible

Assume as required



Calculate accordingly

Energy Treasure Hunt Schedule



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

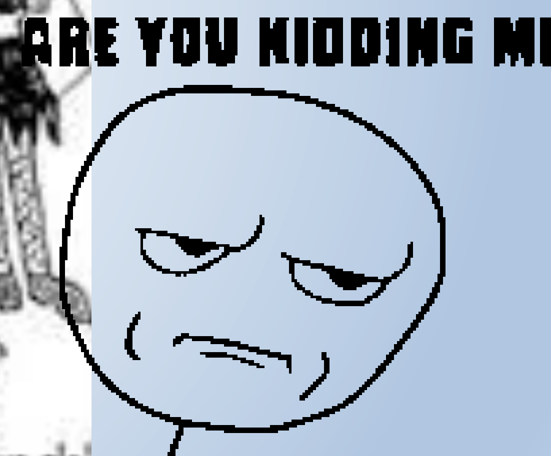
Energy Treasure Hunt Prospects

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



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.

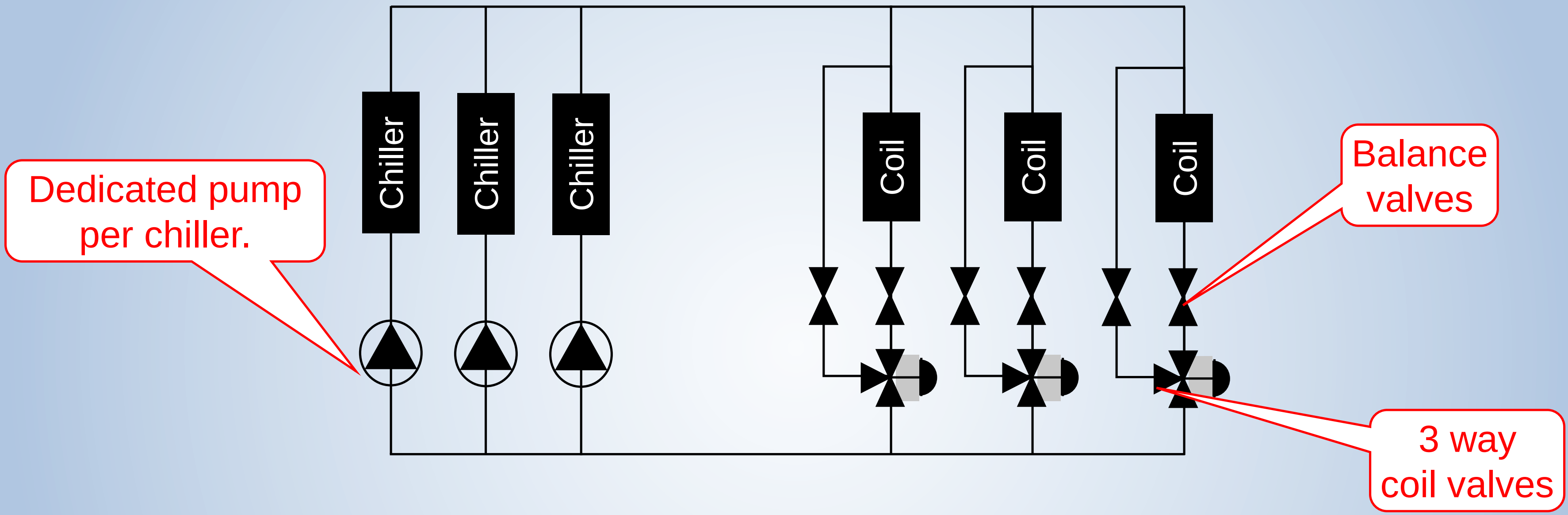
 # 1 Cause: Mechanical system design . . . . .

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

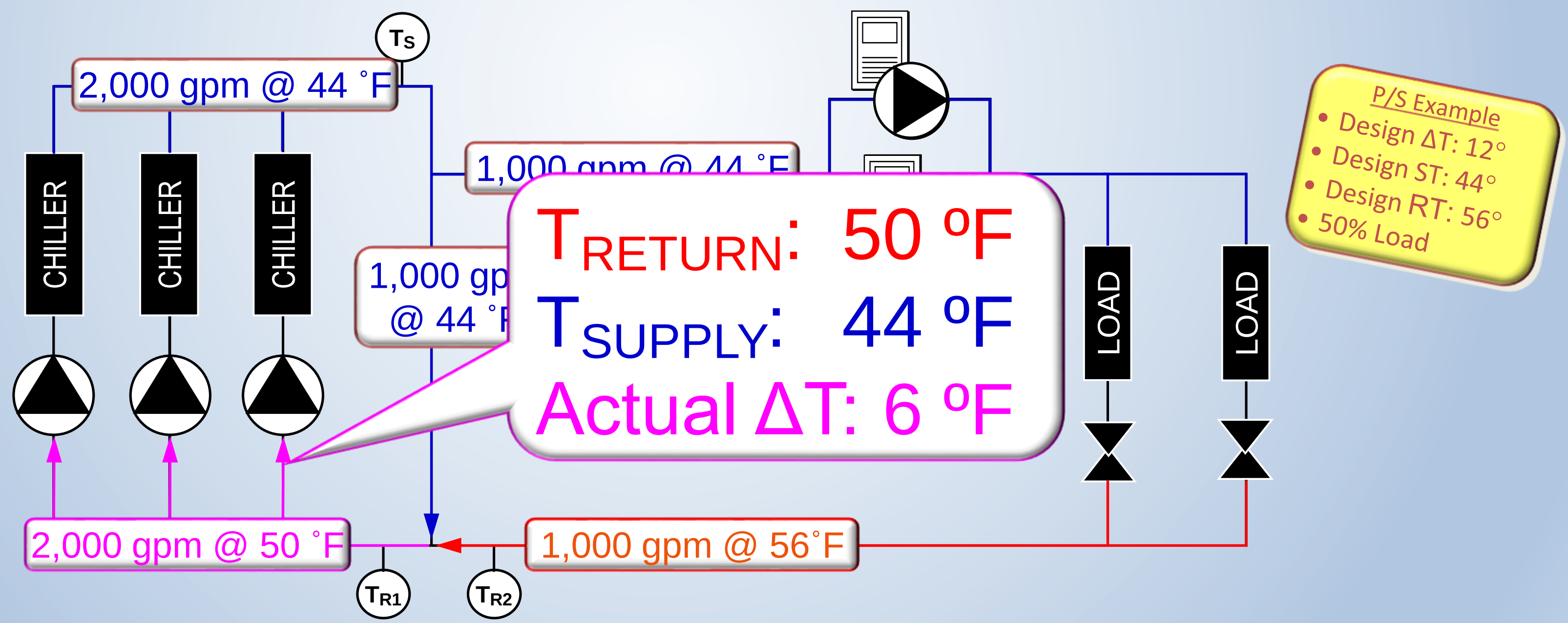


- Limited ability to modulate plant operation.
- Constant system flow regardless of load.
- Chiller staging often requires manual re-balancing so chillers often run continuously.

ETH Prospect: Outdated System Design

Primary/Secondary System: Excess Flow/ Low ΔT

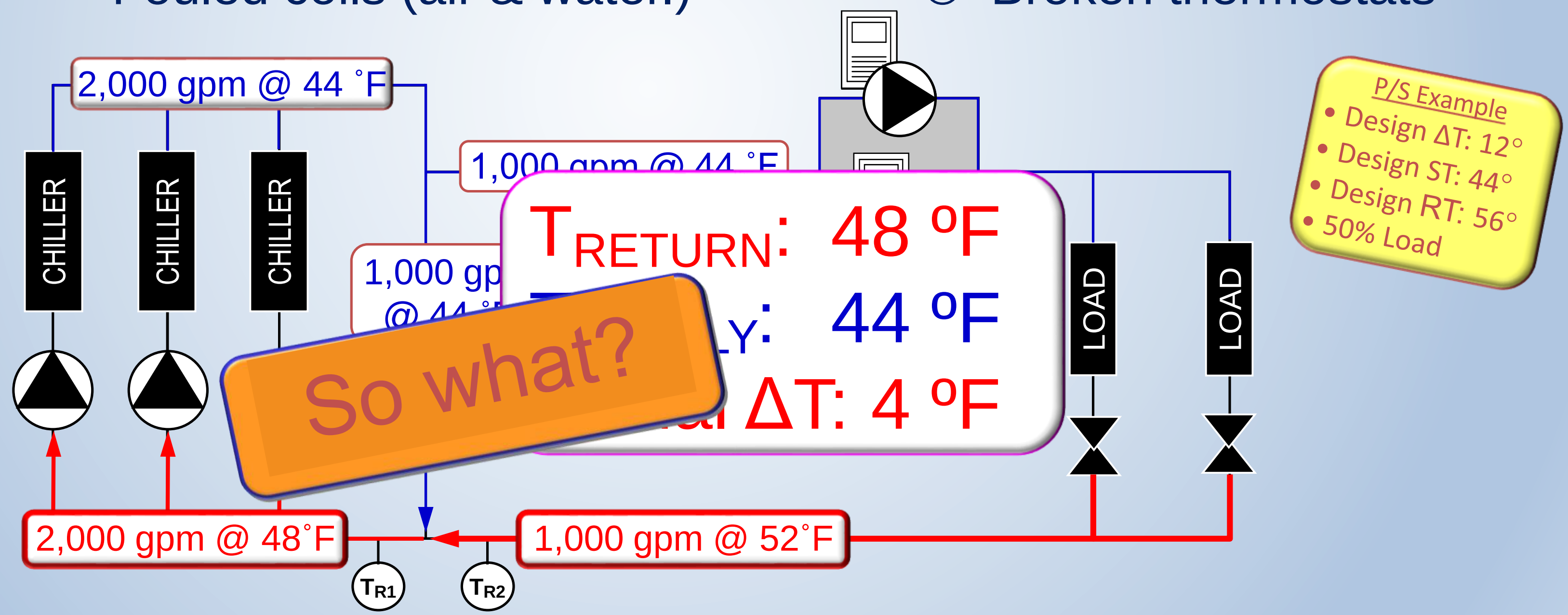
- Chilled water bypassed through decoupler line and blends with warm return water.



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
  - Fouled coils (air & water.)
  - ⊗ Undersized coils
  - ⊗ Broken thermostats

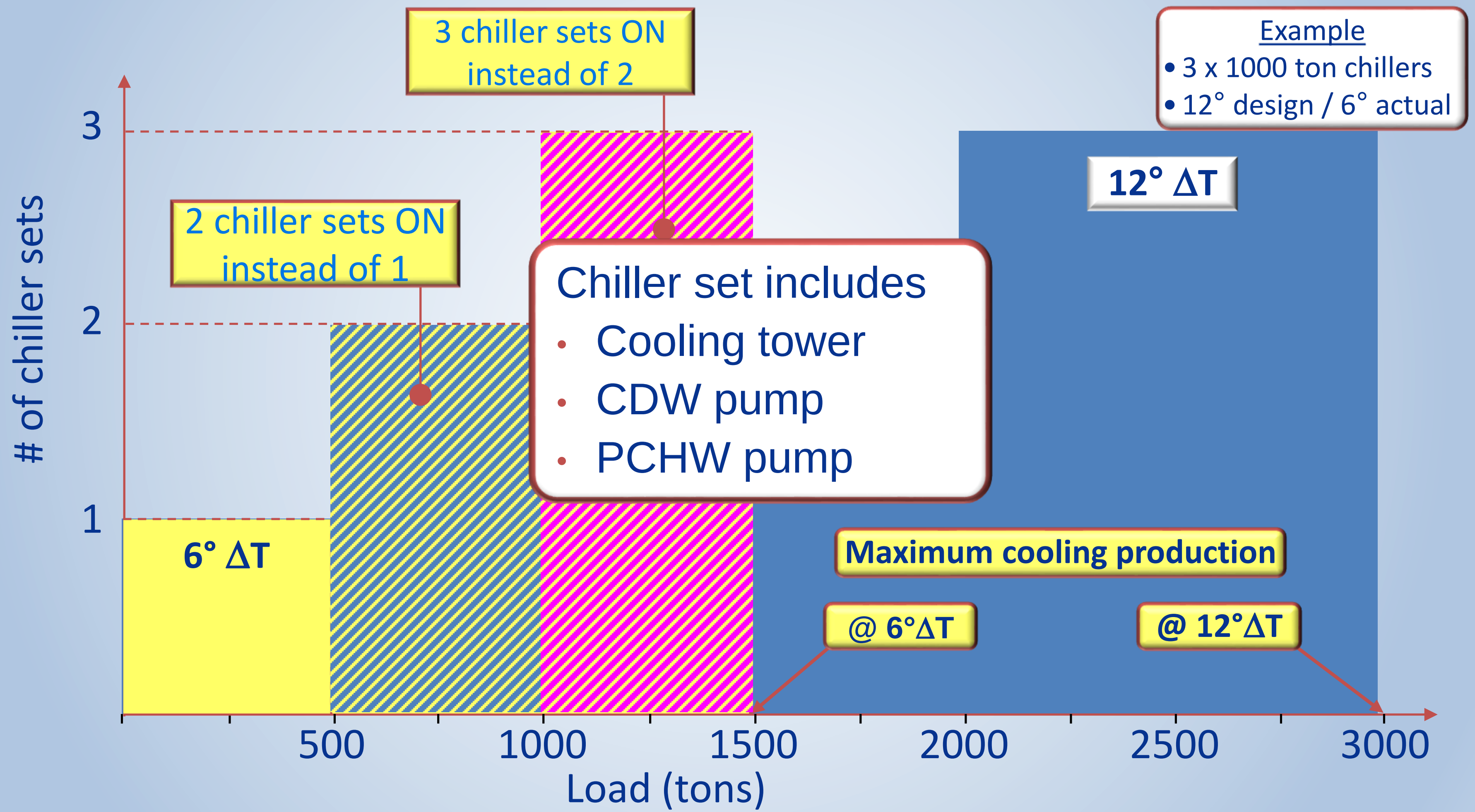


ETH Prospect: Outdated Mechanical Design
ΔT Effect on Pumping Energy

- ✓ CHW flow (gpm/ton) = 24/ ΔT (˚F)
  - 12 ˚F Design ΔT ⇒ 2 gpm/ton
  - 6 ˚F Actual ΔT ⇒ 4 gpm/ton
- ✓ Affinity law: Pump power proportional to $flow^3$.
  - 12 ˚F Design ΔT ⇒ 2 gpm/ton ⇒ n kW
  - 6 ˚F Actual ΔT ⇒ 4 gpm/ton ⇒ 8n kW
- ✓ ½ ΔT ⇒ 8 x pump power

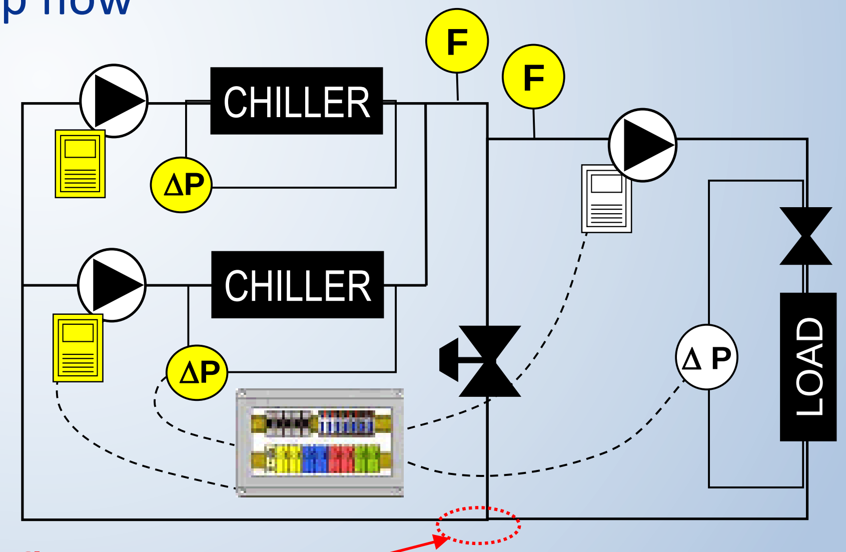
Primary/Secondary System with Low ΔT

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.



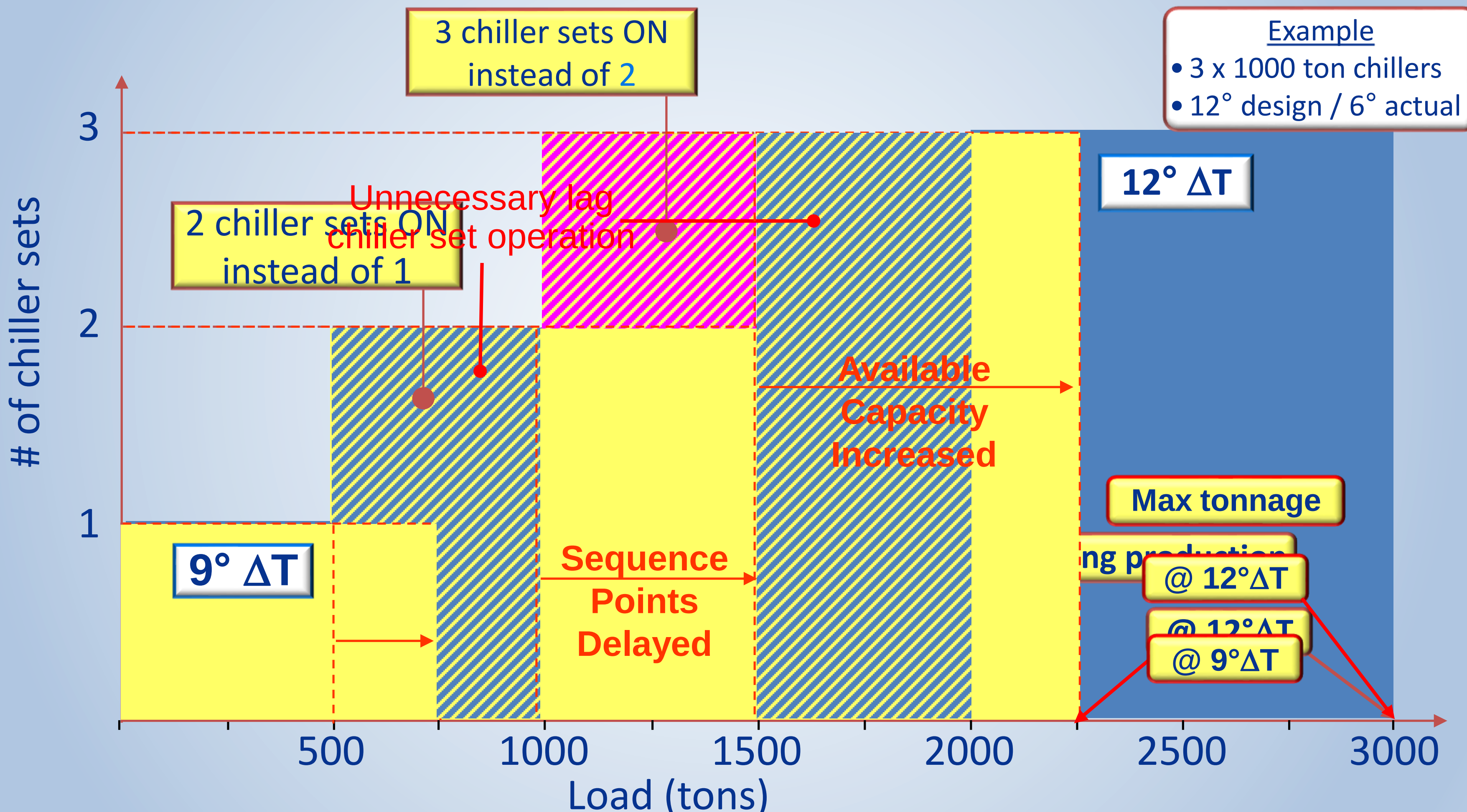
Reduce flow & blending, increase ΔT

Primary/Secondary System with Low ΔT

Optimization Opportunity

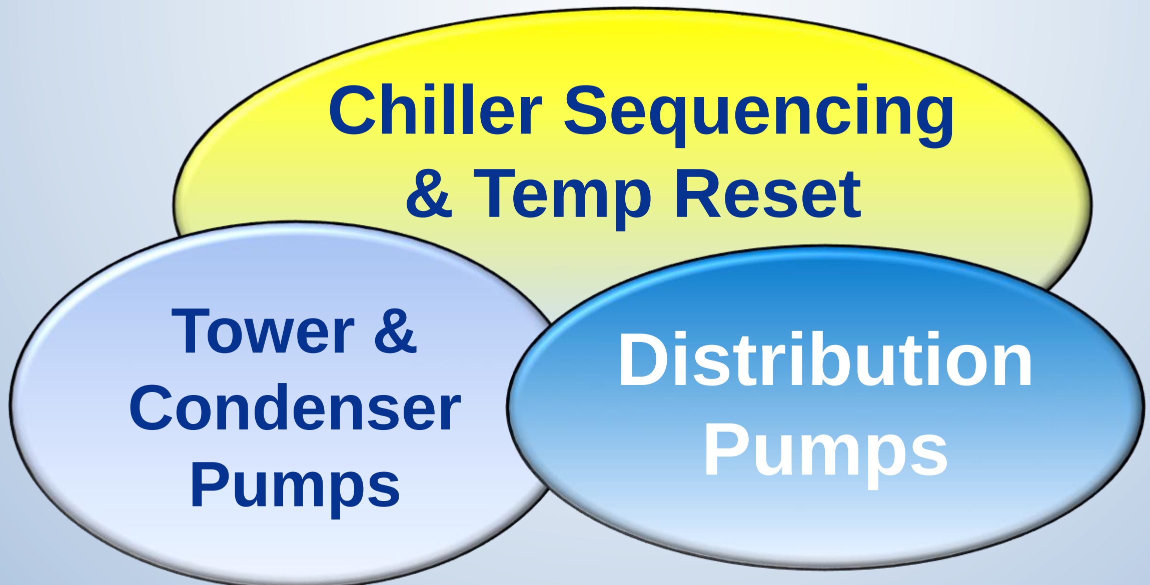
Effect on Chiller Loading and Capacity

3° ΔT Increase Chiller Loading and Capacity



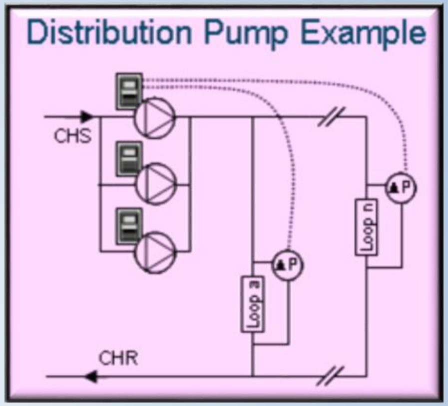
ETH Prospect: Control Strategy

- ***Standard Goal:*** make enough cold water to meet design day.
- ***Energy Goal:*** meet demand at the lowest kW per ton.
- 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

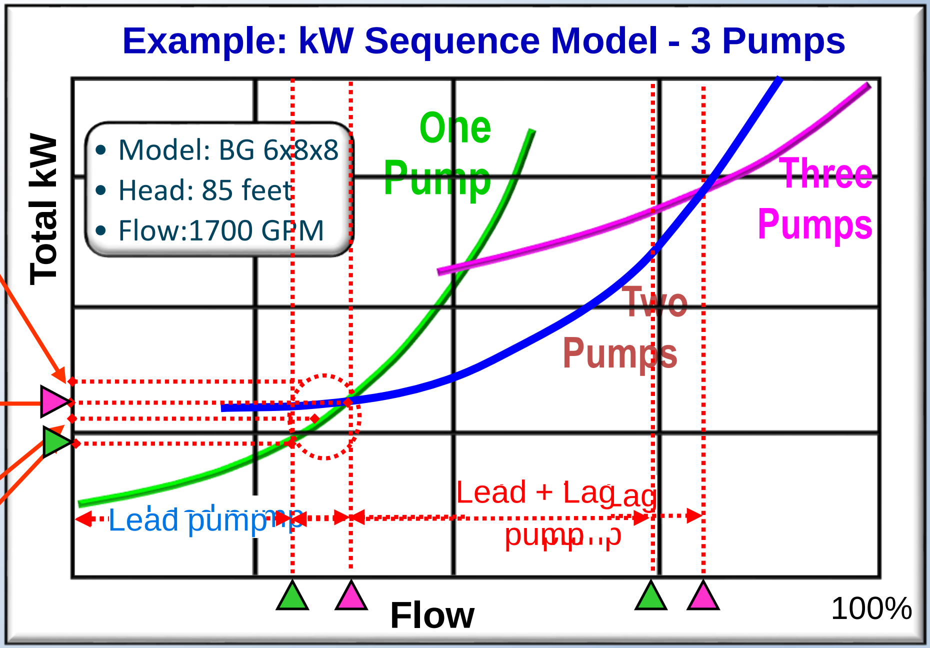
- Pump speed regulated to demand (remote DP.)
- # of pumps to run for lowest pump power?
- *Pump kW Sequence Model* – based on specific hydronic system and affinity laws.
- Adaptive algorithm auto resets setpoint to minimize pump power.



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 ~ 50°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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