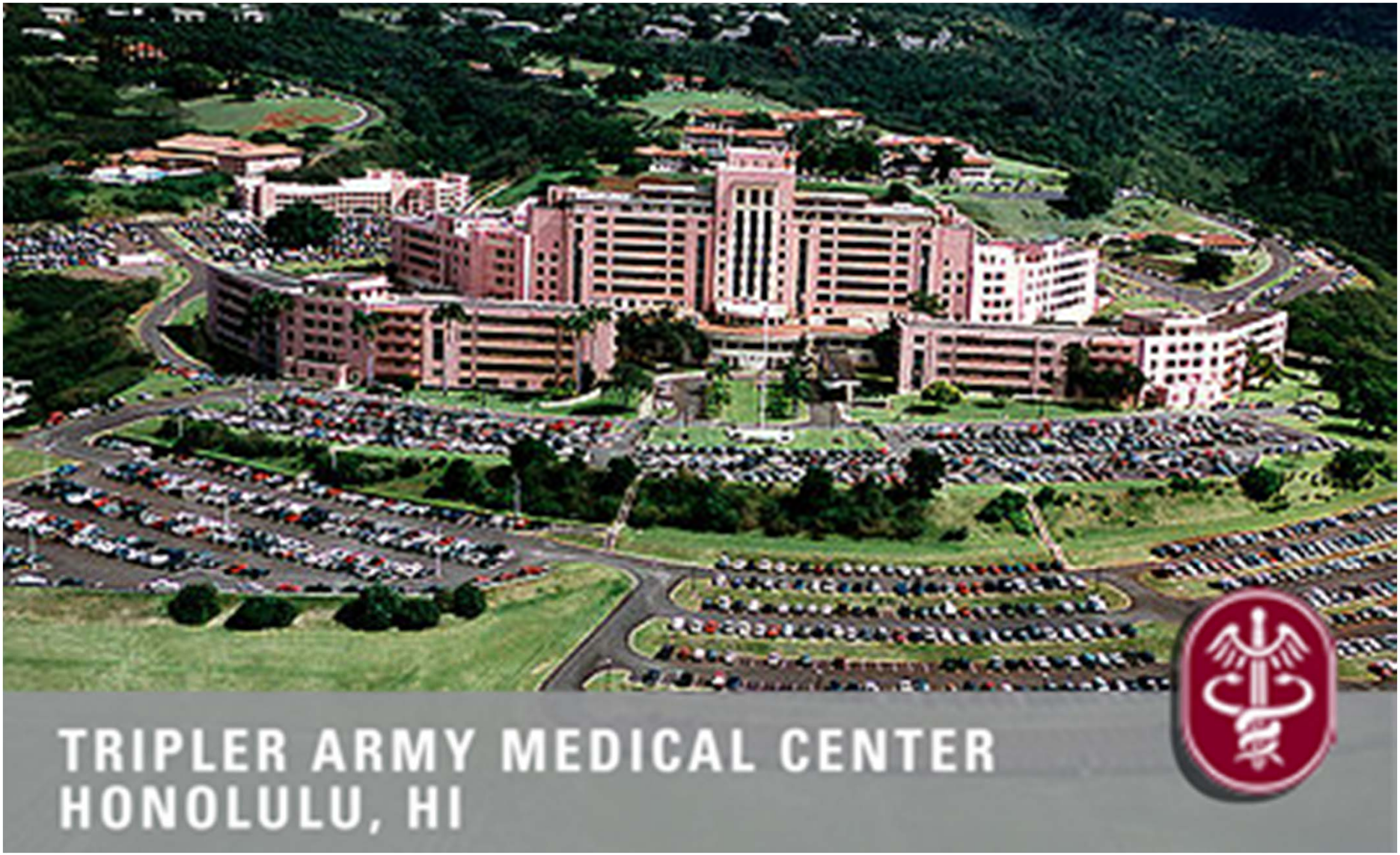
# Continuous Commissioning® Process
# Case Study of
# Tripler Army Medical Center
# Honolulu, HI




Proceedings of the Eleventh International Conference Enhanced Building Operations, New York City, October 18-20, 2011


# Commissioning Consulting Firm
## specializing in

- Continuous Commissioning®
- New Building Functional Commissioning
- Energy Analysis
- Project Management


TRIPLER ARMY MEDICAL CENTER
HONOLULU, HI

# Presentation Outline

- Facility Management's Objectives
- Project Description
- CC ® Process applied
- Tripler CC ® Measures
- Energy Savings
- Training

# Facility Management Objectives

- Identify and solve existing operational problems
- Improve building thermal comfort
- Verify indoor  air quality
- Minimize building energy consumption
- Minimize total operating cost
- Document Energy and Cost Savings

# CC® Process

## Preliminary CC ® Assessment

- Field Investigations
- Drawing Reviews
- Utility Bill Analysis

## Develop Comfort Baseline

- Temperature, RH, $CO_2$

# CC® Process

## Develop CC® Implementation Plan

- Validate sensors and equipment functionality
- Review EMCS programming
- Investigate reported problem areas

## Implement the Plan

- Fine Tune with Adjustments over time

## Present Results

- Final Report and Savings Report
- Training Workshop

# CC® Process

## Continue to Monitor the Facility

- "Continuous" part of the CC ® Process
- To insure a continuity of savings, continue to monitor and fine tune the systems
- Institute a program to ensure retrofits and additions are accomplished in concert with the established CC® program

# Tripler Site Description

- Full Service Hospital
  - 1.2 Million Sq Ft
- Over 75 Major AHUs
  - Mostly SDVAV & SDCAV AHUs with RA fans
- JCI Metasys EMCS
- Two Main chilled water loops
  - Non-Critical Loop (two 900 ton Chillers)
  - Critical Loop (two 600 ton Chillers)
- Central Plant is remote to the main building
- Steam Plant
  - Two 150 Hp fire tube boilers

# CC ® Measures Employed

- Equipment Maintenance & Sensor Calibrations
  - Over 300 items repaired or replaced
  - Verified and adjusted valve and damper operation
  - Tuned PID loops
  - Verified air flows and static pressure readings with EMS
  - Verified static pressure drops across coils
  - Set up trend logs on key components in EMS
    - Supply Air Temp, SP, Fan Speed, CHW Valve position, etc.

# CC® Measures Employed

- AHUs (mostly non-critical)
  - Static pressure reset schedules
  - Occupancy schedules
  - OA modulated based on $CO_2$ on certain AHUs
  - OA adjusted on other AHUs
  - Adjusted flow differential on return air fans
- Terminal Box (over 300 boxes programmed)
  - Verified damper, flow and reheat operation vs. set points
  - Occupancy scheduling
  - Temperature set points with dead bands for both occupied and unoccupied time periods
  - Air flow minimums and maximums

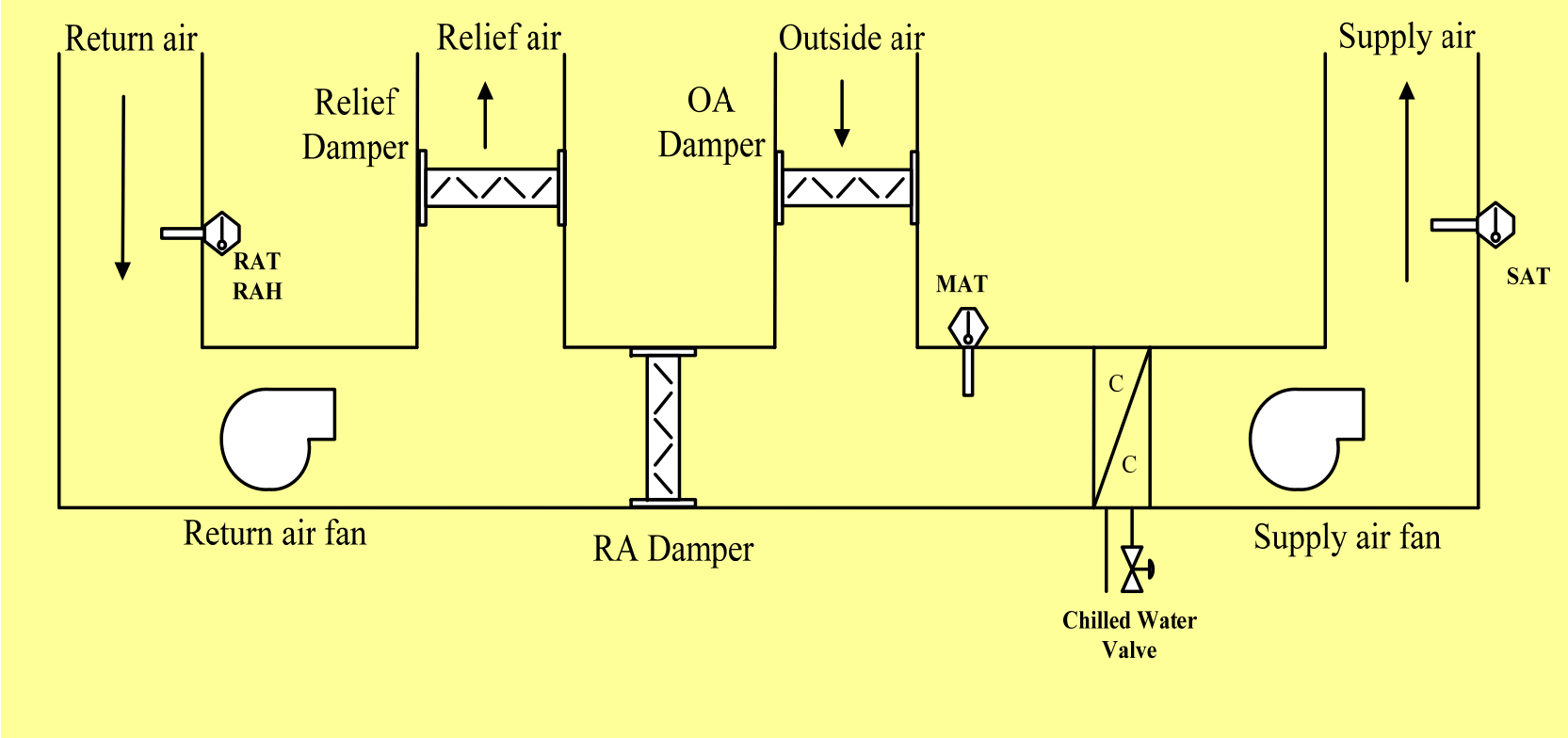
# CC ® Measures Employed

## Chiller Plant

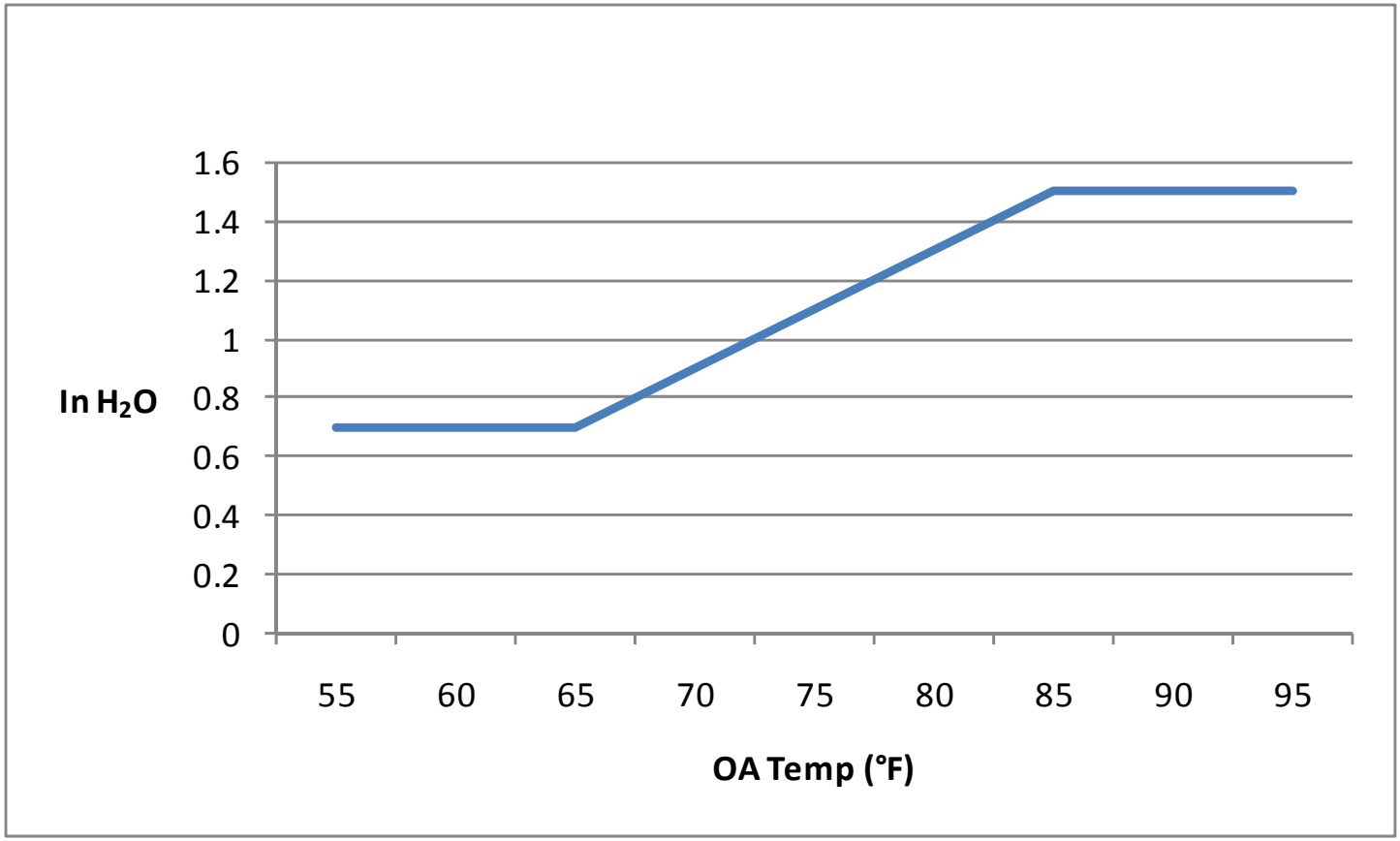
- Simplified critical and non-critical loop DP sensor control logic.
  - Implemented a linear re-set schedule based on OAT
  - Optimized chilled water differential pressure (DP)
  - Repaired make up water pressure regulators and adjusted expansion tank pressures
- Extended the existing combined loop operation time by 3 hours daily.
- Optimized the condenser water heat reclaim operation
- Optimized chilled water supply temperature

## Boiler Plant

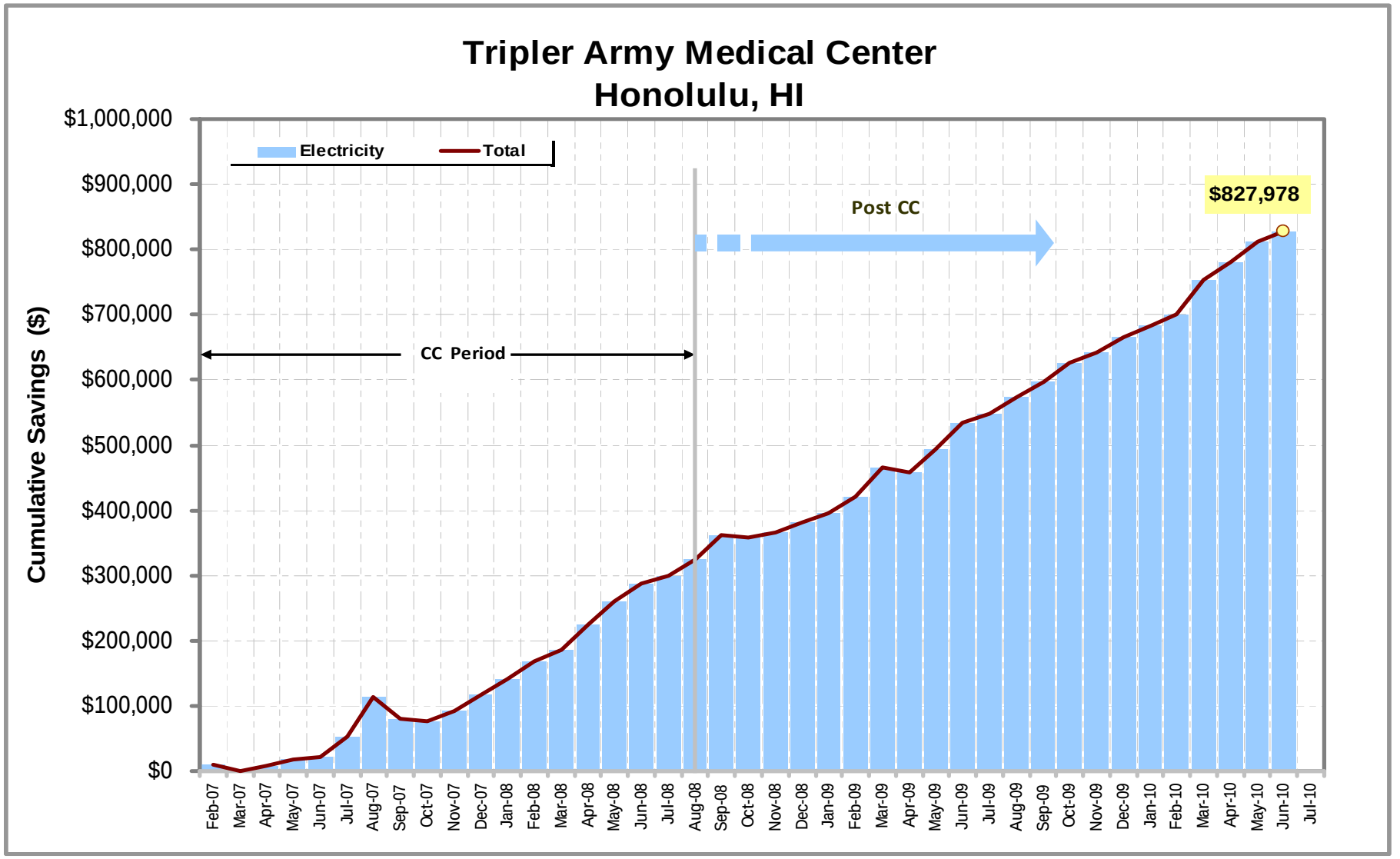
- Trended steam pressure and flow
- Optimized steam pressure reductions




# Typical Single Duct Constant Volume or Variable Volume AHU (SDCAV or SDVAV)




# Typical Static Pressure Linear Reset Schedule




# Cumulative Cost Savings based on Audit Rates (February 2007 - June 2010)

# CC® Energy Savings Results

Total Cumulative Energy Savings

(2/28/2007 – 6/30/2010)

$827,978

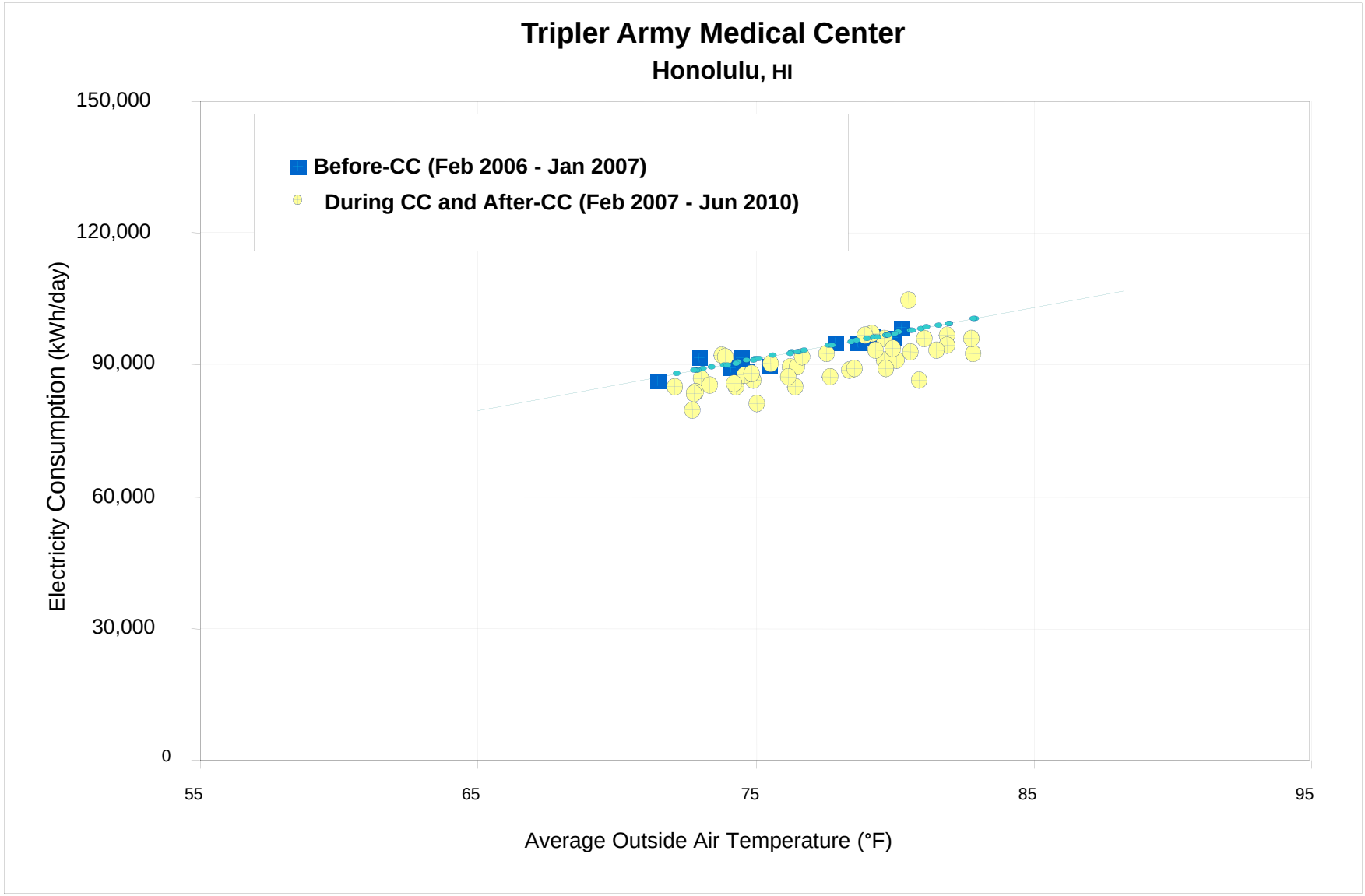
# Energy Savings

February 28, 2007 to June 30, 2010

| | |
|---|---|
| Electricity | 5,046,918 kWh |
| Emissions | Reductions |
| $CO_2$ | 8,736,266 lbs |
| $SO_2$ | 21,032 lbs |
| $No_x$ | 19,583 lbs |

Projected Fuel Oil savings based on steam pressure reductions this past year (10/2010 – 9/2011):

13,000 gal ~ $65,000.00




# Electricity Consumption Patterns versus Outside Temperature

**Tripler Army Medical Center**
**Honolulu, HI**

| | | | | | | | | | PRICE $/kWh |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Measured | Baseline | Savings | | $0.1641 |
| Month | Day | Year | Days/Mo | Tdb | Total Cons | Total Cons | | | |
| No. | | | | °F | [kWh] | kWh | kWh | % | USD |
| 2 | 28 | 2007 | 28 | 73.1 | 2,428,000 | 2,489,405 | 61,405 | 2.47% | $10,074 |
| 3 | 31 | 2007 | 31 | 73.9 | 2,848,000 | 2,783,918 | (64,082) | -2.30% | ($10,513) |
| 4 | 30 | 2007 | 30 | 75.6 | 2,708,000 | 2,756,750 | 48,750 | 1.77% | $7,998 |
| 5 | 31 | 2007 | 31 | 77.6 | 2,860,000 | 2,921,410 | 61,410 | 2.10% | $10,075 |
| 6 | 30 | 2007 | 30 | 79.7 | 2,876,000 | 2,900,423 | 24,423 | 0.84% | $4,007 |
| 7 | 31 | 2007 | 31 | 80.1 | 2,820,000 | 3,013,193 | 193,193 | 6.41% | $31,695 |
| 8 | 31 | 2007 | 31 | 80.9 | 2,676,000 | 3,042,081 | 366,081 | 12.03% | $60,058 |
| 9 | 30 | 2007 | 30 | 80.6 | 3,136,000 | 2,932,272 | (203,728) | -6.95% | ($33,423) |
| 10 | 31 | 2007 | 31 | 79.3 | 3,008,000 | 2,981,746 | (26,254) | -0.88% | ($4,307) |
| 11 | 30 | 2007 | 30 | 76.3 | 2,680,000 | 2,781,168 | 101,168 | 3.64% | $16,597 |
| 12 | 31 | 2007 | 31 | 75.0 | 2,672,000 | 2,824,142 | 152,142 | 5.39% | $24,960 |
| 1 | 31 | 2008 | 31 | 72.9 | 2,600,000 | 2,748,083 | 148,083 | 5.39% | $24,294 |
| 2 | 29 | 2008 | 29 | 74.3 | 2,460,000 | 2,620,046 | 160,046 | 6.11% | $26,257 |
| 3 | 31 | 2008 | 31 | 76.6 | 2,768,000 | 2,882,649 | 114,649 | 3.98% | $18,809 |
| 4 | 30 | 2008 | 30 | 76.5 | 2,548,000 | 2,786,830 | 238,830 | 8.57% | $39,181 |
| 5 | 31 | 2008 | 31 | 78.5 | 2,744,000 | 2,952,127 | 208,127 | 7.05% | $34,144 |
| 6 | 30 | 2008 | 30 | 79.7 | 2,732,000 | 2,900,423 | 168,423 | 5.81% | $27,631 |
| 7 | 31 | 2008 | 31 | 81.1 | 2,976,000 | 3,049,760 | 73,760 | 2.42% | $12,101 |
| 8 | 31 | 2008 | 31 | 80.6 | 2,880,000 | 3,031,477 | 151,477 | 5.00% | $24,851 |
| 9 | 30 | 2008 | 30 | 79.7 | 2,672,000 | 2,901,485 | 229,485 | 7.91% | $37,648 |
| 10 | 31 | 2008 | 31 | 79.0 | 3,000,000 | 2,971,507 | (28,493) | -0.96% | ($4,674) |
| 11 | 30 | 2008 | 30 | 76.7 | 2,748,000 | 2,796,384 | 48,384 | 1.73% | $7,938 |
| 12 | 31 | 2008 | 31 | 74.7 | 2,712,000 | 2,813,172 | 101,172 | 3.60% | $16,598 |
| 1 | 31 | 2009 | 31 | 72.1 | 2,636,000 | 2,721,023 | 85,023 | 3.12% | $13,949 |
| 2 | 28 | 2009 | 28 | 72.8 | 2,332,000 | 2,481,148 | 149,148 | 6.01% | $24,469 |
| 3 | 31 | 2009 | 31 | 72.8 | 2,468,000 | 2,744,060 | 276,060 | 10.06% | $45,289 |
| 4 | 30 | 2009 | 30 | 73.9 | 2,748,000 | 2,697,299 | (50,701) | -1.88% | ($8,318) |
| 5 | 31 | 2009 | 31 | 77.8 | 2,704,000 | 2,926,530 | 222,530 | 7.60% | $36,507 |
| 6 | 30 | 2009 | 30 | 82.9 | 2,768,000 | 3,014,017 | 246,017 | 8.16% | $40,361 |
| 7 | 31 | 2009 | 31 | 81.9 | 2,992,000 | 3,079,745 | 87,745 | 2.85% | $14,395 |
| 8 | 31 | 2009 | 31 | 81.9 | 2,924,000 | 3,079,745 | 155,745 | 5.06% | $25,551 |
| 9 | 30 | 2009 | 30 | 82.8 | 2,872,000 | 3,010,832 | 138,832 | 4.61% | $22,776 |
| 10 | 31 | 2009 | 31 | 81.6 | 2,888,000 | 3,065,484 | 177,484 | 5.79% | $29,117 |
| 11 | 30 | 2009 | 30 | 79.4 | 2,792,000 | 2,889,453 | 97,453 | 3.37% | $15,988 |
| 12 | 31 | 2009 | 31 | 74.3 | 2,652,000 | 2,798,911 | 146,911 | 5.25% | $24,102 |
| 1 | 31 | 2010 | 31 | 74.9 | 2,724,000 | 2,822,314 | 98,314 | 3.48% | $16,129 |
| 2 | 28 | 2010 | 28 | 73.4 | 2,384,000 | 2,499,644 | 115,644 | 4.63% | $18,972 |
| 3 | 31 | 2010 | 31 | 75.1 | 2,512,000 | 2,829,627 | 317,627 | 11.23% | $52,109 |
| 4 | 30 | 2010 | 30 | 76.2 | 2,616,000 | 2,777,275 | 161,275 | 5.81% | $26,458 |
| 5 | 31 | 2010 | 31 | 78.6 | 2,764,000 | 2,957,612 | 193,612 | 6.55% | $31,763 |
| 6 | 30 | 2010 | 30 | 80.0 | 2,812,000 | 2,911,747 | 99,747 | 3.43% | $16,364 |
| | | | | | **112,140,000** | **117,186,918** | **5,046,918** | **4.31%** | **$827,978** |

# TRAINING

# Troubleshooting

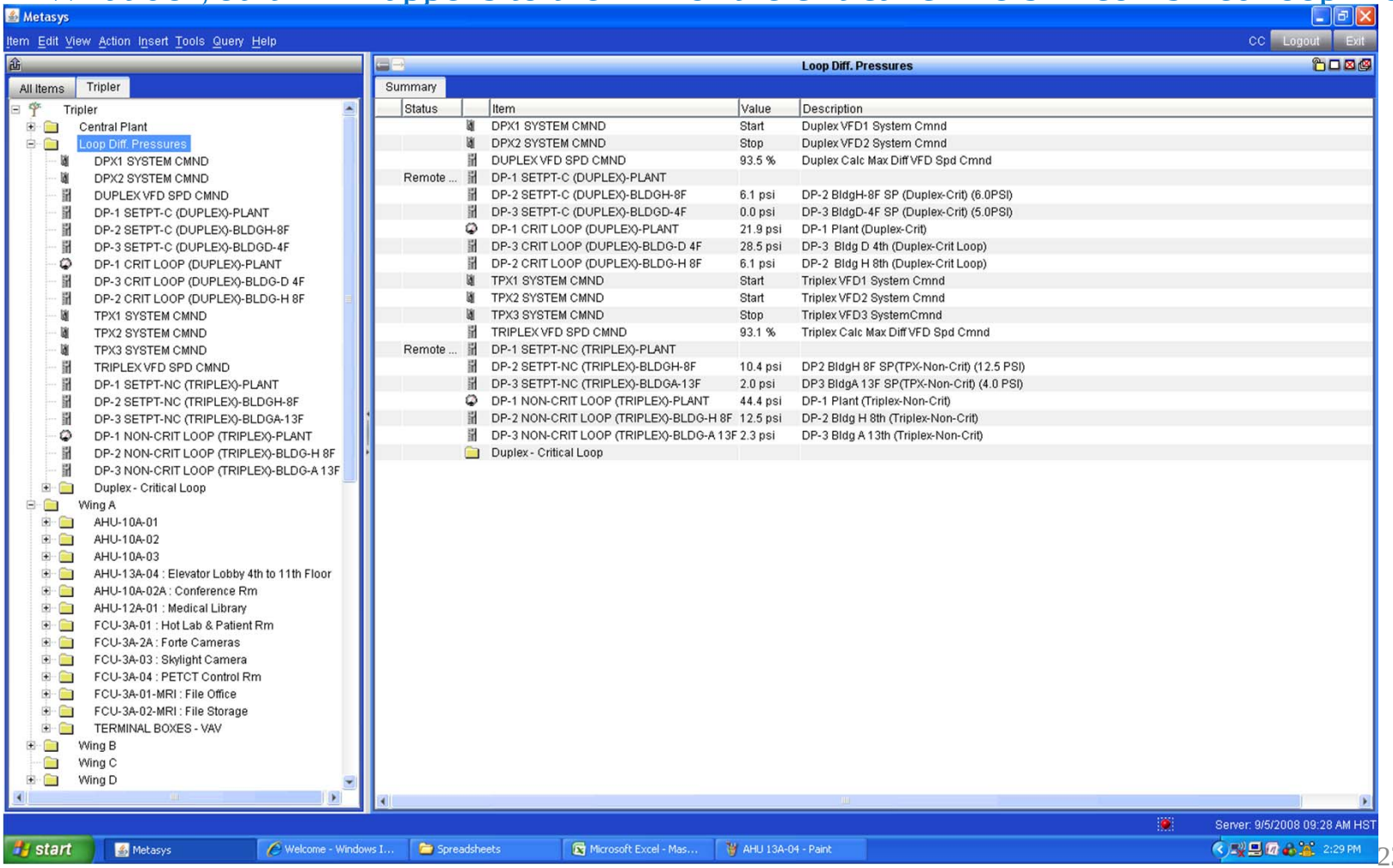
- Start remotely with the location of the issue
- Continue to move towards the primary cooling/heating source
    - Zone
        - » Box
            - – AHU
    - Hot/Chilled water system

# AHU Trend Troubleshooting

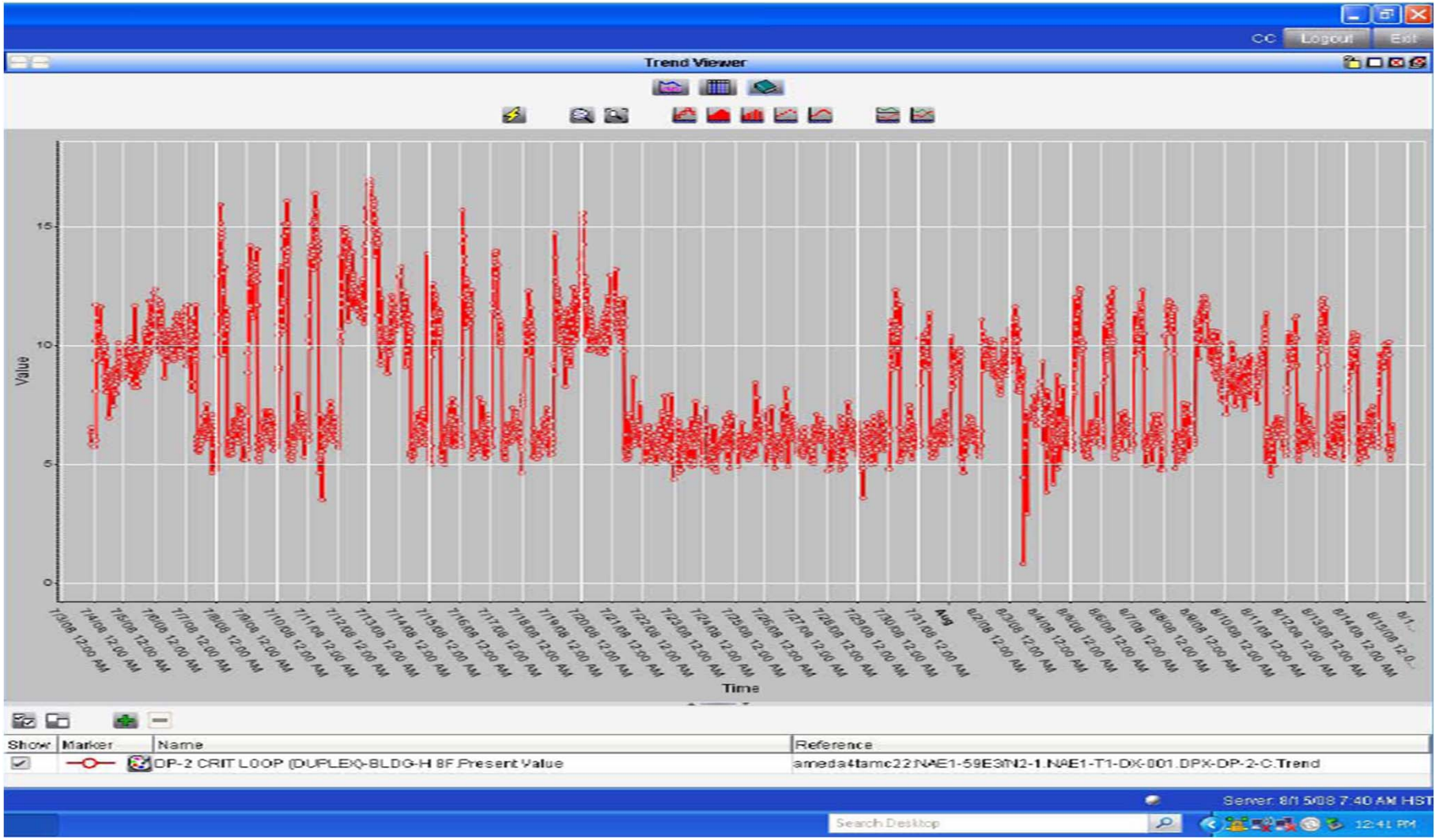
- Notice start time of DAT rise and DP drop compared to scheduled fan set back
- Notice the effect on the DAT immediately after the fan slows down
- Based on the triplex pumps running at full speed, what is your conclusion?

# DP Troubleshooting

- Why is the level 4 set point 0?
- What is the driving DP set point on the comfort loop?
- What do you think happens to the DP for the critical chillers in combined loop mode?



# Critical Loop Differential Pressure



# HVAC
# CC® Energy Efficiency with New Construction or Remodels

# CC® Energy Efficiency with New Construction or Remodels

Items to Consider

- Lighting
- Air Handling Units
- Terminal Boxes
- TAB and Commissioning

# Lighting

- ✓ T-8 system or better
- ✓ Electronic Ballasts
- ✓ Motion Sensors
  - Conference Rooms
  - Break-rooms
  - Rest rooms
  - Storage rooms
  - Offices

# Air Handling Units

- ✓ DDC Controls (tied into the front end!!!)
- ✓ High Efficiency VFD Compatible Motors
- ✓ Variable Frequency Drives
- ✓ Proper Sensors
- ✓ Coils – 8 row max, with 12 fins/inch
  - If more capacity needed, split into two series coils with space to clean
- ✓ UV lights (optional)

# Terminal Boxes

- ✓ DDC Controls (mapped back to the front end!!)
- ✓ Program Them
  - Occupied / Unoccupied schedule
    - Max / Min Flows
    - Temperature Set Points
- ✓ Hot water re-heat preferable to electric in this case
- ✓ Ensure Box is accessible for maintenance
- ✓ Leave manual balance dampers as set by the TAB contractor

# Specifications

- ✓ Independent TAB
- ✓ Commissioning
  - Review drawings prior to construction
  - Inspections during construction
  - Validation after construction
- ✓ Ensure EMS programming is working
- ✓ Re-inspect system in opposite season prior to end of warranty period

# Any Questions ?