Process & Benefits of Monitoring Based Commissioning

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Overview

This presentation will discuss:

- **Retro-commissioning (RCx) & monitoring-based commissioning (MBCx)**

- **RCx/MBCx process and benefits**

- **Example projects & use of data**

- **Utility programs and initiatives**

- **Questions**

Retro-Commissioning - Defined

- **Retro-commissioning is a systematic process for investigating how and why an existing building's systems are operated and maintained, and to identify ways to improve overall building performance.**

- **Benefits from RCx?**
    - **Low cost energy savings**
    - **Optimum system energy performance**
    - **More comfortable buildings**
    - **Better maintained equipment**
    - **Fewer complaints**
    - **More efficient allocation of resources**
    - **Improved indoor air quality**

- **RCx vs. Retrofit (low-cost vs. capital intensive)**

- **Persistence issue (Sustained energy performance)**

RCx / Monitoring Based Cx Process Comparison
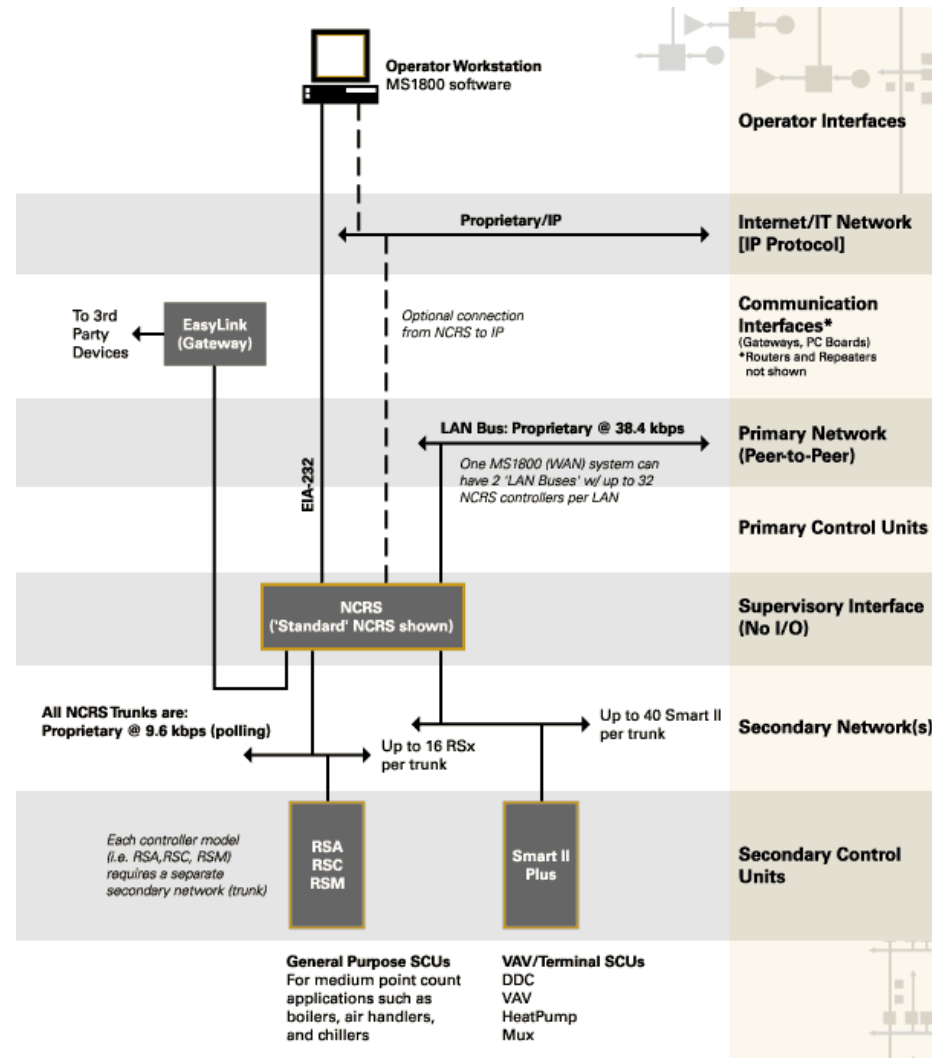
RCx Process

- **Planning Phase**
    - Review available info./ visit site
    - Write RCx Plan
- **Pre-Investigation Phase**
    - Inventory equipment
    - Address deferred maintenance
    - Pre-functional testing
    - Initiate trends
- **Investigation Phase**
    - Document operation conditions
    - Functional testing
    - Assess sequences
    - Make recommendations
- **Implementation Phase**
    - Install & commission measures
    - Document improved performance
- **Turnover Phase**
    - Systems Manual
   - Training

MBCx Process

- Identify and track energy and operational parameters, add points where necessary
    - Whole-building energy (e.g. electric and gas)
    - Systems: Chiller & fan kW, lighting, etc.
    - Independent parameters (OAT, etc.)
- Develop M&V Plan
    - Develop baseline energy models
- Collect post-installation data
- Develop post-install model
- Determine savings
- **Persistence Phase**
    - Establish energy and performance tracking system
    - Provide periodic reports
        - Savings
        - Operations
    - Address deficient performance
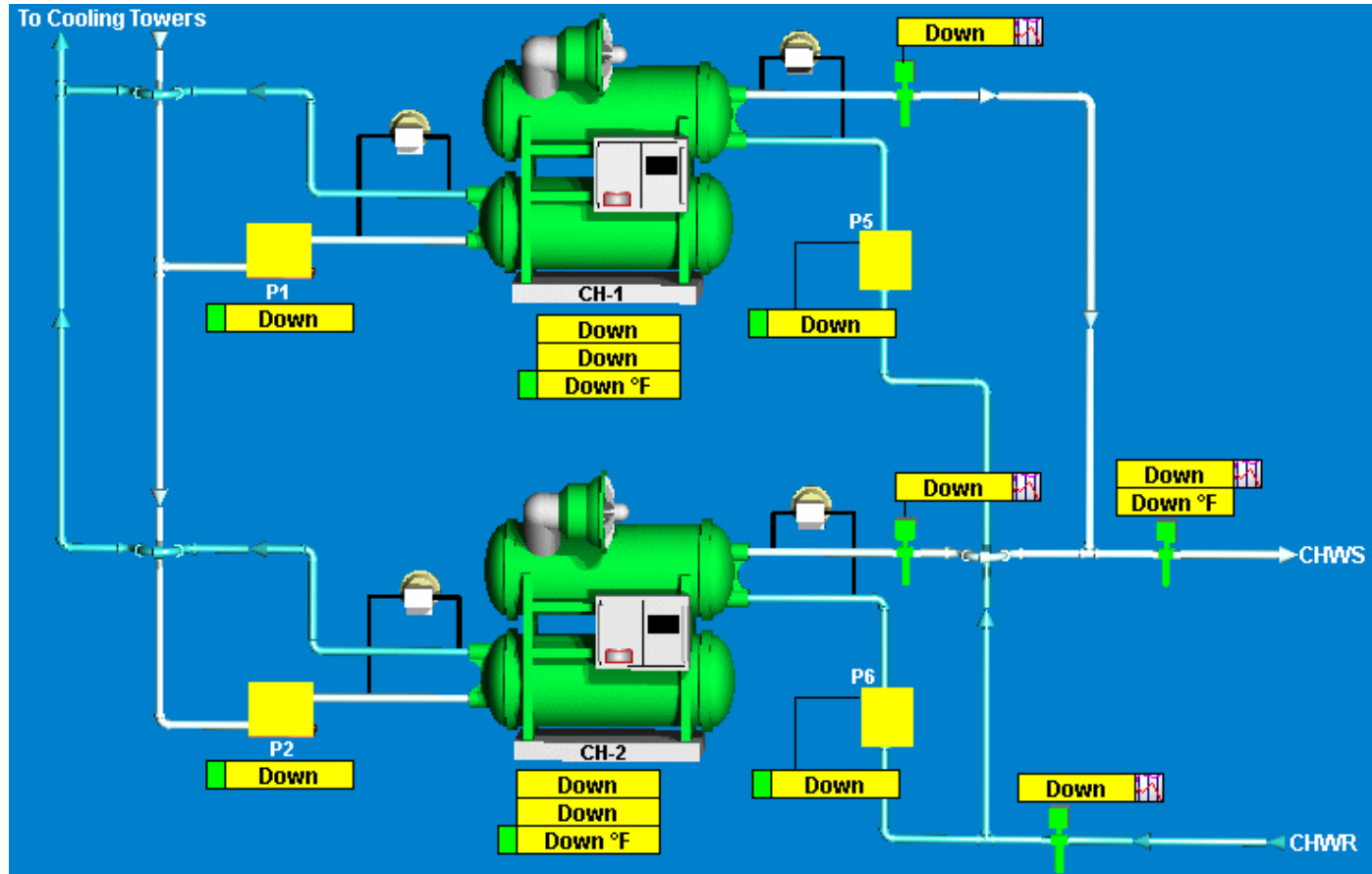
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Building Automation Systems (BAS)

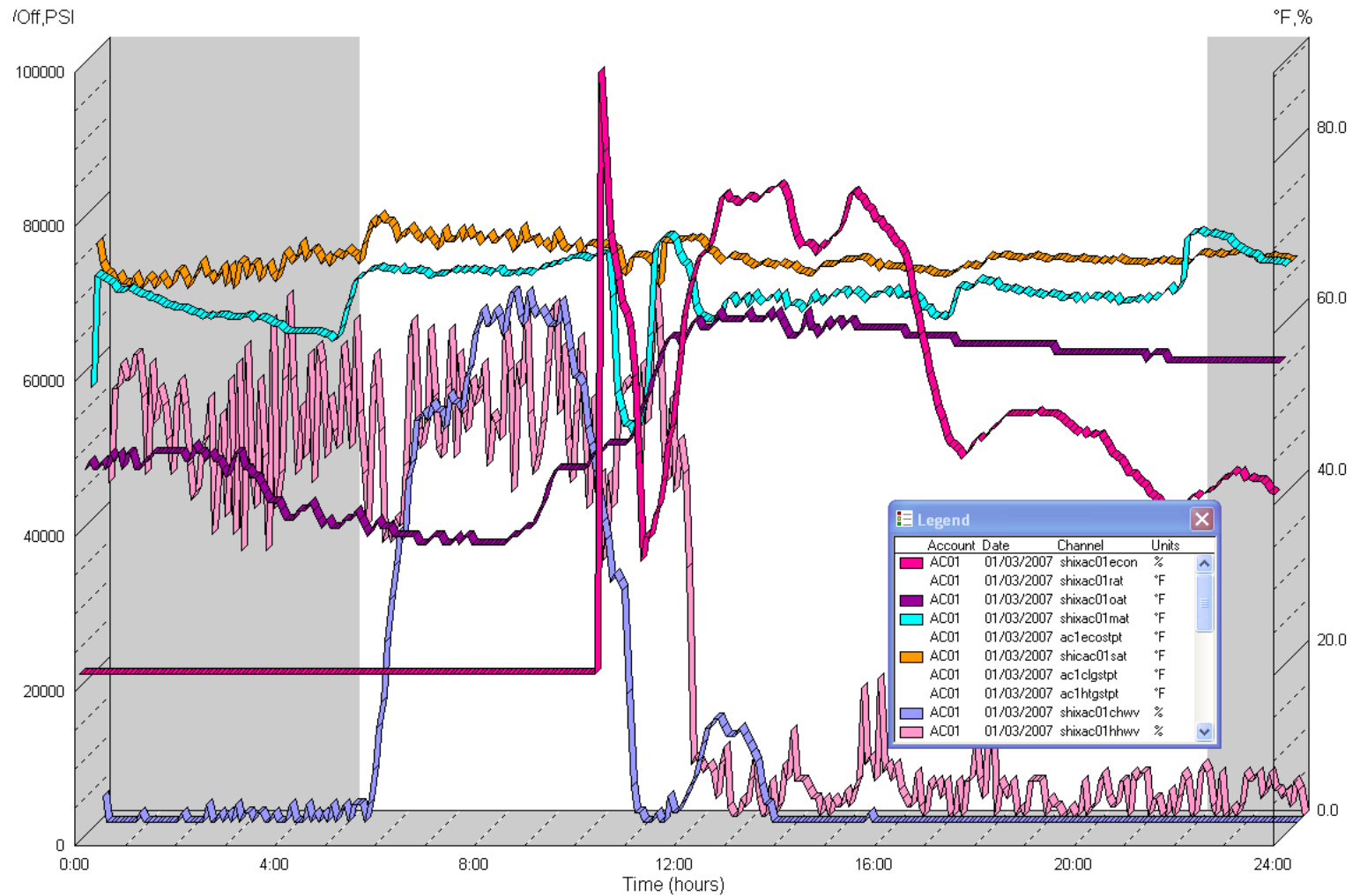- **Manufacturer data / architecture at: DDC Online**

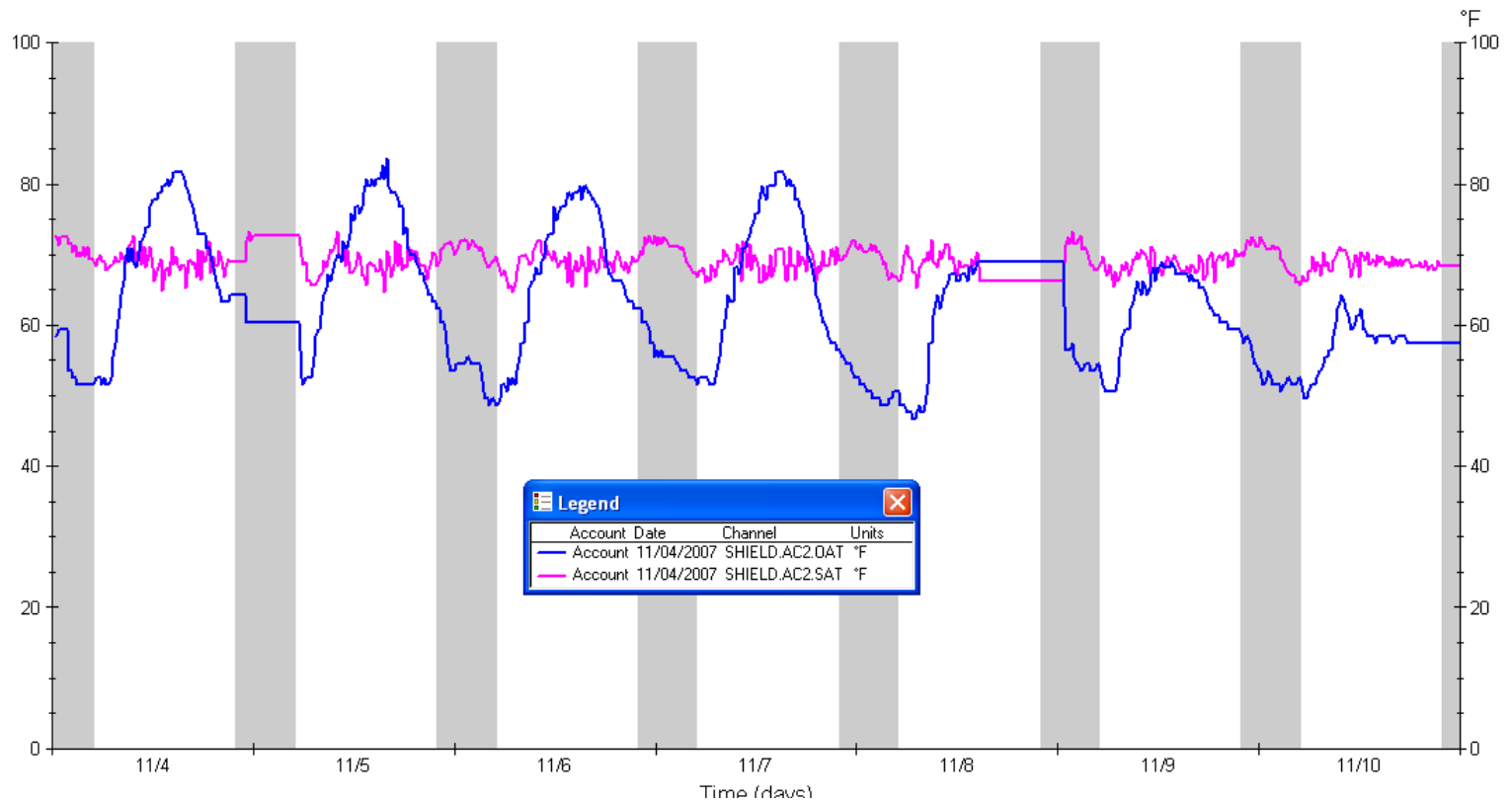# Typical BAS Graphic
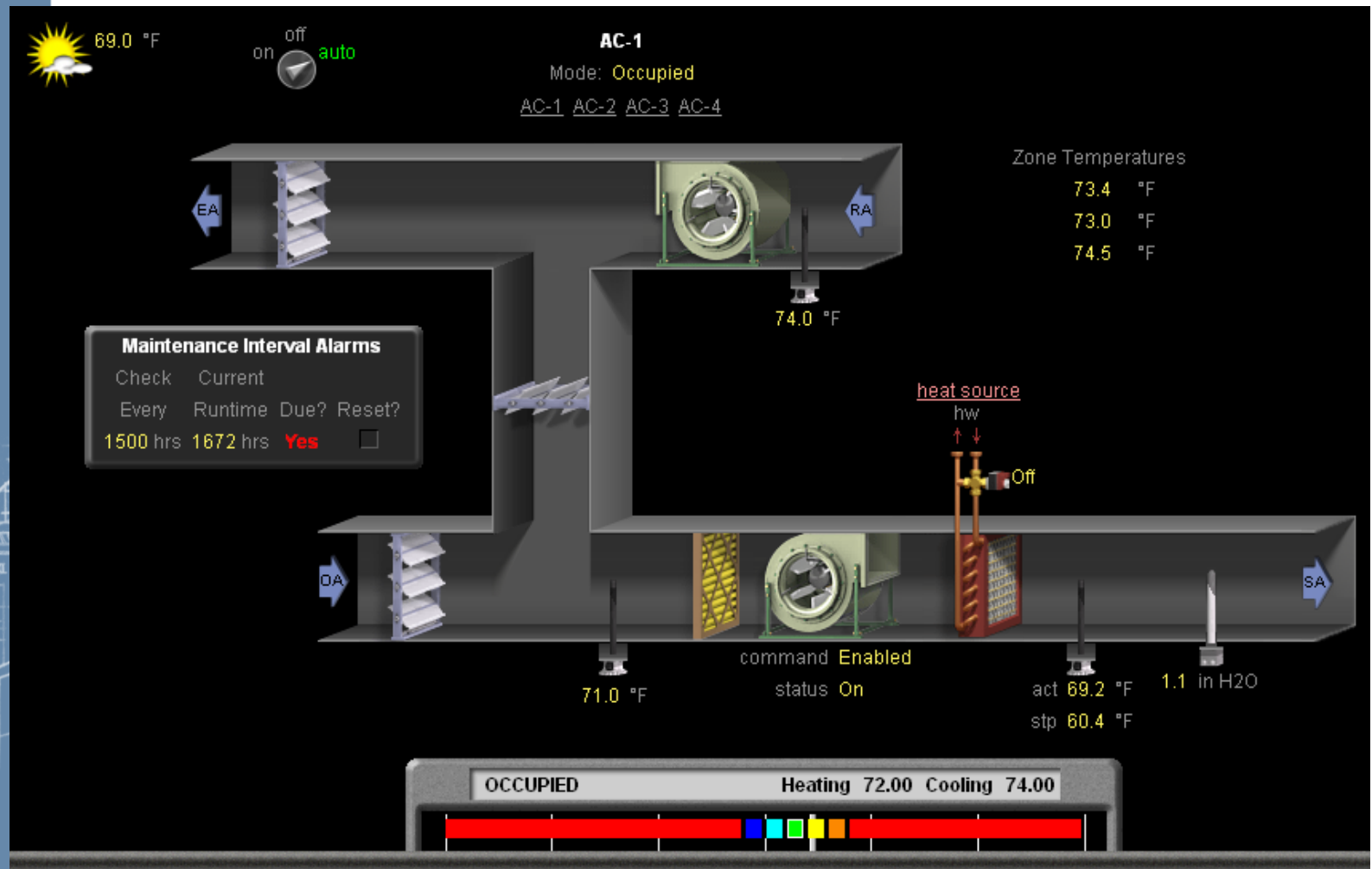
BAS Graphic of CHW System
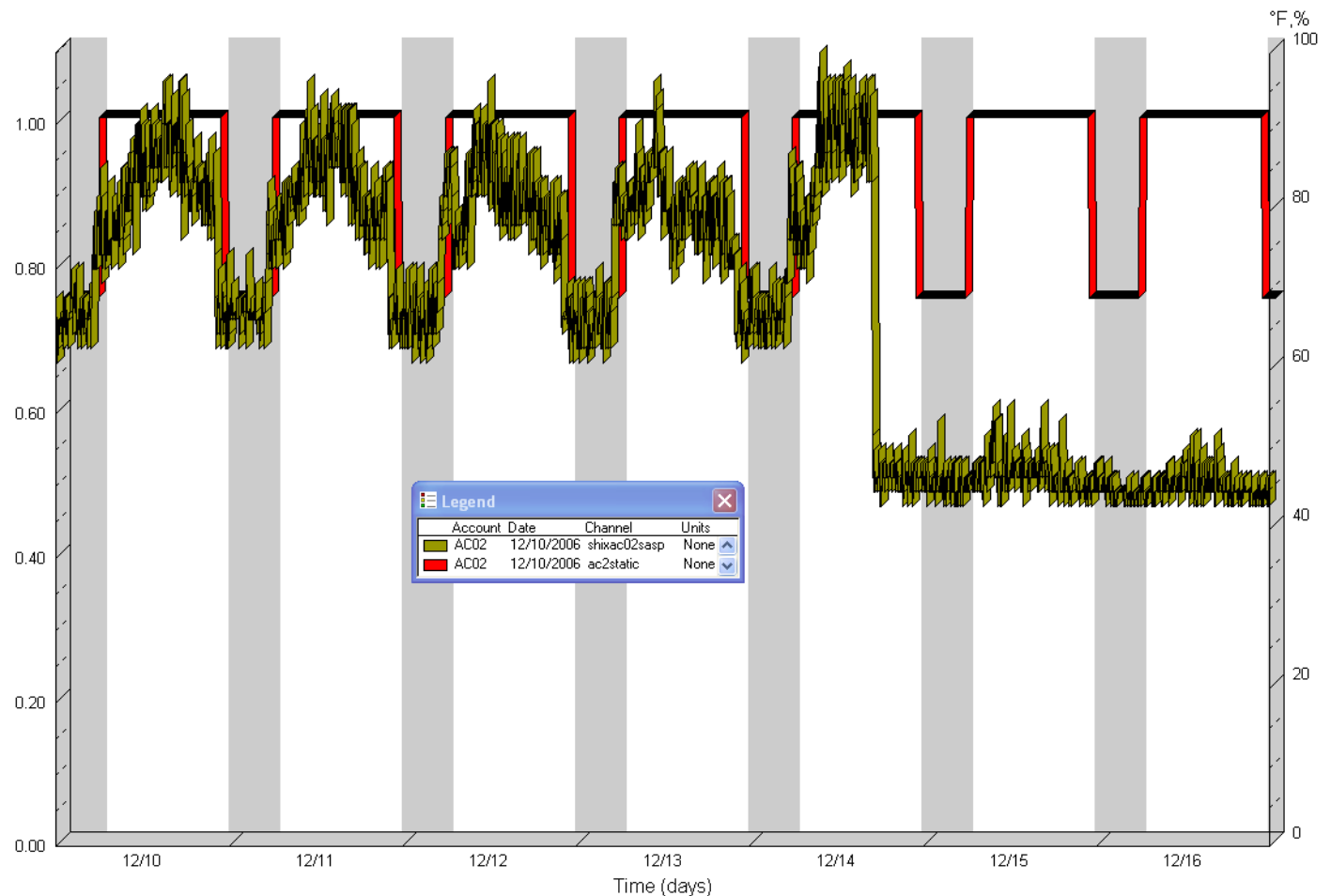
RCx Process - Diagnostics

RCx Diagnostics, cont.
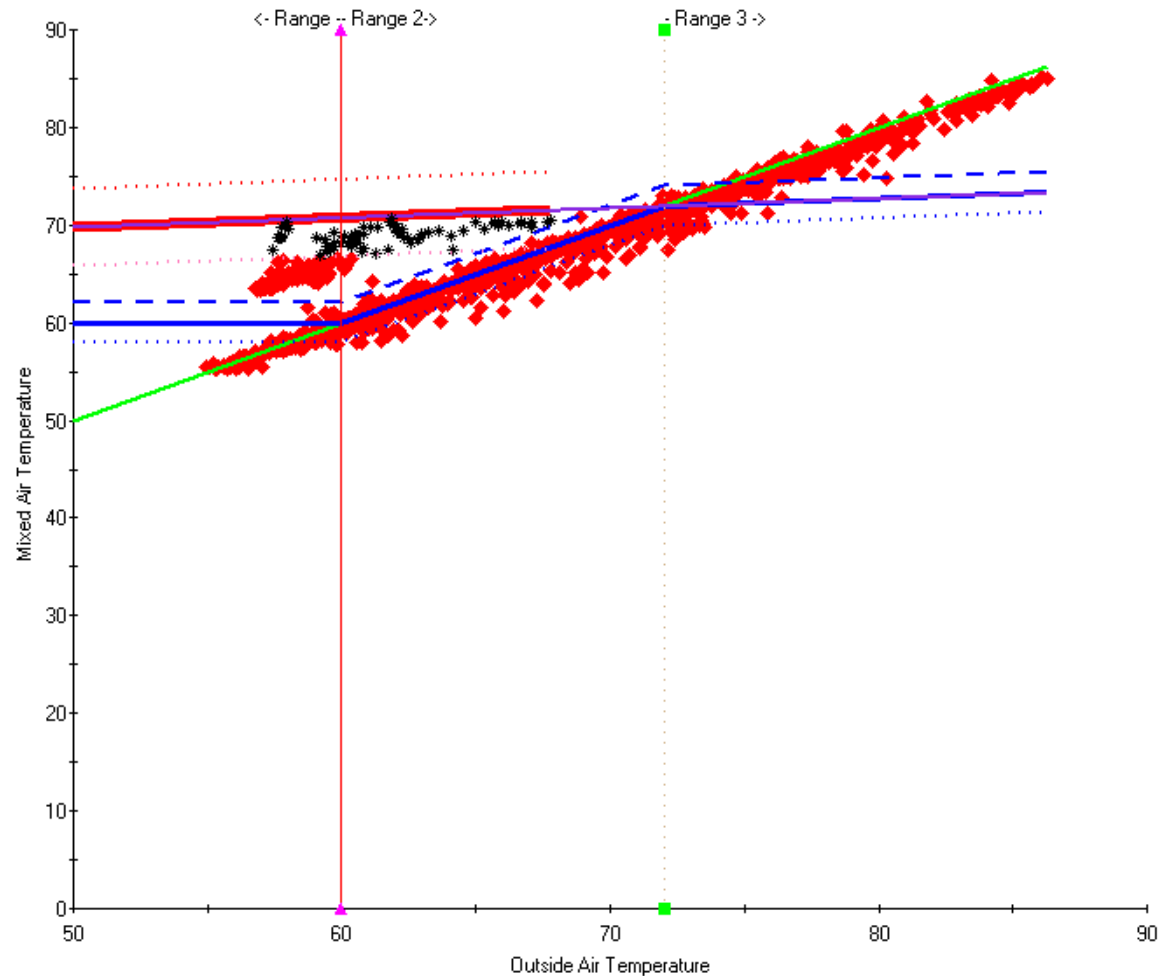
- **Supply air temperature night reset – not working**

RCx Disgnostics, cont.
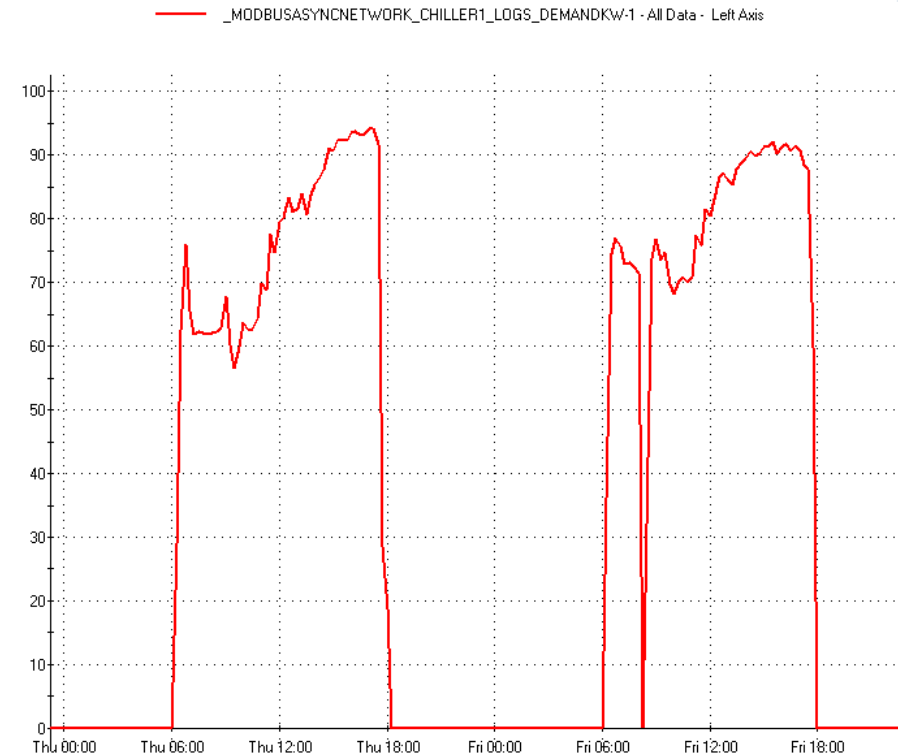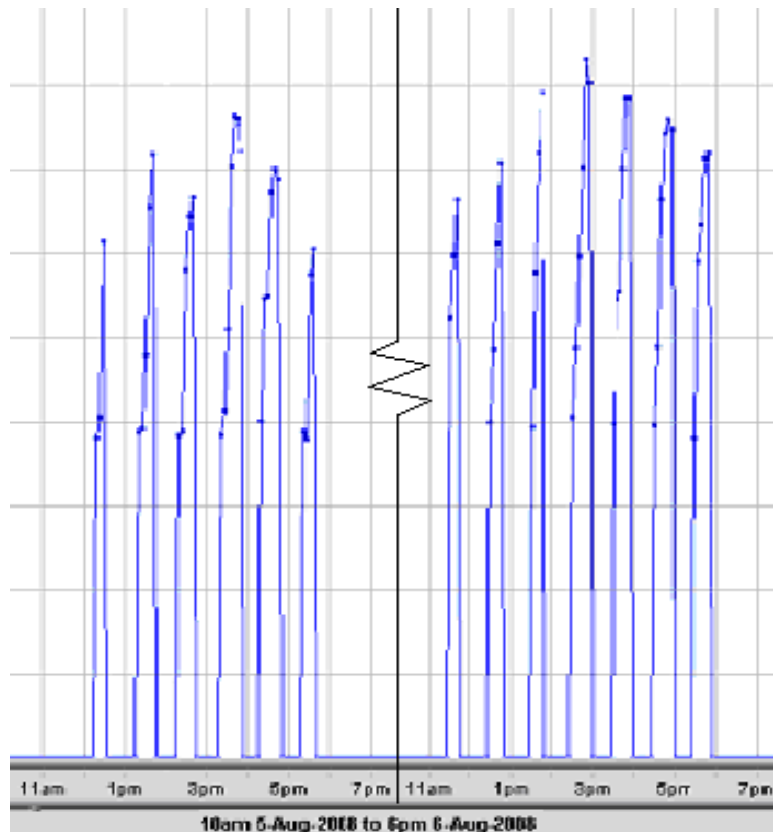
- **Faulty fan static pressure control – not working**

RCx Diagnostics, cont.

- **Economizer (free cooling) problems**

RCx Diagnostics, cont.

- **Chiller Cycling**

The Building Tune-Up Case Study I

One Market

- **Commercial Office Multi-tenant 1.4M sqft of conditioned space**

- **Savings 1.3GWh**

- **Study identified 1.6 GWh of cost-effective savings**

- **Implemented in two months**

- **40% of savings disappeared in less than a month**

The Building Tune-Up Case Study II

Large San Francisco Retailer

- **Multi-story retail site 700Ksqft**
- **Study costs - $33K**
- **Savings $50,000 Annually**
- **Implemented in two months**
- **60% of savings disappeared in less than a month**

MBCx Process Advantages

- RCx – typically a "one-time" intervention
  - Without proper training or full understanding of systems, control settings can be overridden and savings lost.
- MBCx:
  - Leave behind system that allows staff to determine whether system is operating efficiently
  - Provide self diagnosis tools so staff can troubleshoot building
- Issues:
  - Need a good monitoring/analysis platform
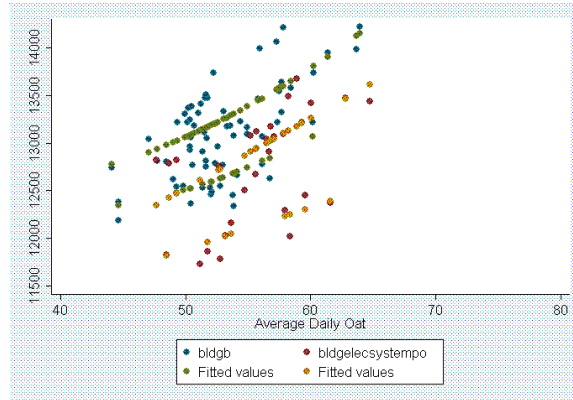 - Who uses it? What skills required?

QuEST Approach: Energy Savings Analysis

- **Select measurement boundary**
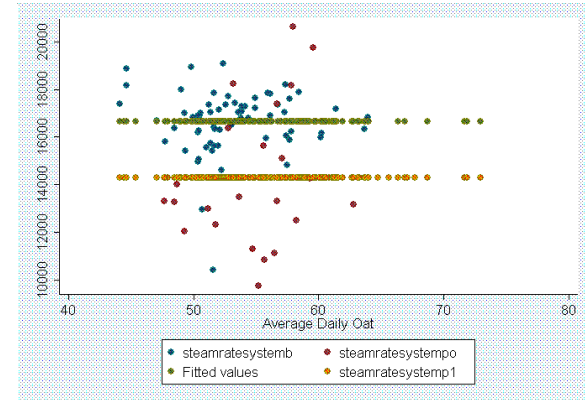 - **Whole Building**
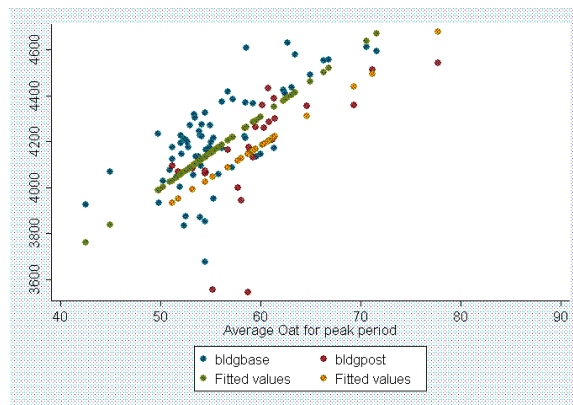 - **HVAC Systems**
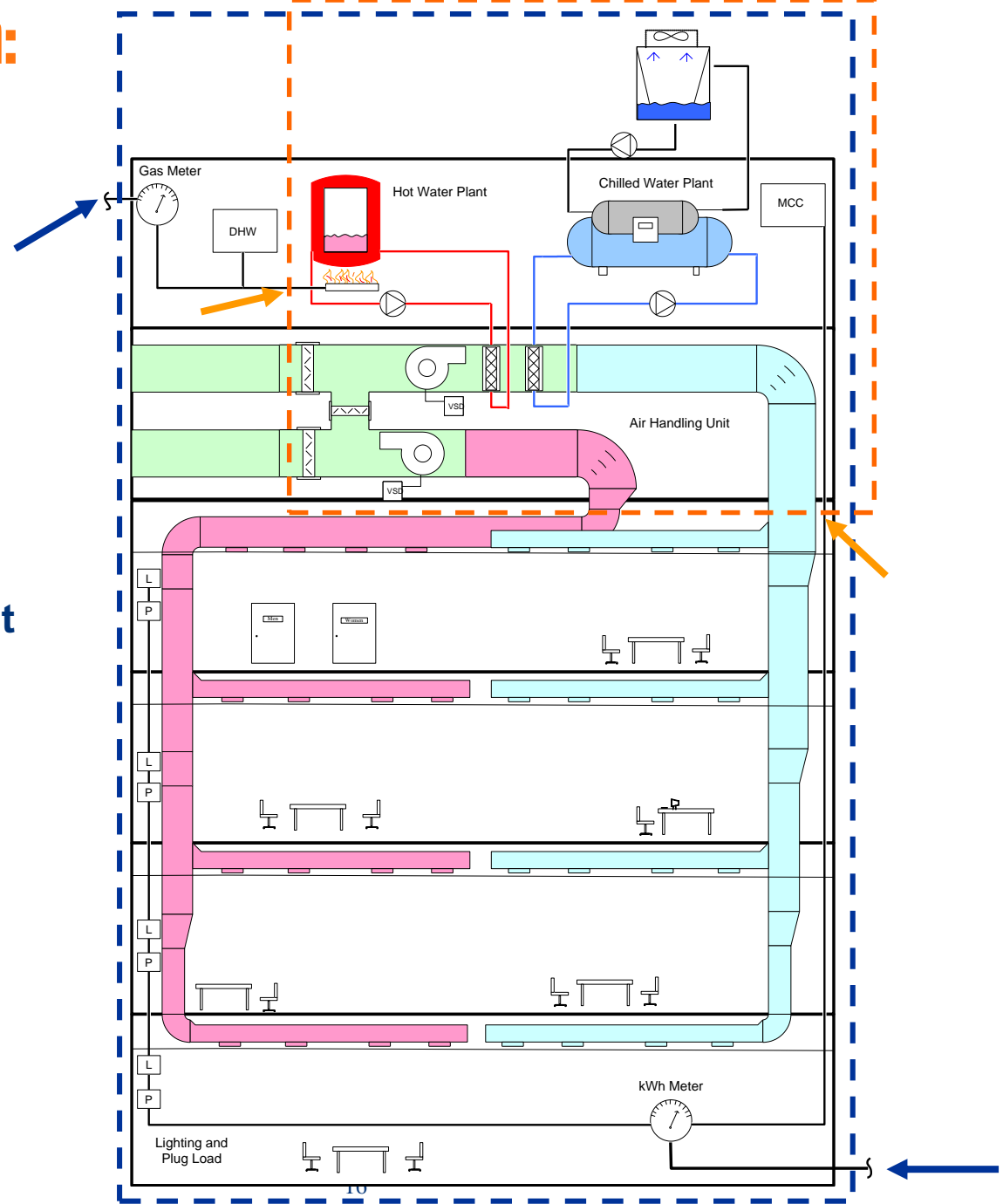
Baseline Model: Soda Hall

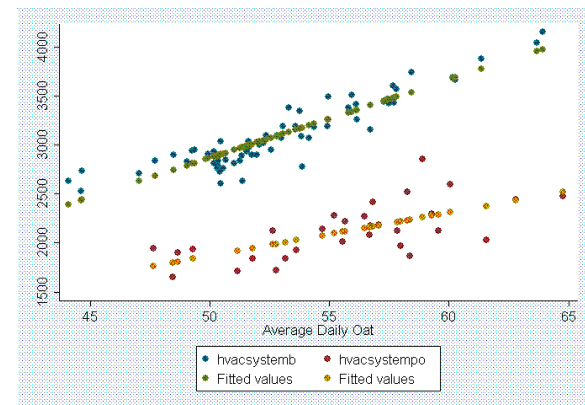- **Total Building Electric**

Building Steam

- **Peak Period Electric**


HVAC System Electric

MBCx Project HVAC Savings

Baseline Model:
kWh = 79.9*OAT + 1129
RMSE = 136 kWh

Post-Install Model:
kWh = 44.1*OAT - 336
RMSE = 213 kWh

Daily kWh Use

Baseline Period

Post-Installation Period

Date Break

Date

HVAC Daily kWh Usage ── Baseline ── Post-Install Model
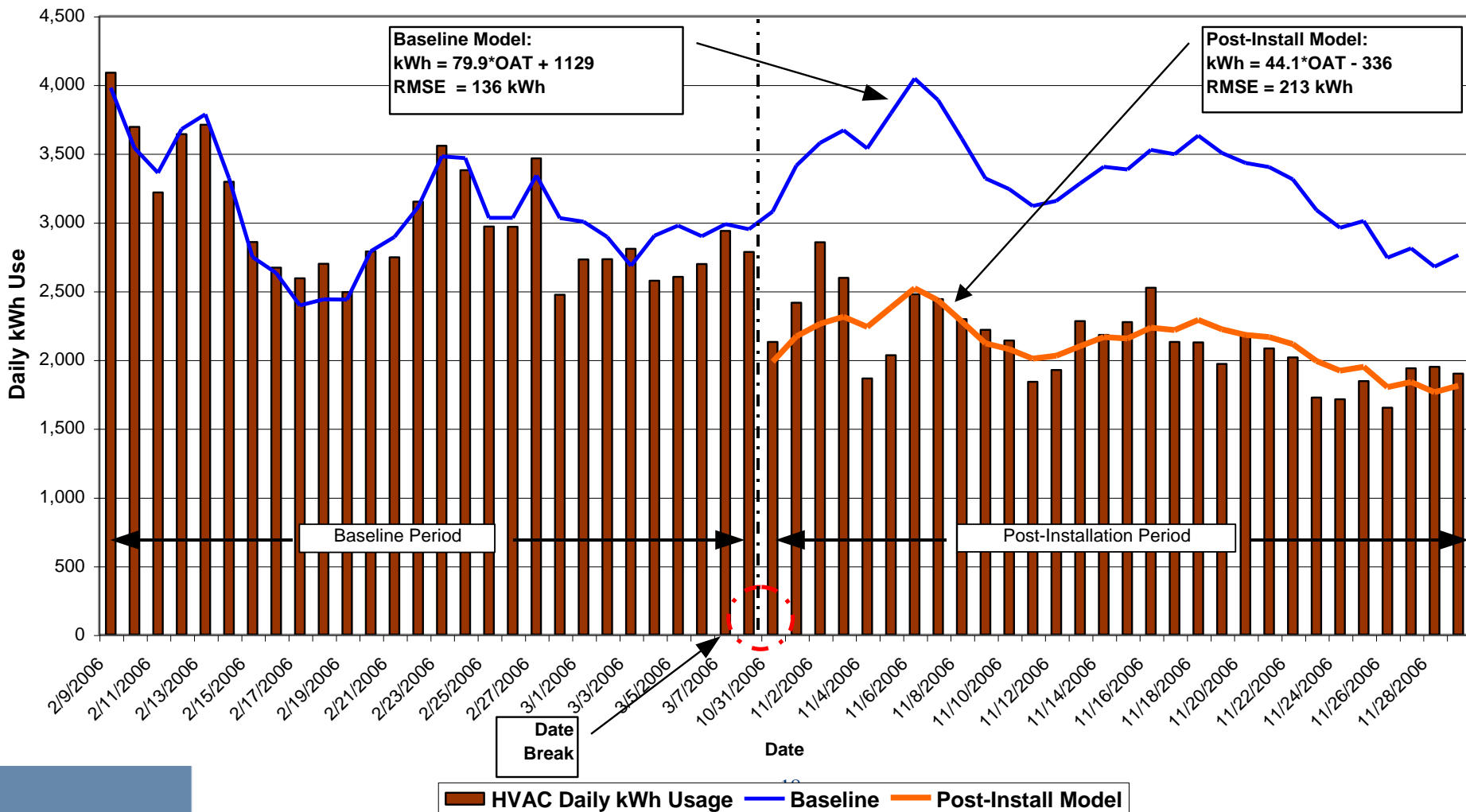
Electric Meter Savings

- **Electric Model**
- **Baseline**
  - **2p Multivariable**
    - **Time unit: Daily**
    - **Ind. Variables**
      - **OAT**
      - **Day of week**
  - **CV-RMSE: 10.5%**
  - **R^2: 0.70**
- **Post-Install**
  - **CV-RMSE: 8.3%**
  - **R^2: 0.77**
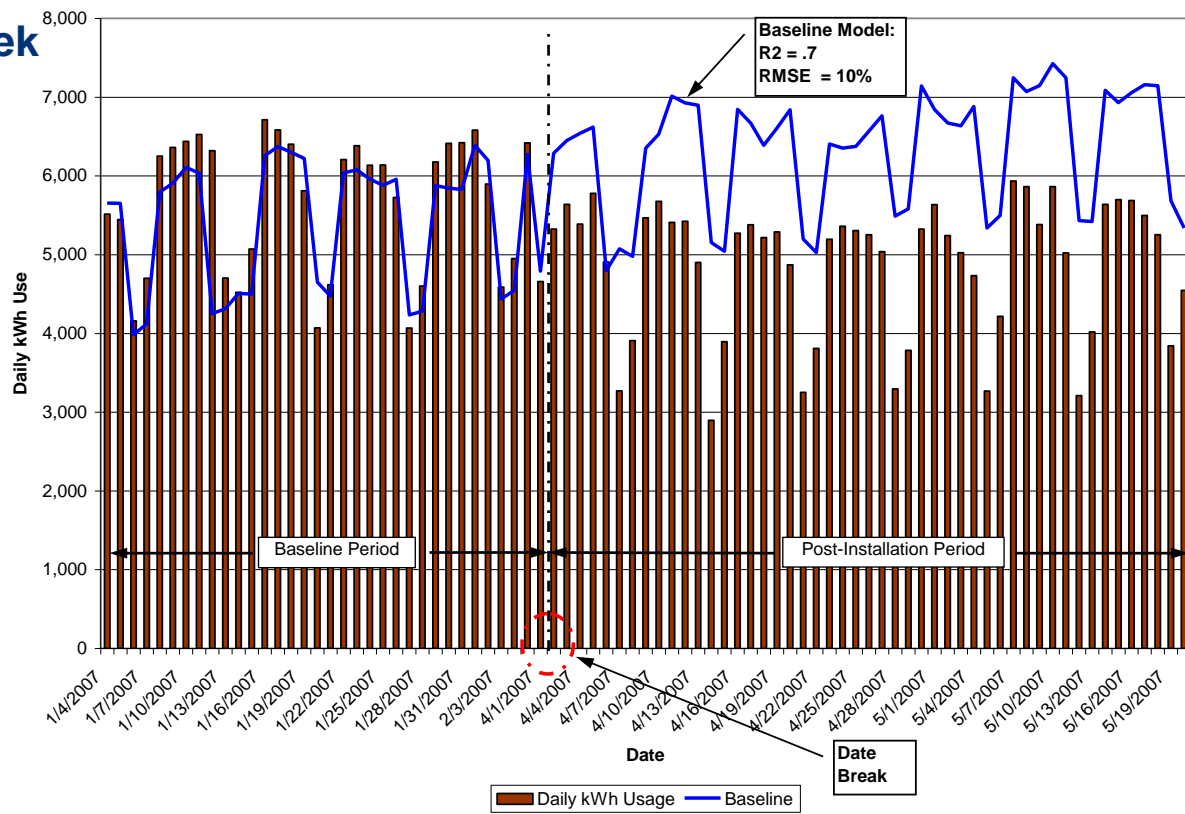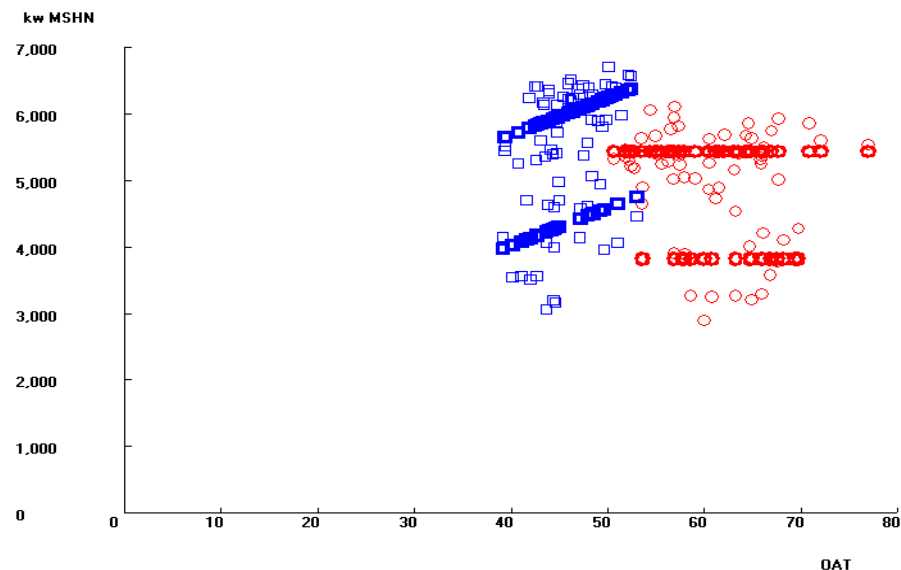
Chilled Water Savings

- **CHW Model**
- **Baseline**
  - **2p**
    - **Time unit: Hourly**
    - **Ind. Variable**
      - **OAT**
  - **CV-RMSE: 28%**
  - **R^2: 0.80**
- **Post-Install**
  - **CV-RMSE: 46%**
  - **R^2: 0.90**

SHIELDS.EXP.CHW.BTONS

AC-01 OAT

Baseline Model:
R2 = .8
RMSE = 26%

Baseline Period

Post-Installation Period

Date Break

Daily CHW Use (Ton-hrs)

Date

Daily CHW Usage — Baseline
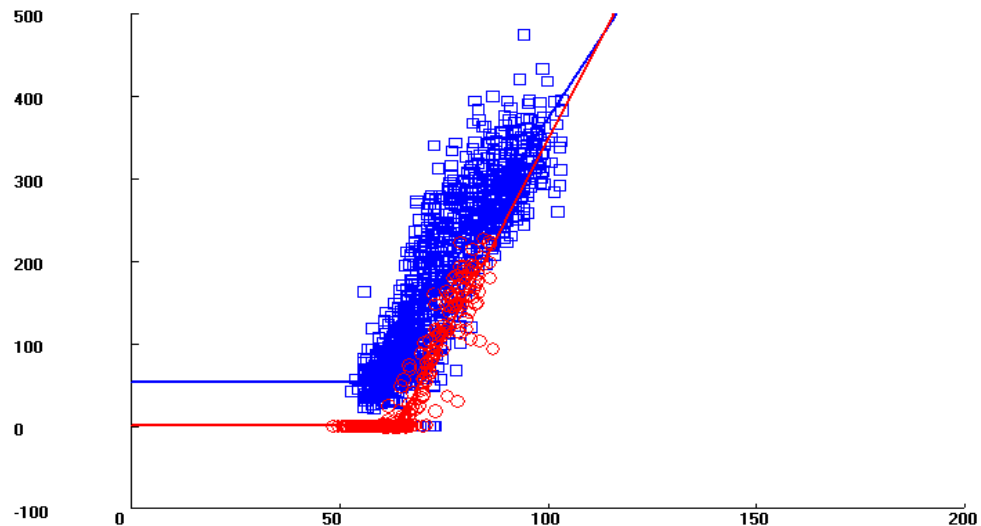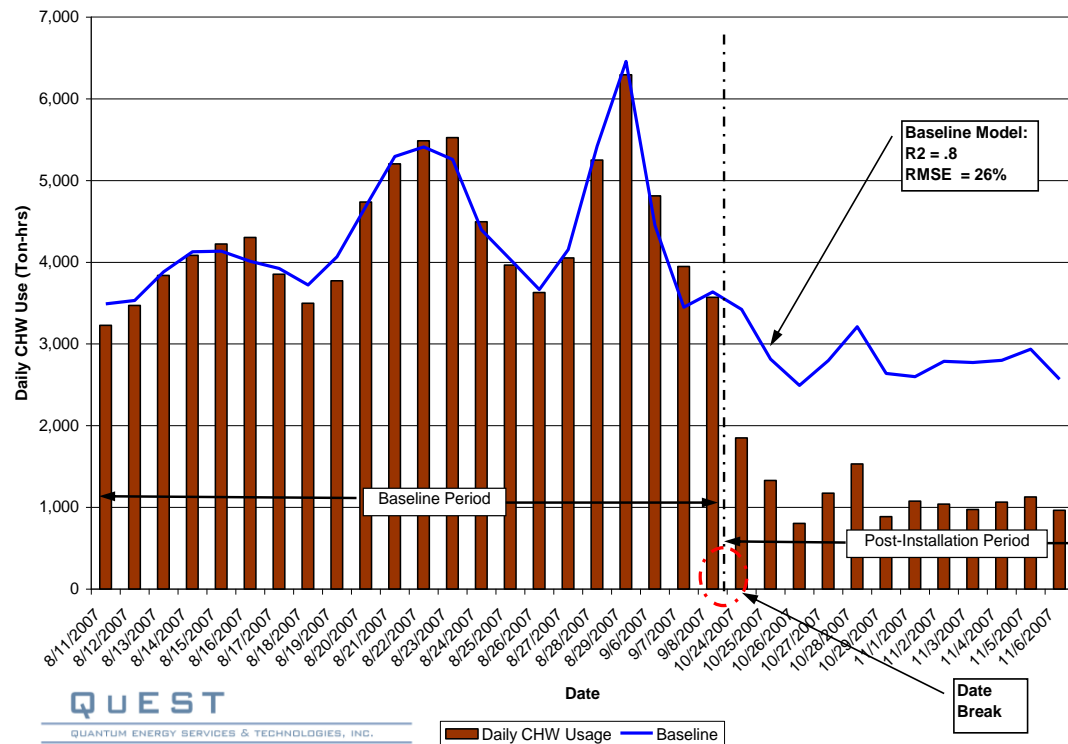
Hot Water Savings

- **HW Model**
- **Baseline**
  - **4p Multivariable**
    - **Time unit: Hourly**
    - **Ind. Variables**
      - **OAT**
      - **Day of week**
  - **CV-RMSE: 4.8%**
  - **R²: 0.69**
- **Post-Install**
  - **CV-RMSE: 64%**
  - **R²: 0.30**
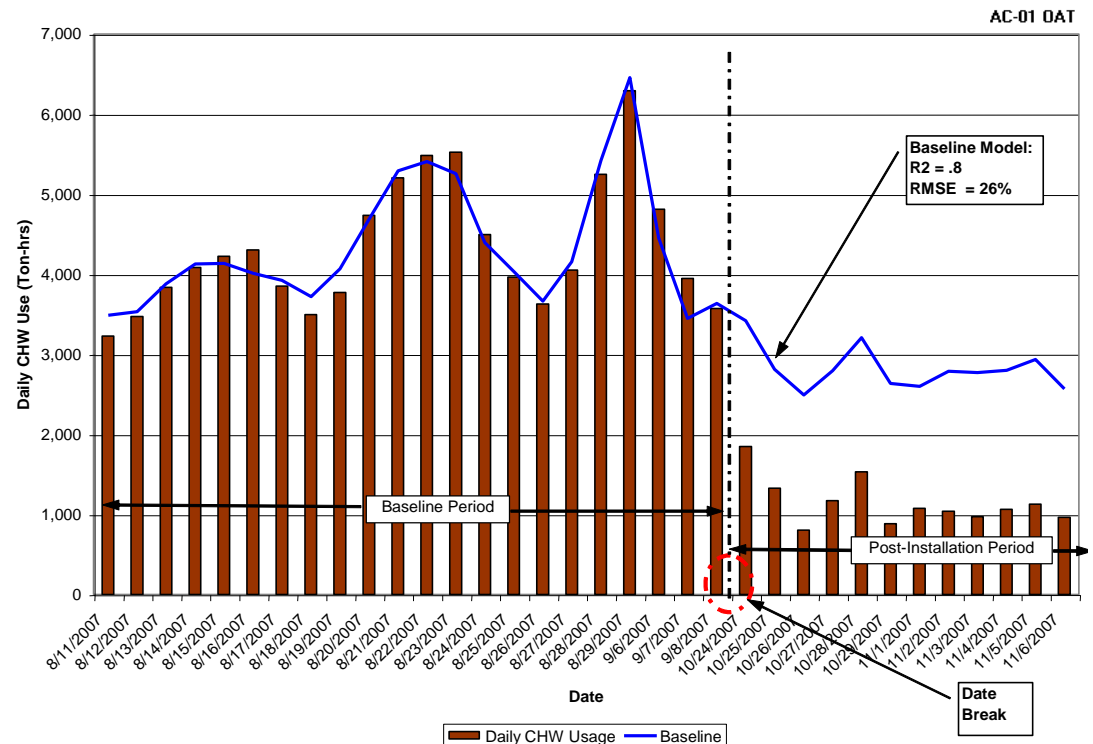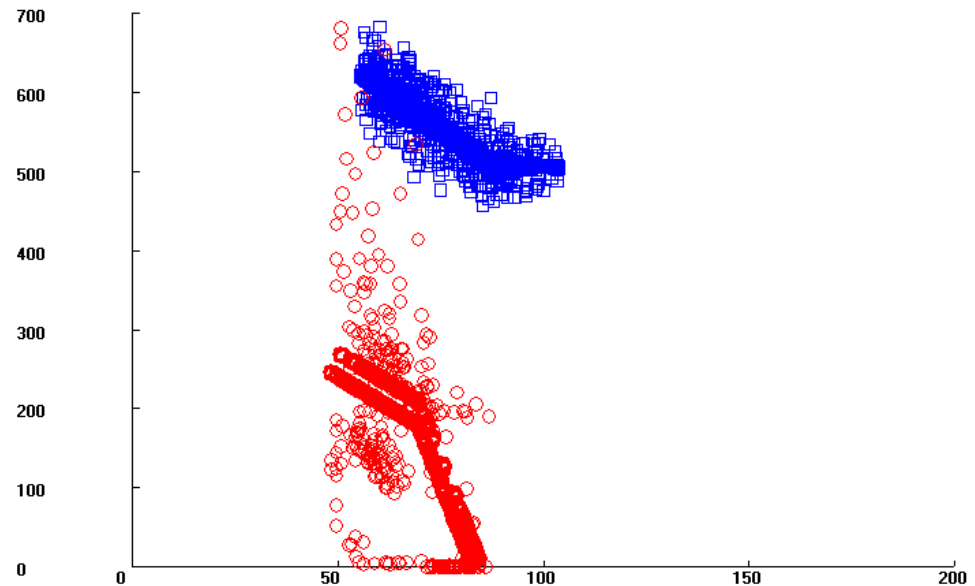
Office Building Savings
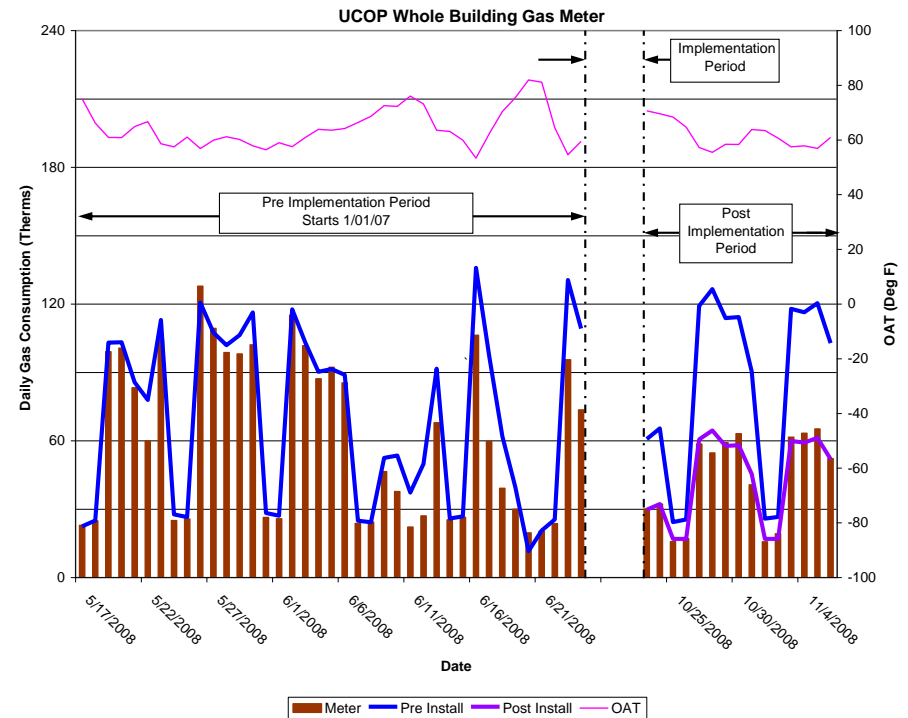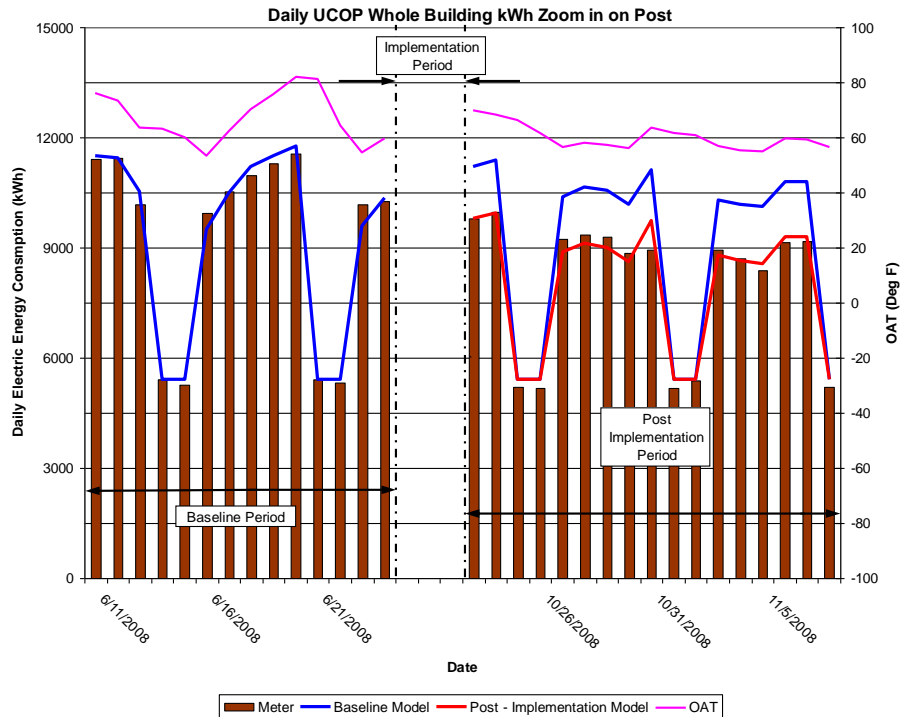
MBCx Costs & Benefits

Building	Metering Costs	MBCx Agent	In-House Costs	Total
Computer Science Building	$ 4,442	$ 62,160	$ 51,087	$ 117,689
Chemistry Building	$ 22,573	$ 53,000	$ 15,300	$ 90,873
University Library (Example 3)	$ 26,000	$ 96,795	$ 57,757	$ 180,552

- **Including all costs and verified savings, project remains cost-effective:**
  - **Computer Science: 1.7 year payback**
  - **Chemistry: 0.7 year payback**
  - **University Library: 1.0 year payback**
- **Added costs of metering hardware and software did not overburden project's costs**

Typical MBCx Project Timeline

3 to 6 mos.

Investigation
-Recommendations

1 to 2 mos.

Implementation

2 to 3 mos.

Turnover
-Verification
-Savings Analysis
-Final Report

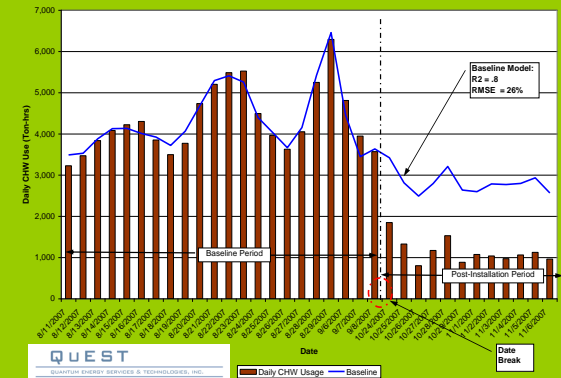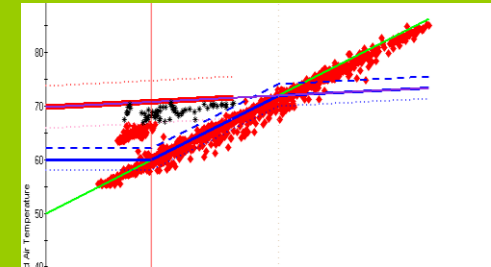**Program Evaluation**

3 to 6 mos.

Persistence
- Performance Tracking

Involved Parties

Operational & Energy Data

Typical RCx Program Incentive Structure

- **Program pays service provider for:**
    - **Initial scoping of project**
    - **Investigations and recommendations**
    - **Implementation assistance**
    - **Verification of installation**
    - **Final report and training**

- **Program pays customer incentives for:**
    - **Measures that save energy at $X/kWh, $Y/therm, $Z/kW**
        - **Lighting vs. HVAC incentive rates may be different**
        - **Capped at a % of measure or overall project cost**
    - **Some RCx programs pay for initial metering costs (UC MBCx)**

Energy Efficiency Spending in California

- **Approximately <u>$3.7B</u> in 2009 to 2011 program cycle**
  - **Approval delayed, bridge funding in place**
  - **Includes Residential, Commercial, Industrial Programs**
- **RCx/MBCx Programs:**
  - **PG&E Core RCx Program, SCE RCx Program**
  - **SDG&E & SMUD RCx Programs**
  - **Various 3rd Party and Local Govt. Programs**
    - **UC/CSU/IOU Partnership (Retrofit and MBCx) ~ $500M**
  - **Nationwide (see map)**
- **Data Center Programs**
  - **PG&E Data Center Cooling Controls Program**
  - **SCE Data Center Optimization Program**
  - **Silicon Valley Power Data Center Optimization Program**

States with RCx Programs

Questions?