17th NATIONAL CONFERENCE ON BUILDING COMMISSIONING

NCBC 2009

EFFICIENCY • PERSISTENCE • PERFORMANCE

# Time Savers for Energy Savers: Available EBCx Tools and Resources

## Based on Natural Resources Canada's Assessment (March 2009)

Existing Building Cx for Energy Savings

June 4, 2009

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P | E | C | I

# Acknowledgements

- RCx Tools assessment developed for Natural Resources Canada's CanmetENERGY
  - Recommissioning Tools Assessment Workshop (Montreal, March 2009)
  - Workshop focused on:
    - Existing RCx tool suitability and adaptability for Canada
    - Gaps in current set of tools
    - Future tool development work
  - Further information (guide, training, tools, etc.) at: www.canmetenergy.nrcan.gc.ca/eng/rcx.html
- This presentation is not as comprehensive; and focuses on most relevant U.S. tools

# AIA Quality Assurance

**Learning Objectives (shared with other "Existing Building Cx for Energy Savings" sessions)**

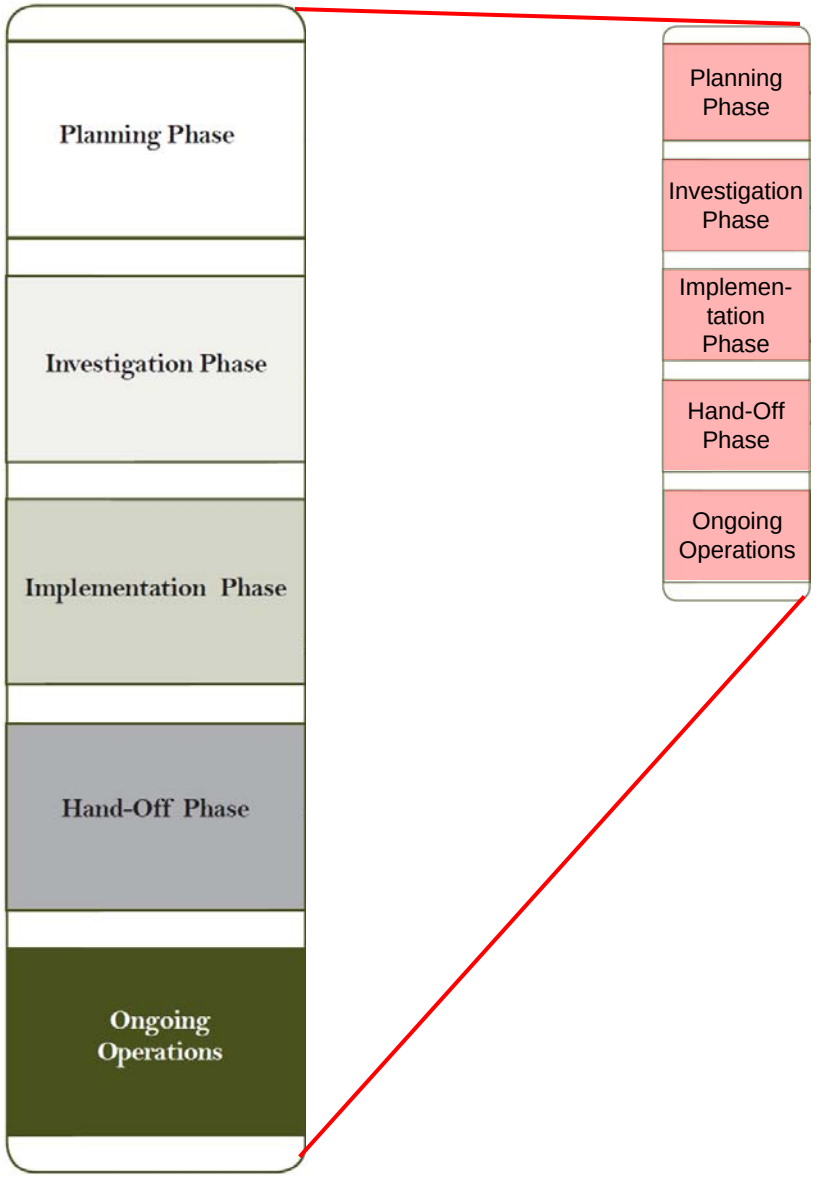
1. **Identify opportunities for improvements in the operation of existing non-residential buildings that will improve energy efficiency**
2. **Outline the underlying engineering principals of the indicators of energy-wasting operations**
3. **Compare the pros and cons of various energy calculation approaches**
4. **Analyze how progressing from data- to knowledge-based control systems insures that building systems sustain operation at commissioned parameters**

# What we'll cover:

- The EBCx Process
  - Brief!
- General overview of tools
  - Not 'hardware' tools, but 'software'
- Tools most applicable for EBCx

# The EBCx Process

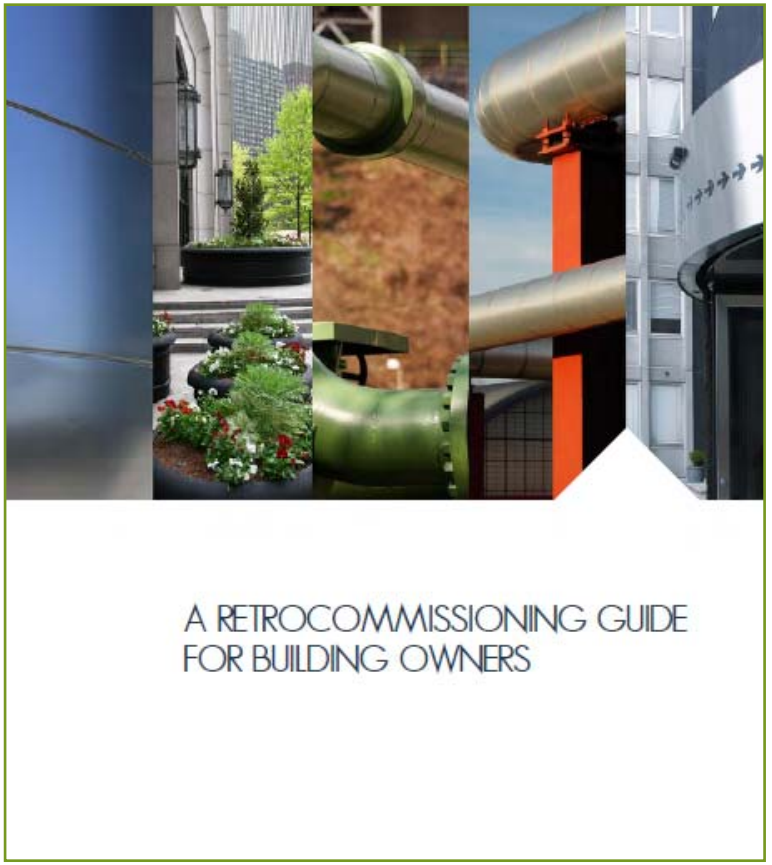
- Tools are available to assist Building Owners and EBCx Providers during each phase
  - From Planning through Ongoing Operations
- Will discuss tools in context of process
- On tools slides, look for key in corner for applicable process



# For more on the EBCx Process …

## EPA Retrocommissioning Guide

- Free and available through PECI's website
  - http://www.peci.org/Library/EPAguide.pdf
- Discusses the process in-depth
- A great resource!



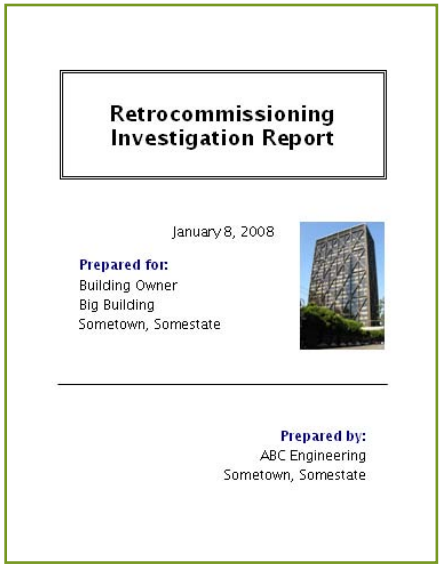
# Purpose of EBCx Tools

- To help quantify and document all aspects of EBCx
  - Savings estimates, measure costs, reports
- To spend more time on what's important, instead of developing calcs / reports from scratch. What's important:
  - Tuned, optimized buildings
    - Low energy use
    - Long equipment life
    - Preventive, not deferred, maintenance
  - Happy occupants

# Types of EBCx Tools

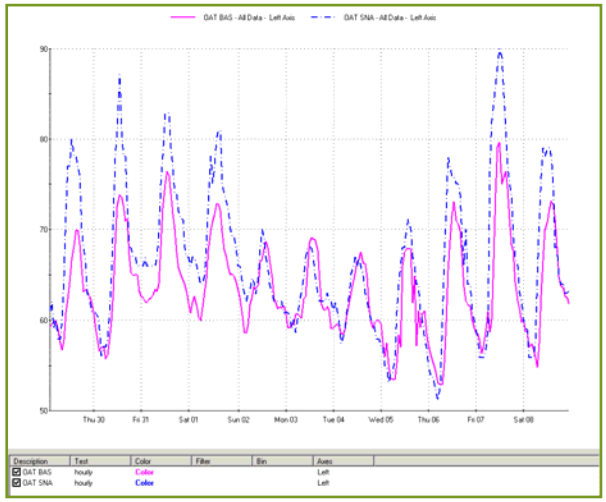
## Non-technical (process-oriented):

- Deliverable templates
- Deliverable samples
  - Templates with an example application




## Technical:

- Energy savings calculation tools
- Data analysis
- Equipment / systems testing guidance



# EBCx Tool Complexity

## Varying levels of complexity

- **Simple**: minimal inputs
  - E.g., benchmarking tools (Portfolio Manager)
- **Complex**: many inputs / steps
  - E.g., measure-specific spreadsheet calcs using trend data

# Tools we'll cover:

## Dave's take on tools most applicable for use with EBCx

- Organized by rough order of EBCx process

## Tools include:

- EPA's *Portfolio Manager*
- CCC's *RCx Toolkit*
  - Templates and sample documents
  - Utility Consumption Analysis
  - Energy Charting and Metrics
  - Fan and Pump Workbooks
  - Findings Workbook

# Tools we'll cover, cont'd:

- Weather / air properties tools
  - BinMaker PRO
  - Degreedays.net
  - PsycExcel, PsyCalc
- Functional Testing and Design Guides
- HVAC Equipment Tools
  - Titus's *TEAMS*
  - USA Coil's coil selection program
  - MotorMaster
  - B&G's *ESP-Plus* (pumps) and *SystemSyzer* (piping)

# Tools we'll cover, cont'd:

- PG&E's *Universal Translator*
- Systems-level performance monitoring
  - AEC's *Enforma*
  - Facility Dynamic's *PACRAT*
- Whole building performance monitoring
  - NorthWrite's *Energy Explorer*
- EERE's *Building Energy Software Tools Directory*

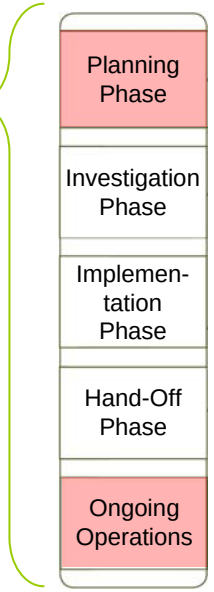
# And now …

## … the EBCx tools universe!

# "Portfolio Manager" ← web search where no URL indicated!

## Energy management / benchmarking tool

For each tool, look at this key for applicable phase




- Track and assess energy and water consumption across portfolio of buildings.
- Helps:
  - Set investment priorities
  - Identify under-performing buildings
  - Verify efficiency improvements
  - Receive EPA recognition for superior energy performance.

# CCC *RCx Toolkit*

## California Commissioning Collaborative

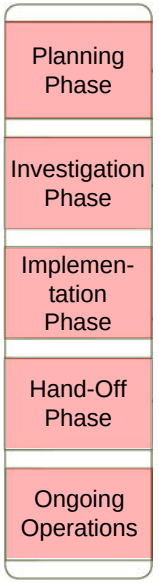
- Committed to improving the performance of buildings and their systems
  - http://www.cacx.org/
- Many tools and resources available for Providers and Owners
- All free and publicly available
  - Developed with public funding

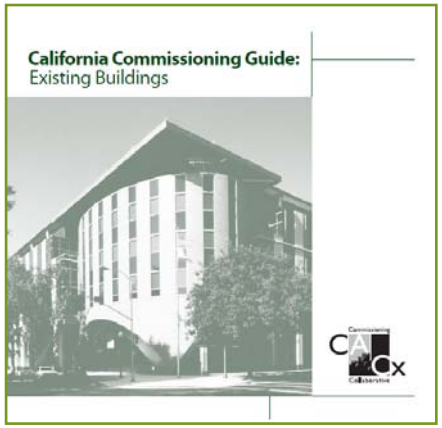
# CCC *RCx Toolkit:* Templates and Docs

## Templates and Sample Documents

- Typical deliverables and reports:
  - RFP Checklist
  - Building Staff Interview Form
  - List of Preferred Building Characteristics
  - Owner's Operating Requirements
  - Ongoing Cx Plan
    - Implementation Report
    - Sequence of Operation
    - Monitoring, Calibration and Training Plans

- MS Word format, customizable
- Referenced in CCC's Cx Guide for Existing Buildings



# Utility Consumption Analysis tool

- Calculates average daily energy consumption for each month based on monthly utility bills
- Normalizes bills to daily usage



**Calculation of Average Daily Utility Use**

**Utility Usage Data**

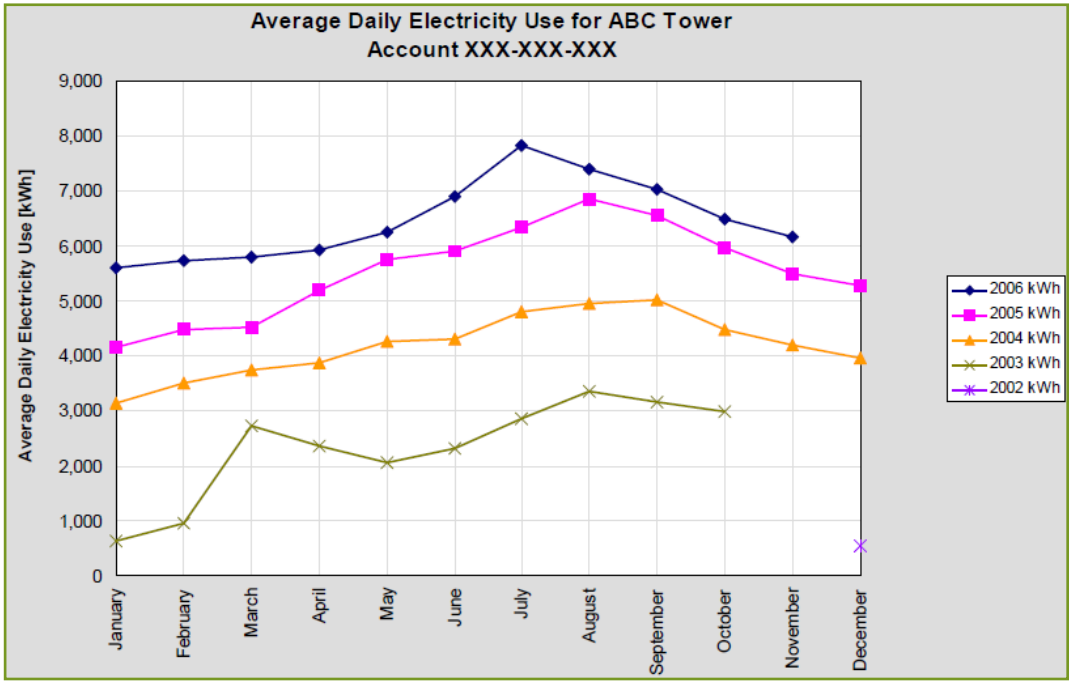
**Project Information**

| | |
|---|---|
| Date: | April 21, 2008 |
| Project Name: | ABC Tower |
| Utility Type | Electricity |
| Utility Units | kWh |
| Utility Company | Pacific Gas and Electric |
| Account Number: | XXX-XXX-XXX |

| Date & Time | Billed Usage, kWh | Calculated Duration in Days | Input Duration in Days | Average Daily Use in Billing Period |
|---|---|---|---|---|
| 11/27/06 12:00 PM | 203,768 | 33.0 | 0.0 | 6,175 |
| 10/25/06 12:00 PM | 197,242 | 30.0 | 0.0 | 6,575 |
| 9/25/06 12:00 PM | 228,469 | 32.0 | 0.0 | 7,140 |
| 8/24/06 12:00 PM | 216,998 | 29.0 | 0.0 | 7,483 |

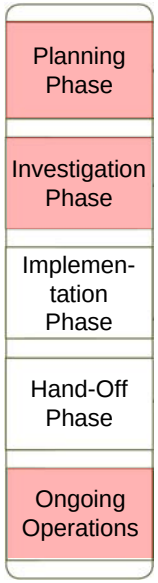
# UCA Output

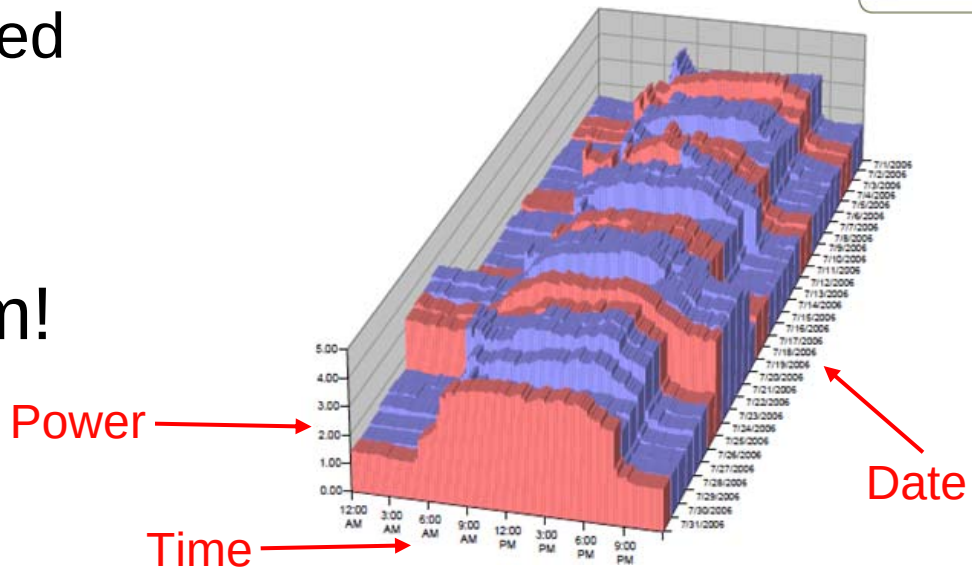
- Not normalized for weather
- Could normalize by applying CDD, HDD, or other drivers



# Energy Charting and Metrics

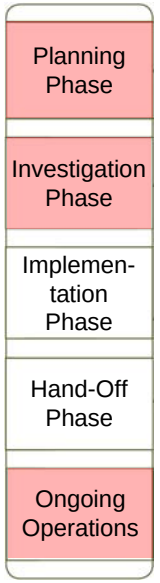
- Excel-based
- Facilitates analysis of building energy info
- Excel capabilities are accessible
  - Other summaries and charts can be added
- Low cost energy information system!

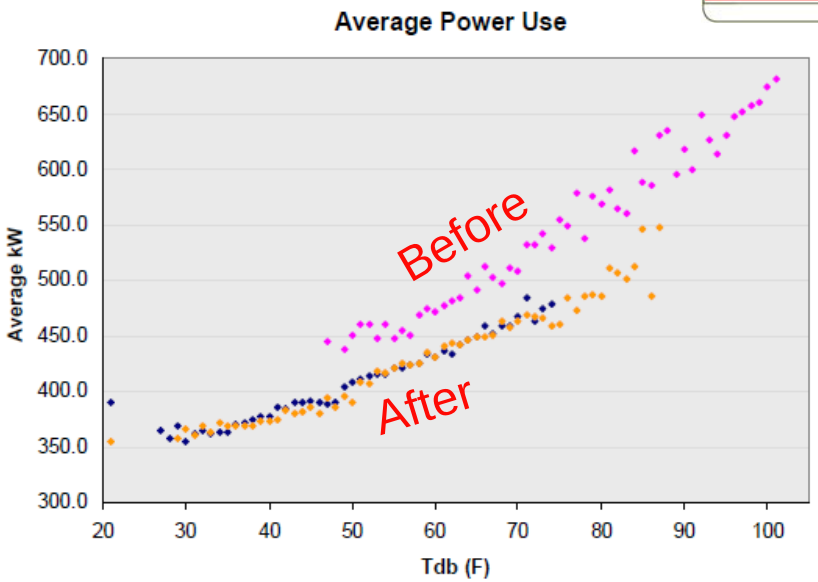


# CCC *RCx Toolkit:* ECAM

- Metrics can be normalized:
  - Building area (e.g., W/sqft)
  - Cooling efficiency (e.g., kW/ton)
  - Airflow (e.g., W/cfm)
- Metrics can be filtered:
  - Time of day, year, month, daytype
  - Pre/post time periods
  - Weather conditions

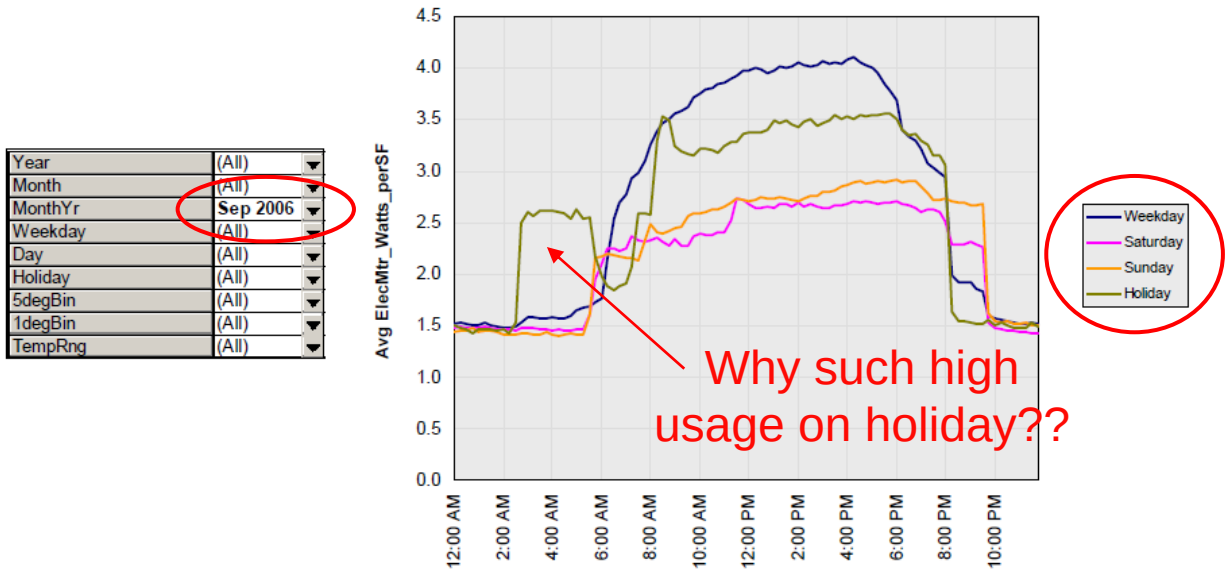


# Energy Charting and Metrics (ECAM)

- Common application: convert utility interval data to useable format
  - For analysis and identification of opportunities
  - Can include relevant independent variables (e.g., OAT) for additional analysis

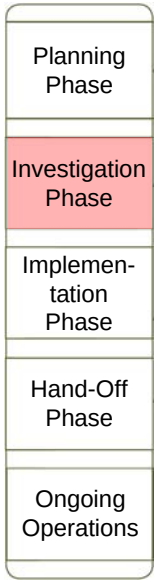




# Fan and Pump Workbooks

- Seven common EBCx measures grouped into two Excel workbooks:

| Workbook | Measure |
|---|---|
| Pump Workbook | Reduce water flow |
| | Reduce differential pressure setpoint |
| | Reset differential pressure setpoint |
| Fan Workbook | Change VAV box minimum flow setpoint |
| | Reduce duct static pressure setpoint |
| | Reset duct static pressure setpoint |
| | Reset supply air temperature setpoint |



# CCC *RCx Toolkit:* Fan Workbook

## Input Screen

- Enter project-specific info
- Worksheets for reference
- Inputs in graphical form

Instructions | Data Input Guidance | *Scroll down to enter project information*

**Project Fan Info**

**Maximum efficiency point**
**Project Fan Design Point**
Design point is optional entry, for reference only

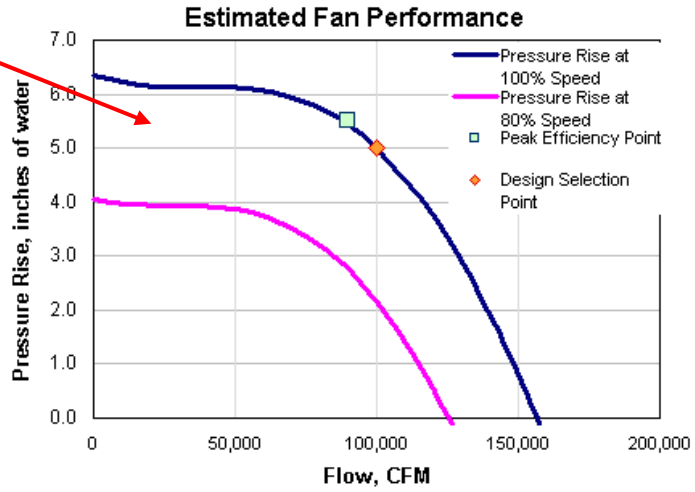
| Speed, rpm | Flow, CFM | static, in. H2O | effy | | Brake HP |
|---|---|---|---|---|---|
| 900 | 90,000 | 5.5 | 68.8% | | 110.0 |
| 900 | 100,000 | 5.0 | 66.5% | | 115.0 |

**Fan Curve:** **Generic (33-inch Backward Inclined - DWDI)**

| Speed, rpm | Flow, CFM | static, in. H2O | effy | | Brake HP |
|---|---|---|---|---|---|
| 1139 | 1 | 6.0 | 0.0% | | 8.5 |
| | 7,000 | 5.9 | 45.1% | | 14.0 |
| | 14,000 | 5.7 | 58.1% | | 21.0 |
| | 22,000 | 5.5 | 69.0% | | 26.8 |
| | 26,000 | 5.2 | 70.8% | | 29.2 |
| | 30,000 | 4.5 | 65.9% | | 31.3 |
| | 34,000 | 3.8 | 61.7% | | 32.0 |
| | 38,000 | 2.5 | 45.4% | | 32.0 |
| | 42,000 | 1.3 | 26.8% | | 31.2 |
| | 45,300 | 0.0 | 0.0% | | 30.0 |

Show Fan Curve Fit Worksheet

Show VFD and Motor Efficiency Worksheet




Planning Phase

Investigation Phase

Implementation Phase

Hand-Off Phase

Ongoing Operations

# CCC *RCx Toolkit:* Fan Workbook

## More input

- Input flows, hours at flows, baseline conditions, and ECM conditions

Instructions | Data Input Guidance | Note: please be patient with this iterative calculation - see notes below | This completes pressure, flow and hours adjustment - SA reset on next tab | **Calculate Energy Use and Savings** | Required Data | Optional Data | Detailed Input

**Scenario Analysis Inputs**

| Design: 100,000 CFM<br>Design SP: 5.00 in wg | Baseline - VSD with high SP setpoint | | This Case Not Used | | Reduce Static Pressure Setpoint | | Reset Static Pressure Setpoint by Zone Damper | | |
|---|---|---|---|---|---|---|---|---|---|
| | Static pressure **setpoint**, in. w.g.: | 2.00 | Static pressure setpoint, in. w.g.: | 2.00 | Static pressure **setpoint**, in. w.g.: | 1.50 | Maximum Static pressure setpoint, in. w.g.: | 1.50 | Use Optimum Reset |
| | | | Copy Flows from Baseline | Copy Hours from Baseline | | | Minimum setpoint for optimum reset: | | 0.60 |

| Ambient Temp, °F | Flow, CFM | Hours at Flow | Flow, CFM | Hours at Flow | Flow, CFM | Hours at Flow | Flow, CFM | Hours at Flow | Static Pressure Setpoint |
|---|---|---|---|---|---|---|---|---|---|
| 102.5 | 100,000 | | 100,000 | | 100,000 | 0 | 100,000 | 0 | 0.70 |
| 97.5 | 100,000 | | 100,000 | | 100,000 | 0 | 100,000 | 0 | 0.70 |
| 92.5 | 100,000 | 10 | 100,000 | 10 | 100,000 | 10 | 100,000 | 10 | 0.70 |
| 87.5 | 96,000 | 20 | 96,000 | 20 | 96,000 | 20 | 96,000 | 20 | 0.64 |
| 82.5 | 92,000 | 60 | 92,000 | 60 | 92,000 | 60 | 92,000 | 60 | 0.60 |
| 77.5 | 88,000 | 500 | 88,000 | 500 | 88,000 | 500 | 88,000 | 500 | 0.60 |
| 72.5 | 84,000 | 800 | 84,000 | 800 | 84,000 | 800 | 84,000 | 800 | 0.60 |
| 67.5 | 80,000 | 1,100 | 80,000 | 1,100 | 80,000 | 1,100 | 80,000 | 1,100 | 0.60 |
| 62.5 | 76,000 | 1,300 | 76,000 | 1,300 | 76,000 | 1,300 | 76,000 | 1,300 | 0.60 |
| 57.5 | 72,000 | 1,400 | 72,000 | 1,400 | 72,000 | 1,400 | 72,000 | 1,400 | 0.60 |
| 52.5 | 68,000 | 1,700 | 68,000 | 1,700 | 68,000 | 1,700 | 68,000 | 1,700 | 0.60 |
| 47.5 | 64,000 | 1,000 | 64,000 | 1,000 | 64,000 | 1,000 | 64,000 | 1,000 | 0.60 |
| 42.5 | 63,000 | 600 | 63,000 | 600 | 63,000 | 600 | 63,000 | 600 | 0.60 |
| 37.5 | 62,000 | 200 | 62,000 | 200 | 62,000 | 200 | 62,000 | 200 | 0.60 |
| 32.5 | 61,000 | 50 | 61,000 | 50 | 61,000 | 50 | 61,000 | 50 | 0.60 |
| 27.5 | 60,000 | 20 | 60,000 | 20 | 60,000 | 20 | 60,000 | 20 | 0.60 |
| 22.5 | 60,000 | | 60,000 | | 60,000 | 0 | 60,000 | 0 | 0.60 |
| 17.5 | 60,000 | | 60,000 | | 60,000 | 0 | 60,000 | 0 | 0.60 |
| 12.5 | 60,000 | | 60,000 | | 60,000 | 0 | 60,000 | 0 | 0.60 |
| 7.5 | 60,000 | | 60,000 | | 60,000 | 0 | 60,000 | 0 | 0.60 |
| | Total Hours: | 8,760 | | 8,760 | | 8,760 | | 8,760 | |
| Weighted average flow: | 73207 | | 73207 | | 73207 | | 73207 | | |

- Then click here …

Planning Phase | Investigation Phase | Implementation Phase | Hand-Off Phase | Ongoing Operations

# CCC *RCx Toolkit:* Fan Workbook

## Output

- Shows baseline and ECM conditions
  - Both text and graphical

**Fan Savings Summary**

| | |
|---|---|
| 418,600 kWh/yr | Baseline - VSD with high SP setpoint energy use |
| 418,600 kWh/yr | This Case Not Used energy use |
| 0 kWh/yr | Savings |
| 372,800 kWh/yr | Reduce Static Pressure Setpoint energy use |
| 45,800 kWh/yr | Additional savings to the reduced flow scenario |
| 305,500 kWh/yr | Reset Static Pressure Setpoint by Zone Damper energy use |
| 67,300 kWh/yr | Additional savings to the improved variable speed scenario |
| 113,100 kWh/yr | Total Annual Fan Energy Savings |

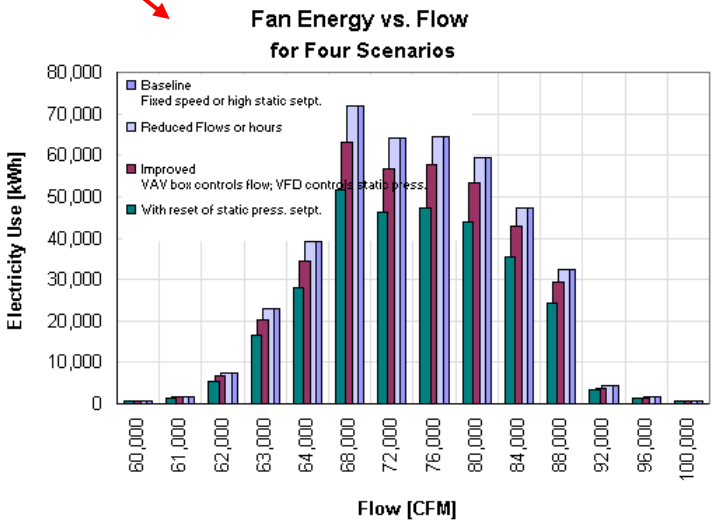
Note: There may be additional savings due to reduced reheat or cooling energy.

Baseline - VSD with high SP setpoint
2" DSP SP

This Case Not Used
Details for case 1

Reduce Static Pressure Setpoint
1.5" DSP SP

Reset Static Pressure Setpoint by Zone Damper
Reset based on box position




Planning Phase

Investigation Phase

Implementation Phase

Hand-Off Phase

Ongoing Operations

# CCC *RCx Toolkit:* Fan and Pump Workbooks

- Pump workbook is similar to fan workbook
- Both fan and pump workbooks:
  - Are Excel-based
  - Model a complete flow loop
  - Utilize a single-zone model
  - Rely on project-specific data for inputs
    - Like all models, beware of GIGO

Planning Phase

Investigation Phase

Implemen-tation Phase

Hand-Off Phase

Ongoing Operations

# CCC *RCx Toolkit:* Findings Workbook

## An organizational tool

- Project progress tracking
- Standard tables for reporting
- Clearly presents prioritized measures for implementation

Planning Phase

Investigation Phase

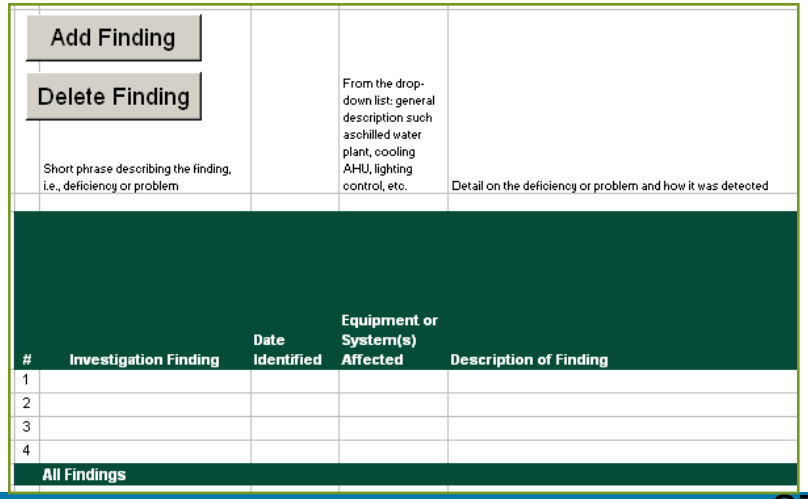
Implemen-tation Phase

Hand-Off Phase

Ongoing Operations

## Can be customized to suit needs:

- Individual RCx projects
- Utility RCx program



# Weather / Air Properties Example Tools

## BinMaker PRO

- U.S. hourly weather data for 239 cities.

## Degreedays.net

- Calculates degree-day data for weather stations worldwide.
- Free!

## PsycExcel, PsyCalc

- Add-in psychrometric programs for Excel.

Planning Phase

Investigation Phase

Implemen-tation Phase

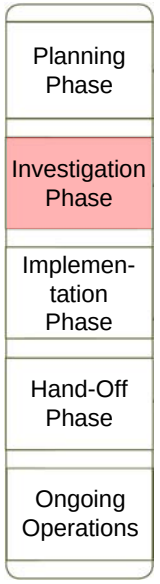
Hand-Off Phase

Ongoing Operations

# Functional Testing and Design Guides

## Three modules:

- Functional Testing Guide: Fundamentals to the Field
  - Explains the “how” and “why” behind the functional tests
- Checklist Tool and Test Directory
  - For systems and components covered in the FT Guide (HVAC, power, etc)
- Control System Design Guide
  - A toolbox of templates for improving control system design and specification
- Available at FTGuide.org



# Functional Testing and Design Guides

- Test forms can be adjusted to suit project-specific conditions

Planning Phase

Investigation Phase

Implemen-tation Phase

Hand-Off Phase

Ongoing Operations

**Combined Forms: Component-Level Prefunctional Checkli**

| ID# | Test Name |
|---|---|
| 276 | Chilled Water Piping Prefunctional Checklist |
| 420 | VFD Pump Application |
| 1009 | Hot Water System Pump Test |
| 1010 | Chilled Water System Pump Test |
| 1011 | Condenser Water System Pump Test |
| 1012 | Data Collection Procedures for Hot Water Heating Pumps |
| 272 | Calibration and Leak-by Test Procedures |
| 281 | Fan-Coil Unit Prefunctional Checklist |
| 282 | Heating Water Piping Prefunctional Checklist |
| 294 | Cabinet Unit Heater Functional Test |
| 300 | Fin Tube Radiator Functional Test |
| 301 | Heating Fan Coil Unit Functional Test |

# HVAC Equipment Tools

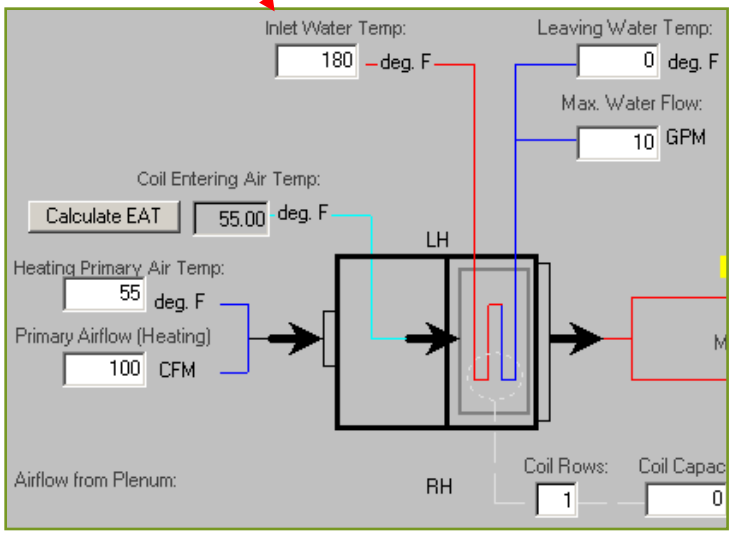
## Titus Teams

- Selection program for grilles, registers, diffusers, and VAV terminals.
- Can test system performance at different conditions.

Planning Phase
Investigation Phase
Implemen-tation Phase
Hand-Off Phase
Ongoing Operations

## USA Coil Selection Program

- Heating / cooling coil selection program. Includes costs.




## MotorMaster+

- Motor selection program.

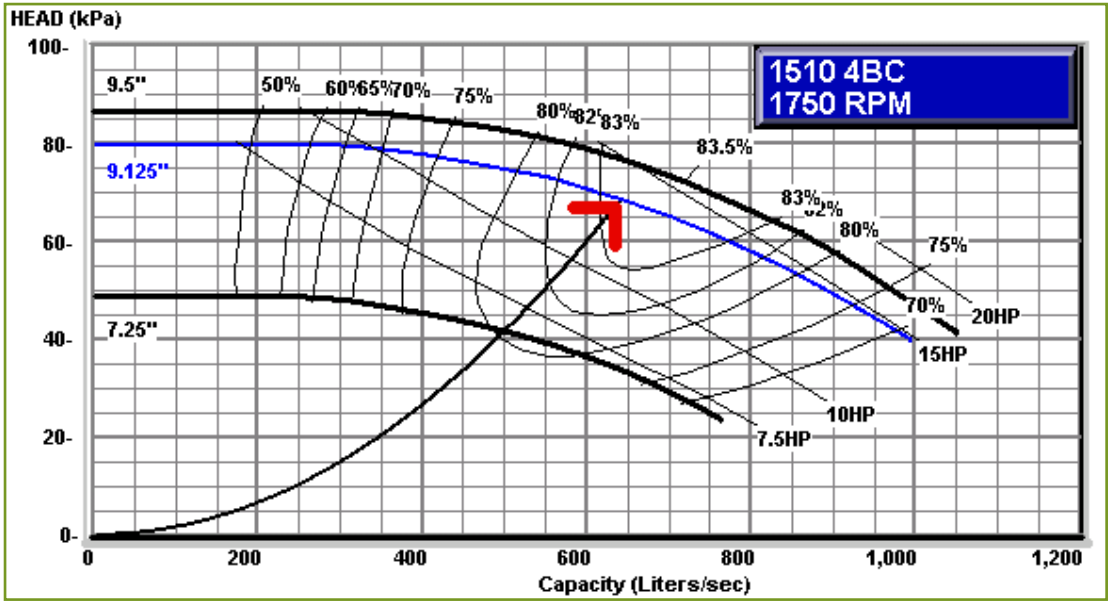
# HVAC Equipment Tools

## ESP Plus (B&G)

- Pump selection program.

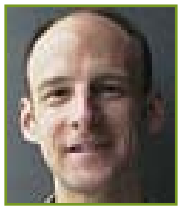
## System Syzer (B&G)

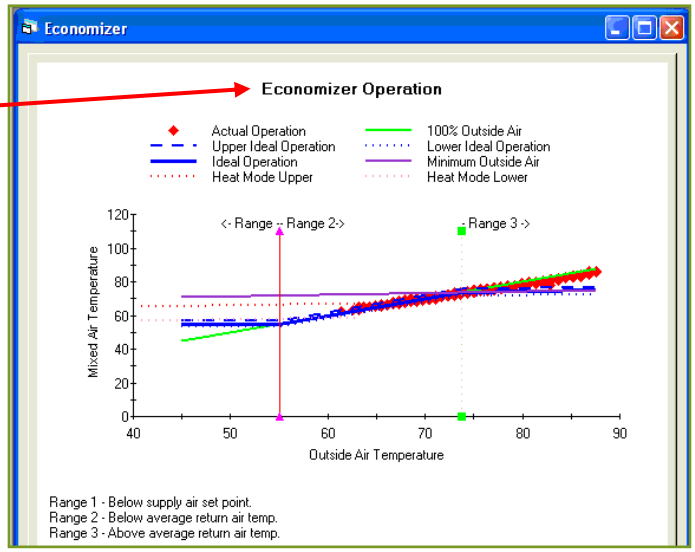
- Calculates fluid properties in piping systems.



# Universal Translator (UT)

- Software for management and analysis of data from loggers and BAS trends.
- Key features of UT:
  - Combines several different types of data sets
  - Filters data for occupied schedules
  - Creates regressions and graphs
  - Analyzes data for certain systems (e.g., airside economizers)
- Stay tuned for more about UT!






Planning Phase

Investigation Phase

Implemen-tation Phase

Hand-Off Phase

Ongoing Operations

# Performance Monitoring Tools

## Systems-level

- Monitors data from a BAS to continuously identify EBCx opportunities
- Examples: Enforma (AEC), PACRAT (Facility Dynamics)

Planning Phase

Investigation Phase

Implemen-tation Phase

Hand-Off Phase

Ongoing Operations

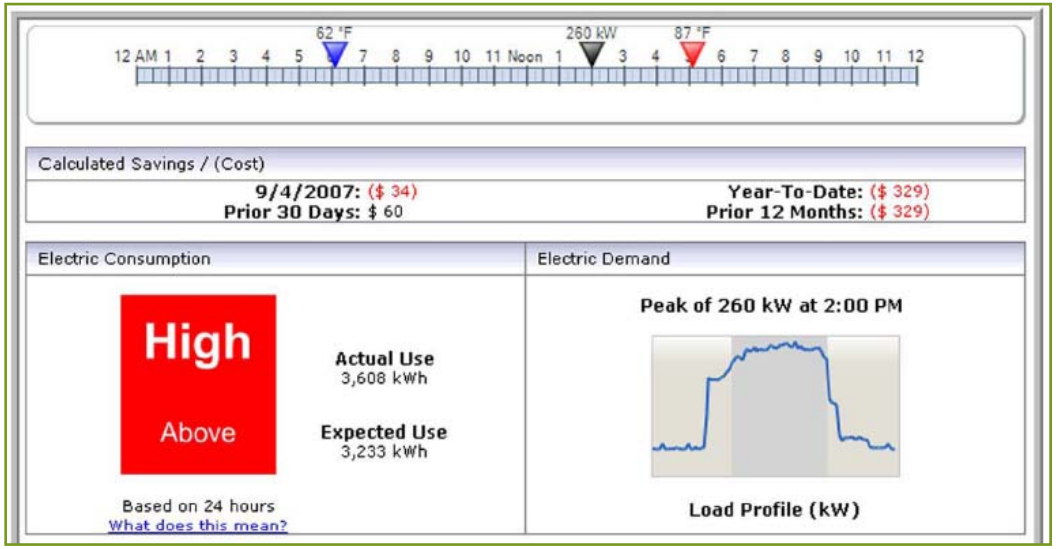
**AHU_CT_12: Sun, 4/13 - Thu, 4/17**

| Day | Mode | Minutes | Rule |
|---|---|---|---|
| Sun, 4/13 | MxOA+MC | 95 | OAT is less than SAT setpoint. MxOA+MC is incorrect mode |
| Sun, 4/13 | MxOA+MC | 290 | MAT is greater than OAT. During economizer cooling, MAT |
| Sun, 4/13 | MxOA | 120 | MAT is greater than OAT. During economizer cooling, MAT |
| Mon, 4/14 | MxOA+MC | 240 | OAT is less than SAT setpoint. MxOA+MC is incorrect mode |
| Mon, 4/14 | MxOA+MC | 480 | MAT is greater than OAT. During economizer cooling, MAT |
| Tue, 4/15 | MxOA+MC | 90 | OAT is less than SAT setpoint. MxOA+MC is incorrect mode |
| Tue, 4/15 | MxOA+MC | 280 | MAT is greater than OAT. During economizer cooling, MAT |
| Wed, 4/16 | MxOA+MC | 525 | OAT is less than SAT setpoint. MxOA+MC is incorrect mode |
| Wed, 4/16 | MxOA+MC | 630 | MAT is greater than OAT. During economizer cooling, MAT |

# Performance Monitoring Tools

## Whole-building level

- Monitors energy consumption, identifies degradation in efficiency.
- Example: Energy Expert (NorthWrite)




Planning Phase

Investigation Phase

Implementation Phase

Hand-Off Phase

Ongoing Operations

# Another tool resource

## Building Energy Software Tools Directory (EERE)

- 364 tools for evaluating energy efficiency, renewable energy, and sustainability in buildings.
  - May be less applicable to EBCx than other tools covered so far
- Includes free and commercially available tools

# Summary

## Lots of tools available to help streamline EBCx projects

- No need to reinvent the wheel.
- And more tools on the way
  - The universe is expanding, right?

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**Thank you!**

Next up: **How to Spot Opportunities for Fast Paybacks**

The signs that signal opportunities, how to spot them, and why they save

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