Commissioning Series Classes

Presented by

Facility Dynamics Engineering

Pacific Energy Center

- Design Details Design Briefs Series Training
- DD Phase AE Coordination Design Brief Training
- Pump Application Design Brief Training
- HVAC Design Fundamentals for the Field
- Functional Testing Guide training
- Analog Lessons for the Digital World – includes lab sessions with control system demonstrators
- Design Review Training – Lecture and afternoon workshop
- Persistence of the Benefits of Commissioning Training (with Hannah Friedman; Presented multiple times with enhancements each time)
- Top 10 Commissioning Issues (Variation of the NCBC workshop)
- Existing Building Commissioning Workshop Series, Eight (going on nine) - year-long sessions to-date with monthly one day classes focusing on hands-on instruction in field techniques for retrocommissioning
- Automated Diagnostics (with Larry Lister and Mark Cherniack) (One time)
- HVAC Calculations (One time)
- Design, Performance, and Commissioning Issues Series
    - Fans, Ducts, and AHUs
    - Economizers
    - VAV Systems
    - Pumps
    - Chilled and Condenser Water Systems
    - Hot Water and Steam Systems
    - Control Systems (includes 6 station afternoon workshop with hands-on experience with controls and concepts)
    - Variable Speed Drives
- Commissioning with Data Loggers (with Ryan Stroupe)
- Control Fundamentals
- Commissioning DDC Controls (with Jay Santos and Brian Russell)
- Commissioning Processes
- Design and Commissioning Tools (One time)
- HVAC Fundamentals for the Field
- Integrated Interactions
- Logic Diagram Workshop
- On Demand Training on Induction Theory, Induction Motors, and Pump/Motor Interactions
- Operating Your Facility with an Eye Towards Sustainable Operations
- RCx 101
- Resources for the Resourceful
- System Diagrams Workshop
- VRF Systems – The Good, the Bad and The Ugly – Cx Providers Perspective Module

San Diego Gas & Electric

- Retrocommissioning Program Training - 2004

Sacramento Municipal Utility District

- Commissioning for Architects – 2006
- Analog Lessons for a Digital World
- Top 10 Commissioning Issues – Variation on the PEC class listed above
- Design Phase Commissioning
- HVAC Fundamentals for Retrocommissioning
- Control System Fundamentals – Presented multiple times
- Economizers – Presented multiple times
- A Technical Overview of Retrocommissioning

- Pumps
- Chilled and Condenser Water Systems Commissioning Issues
- Retrocommissioning 101 (Variation on the PEC class)

UC Berkeley

- MBCx Technical Fundamentals – 10 half day sessions designed to support the MBCx process for the PPCS and Capital Projects staff
- MBCx Implementation - 2 half day sessions designed to ensure persistence of the MBCx implementations to date

NYSERDA

- The NYSERDA - Retro-commissioning Initiative - Orientation and Training – Spring and Fall - 2004

STAC

- Developed and presented Retrocommissioning Tools and Techniques – Hands-on Training at the NYMEX Building
- Worked on developing the NYMEX class above into a portable training class that could be held in other venues

University of Wisconsin

- The Commissioning Process for Retro-Commissioning Projects – 2005 – Las Vegas - Typical Retro-Commissioning Opportunities Module
- Commissioning DDC and Pneumatic Controls for New and Existing Buildings – Lead Instructor, co-taught with Larry Luskay and Jay Santos. Three day class with a significant hands-on component using control system demonstrators to illustrate lecture principles. Repeated as demand dictates.
- DDC Controls – Co-taught with Jay Santos, Steve Briggs, and Bob Schultz. Four and a half day class focusing on DDC control system design and procurement. Repeated 2 to 4 times a year

Marriott

- Marriott Retrocommissioning program development team
- 2007 Advanced Engineering Management Program – Multi-week/multi-session hands-on retrocommissioning training program – delivered technical track.
- 2008 Advanced Engineering Management Program – Similar to above
- 2011 – 2012 Advanced Engineering Program – Similar to above but with business skills, presentation skills, and communications skills tracks
- 2012-2013 Advanced Engineering Program – Similar to above but converted to a real time in-building training process
- 2013-2014 Advanced Engineering Program – Similar to above – currently in planning phase

ASHRAE Golden Gate Chapter

- A Retro commissioner's Retrospective on Retrofits

Electric League of the Pacific Northwest

- Powerful Business – 2011 – Building Optimization and Commissioning
- Practical Existing Building Commissioning Workshop – 3 day workshop – 2011 – Co-presented with Jay Santos

Energy Center of Wisconsin

- Facility Operations and Maintenance: Achieving Operational Efficiency Workshop - 2011

City of Palo Alto Utilities

- Retrocommissioning – What and Why – 2002
- Functional Testing Guide Workshop – 2007
- RCx 101 Workshop – Spring 2007
- RCx 101 Workshop – Fall 2007
- Introduction to Retrocommissioning – Spring 2013

California Department of General Services

- Introduction to Commissioning

ASHRAE Inland Empire Chapter

- Cost And Energy Saving Duct, Piping, and Control System Design Details
- The AHU from Hell; a Case Study

Southern California Edison

- Fundamentals of Pump Troubleshooting Workshop (complemented Pump Troubleshooting Design Brief)
- Emerging Technologies Summit – 2010 - Advanced Air Filtration

Building Commissioning Association

- Commissioning Control Sequences Webinar
- Lessons in Commissioning Control Systems

Better Bricks

- An O&M Formula for Improved Life Cycle Cost

Arizona Public Service Company (APS)

- Using Energy Management and Control Systems to Support Retrocommissioning Projects and Processes Workshop

Class Descriptions

Advanced Engineering Training

This class will highlight the engineering technical and management fundamentals necessary to implement MRCx and MCCx in typical Marriott facilities. The content will be an expanded and improved version of the content used for the first year class, reformatted to allow a significant portion of the lecture content to be delivered via Microsoft Live Meeting®, thereby allowing more time for interactive and hands-on exercises when the group meets formally in San Francisco at the Pacific Energy Center (PEC). Training through the classes at the PEC will focus primarily on engineering technical fundamentals. Training subsequent to the PEC classes will focus on related engineering management fundamentals and will occur primarily at the fall class at Starr Pass.

Airside Economizers: Design, Performance and Commissioning Issues

This class will cover airside economizer cycles with an emphasis on how proper operation can significantly reduce a building's mechanical cooling requirement and therefore, its energy consumption. Related indoor environmental quality issues, operational issues and costs will also be discussed. The class will begin with an overview of why economizers are useful and the theory behind their application and operation and then move on to discuss commissioning, operations and maintenance issues including assessing performance, determining proper set points, and assessing economizers during design review and construction observation. Many of the principles discussed will be illustrated by mini case-studies based on actual field experiences. Interactive exercises involving the economizer on the PEC air handling system are also anticipated, pending class size and weather conditions. Class content will be drawn from a number of resources including the Economizer chapter of the *Functional Testing Guide* (www.ftguide.org). A recommended reading list will be developed for you to distribute to class attendees prior to the class to allow them to better prepare themselves for the content of the class.

Note that while water side economizers will be mentioned briefly during the early portions of the class, including references to related resources, the focus of the class will be on air side economizers.

Proposed Agenda:

- Introduction and Overview of Economizers: What They Are and Why We Need Them
- Economizer Control Processes, and Related Integration and Interaction issues
- Economizer Dampers, Actuators, and Linkage Systems
- Economizer Sensors and Controllers
- Installation, Commissioning, and Operation of Economizers

ALC Control Conversion

Analog Lessons

Automated Fault Detection and Diagnostics

This class will provide an overview of automated fault detection and diagnostic principles and techniques by beginning with the processes used to manually troubleshoot, identify and diagnose problems and then expand the focus to discuss how technology can be leveraged to automate these processes. Topics will include techniques that can be implemented using standard data loggers and the standard capabilities included with most current technology DDC systems as well as automated fault diagnostic packages that are available and/or under development in the commercial and public sectors.

Proposed Agenda:

Automated Fault Detection and Diagnostic Principles
The Troubleshooting and Diagnostic Process

- Key fault indicators
- Filtering information to identify the root cause of a problem
- Troubleshooting logic and flow charts
- Targeting issues at the appropriate resources for resolution

Using Data Loggers for Semi-automated Diagnostics and Fault Detection

- Identifying logger requirements
- Including diagnostic data logging as a part of normal Preventive Maintenance procedures
- Case studies where loggers are used for semi-automated diagnostic monitoring

Leveraging DDC System Capabilities to Support Automated Fault Detection and Diagnostics

- Identifying diagnostic and monitoring point requirements
- Leveraging DDC system alarm capabilities
- Leveraging DDC system I/O and logic to develop “Smart Alarms”
- Leveraging the reporting capabilities of DDC systems to target issues at appropriate resources
- Including diagnostic trend analysis as a part of normal Preventive Maintenance procedures
- “Smart Alarm” examples
- DDC based diagnostics case studies

Existing and Emerging Automated Fault Detection and Diagnostic Products
Enforma

Whole Building Diagnostician

Encore

Universal Translator

PACRAT

Chilled and Condenser Water Systems: Design, Performance, and Commissioning Issues

This course will endeavor to use the "System Concept" as a method to focus on the integrated design and operation of chilled and condenser water systems. We have targeted this topic because chilled and condenser water systems are frequently selected as an efficient means of providing cooling, especially for large buildings and campuses. But, there is more to the efficient operation of these systems than simply selecting a high efficiency chiller and lowering the condenser water temperature. Paying attention to the details and the integration of the various components is the key to success from the point when the system comes to life as a design concept all the way through commissioning and operation.

Proposed Agenda:

- Variable Flow and Constant Flow Pumping Systems
- Chilled Water System Control Issues and Strategies
- Condenser Water System Control Issues and Strategies
- A Day in the Life of a Typical Variable Flow Chilled Water Plant
- Using Trend Data to Inform Equipment Selections for Upgrades and Improvements
- Assessing Power and Energy Consumption

Proposed Learning Points:

- Attendees will recognize that for chilled and condenser water systems, the integrated operation and efficiency of all of the elements of the system is just as important, or maybe even more important than the efficiency and characteristics of any given element.
- Attendees will recognize that for chilled and condenser water systems, the load profile that must be met by the system on both a daily and seasonal basis is likely to be more important that the design load condition in terms of determining how the system should be designed, controlled, and optimized.
- Attendees will recognize the important of trending and data logging and analysis for optimizing condenser and chilled water system performance and be acquainted with tool and techniques to help them move forward in applying these techniques.

Commissioning with Data Loggers

In addition the class description we already have developed (I can't seem to find a copy), I would like to suggest we add the following pre-class reading recommendations to the description on the web site.

There are several publically available resources, listed below, which will be referenced in the course of the class. Attendees may find it beneficial to review these resources prior to the class to enhance their learning experience or to allow any questions that come up as a result of reviewing them to be discussed in the class.

- *A paper titled Data Logger Essentials, that was presented at the 2006 National Conference on Building Commissioning discusses the application of data loggers to building commissioning processes from a practical, hands-on perspective. (http://www.peci.org/ncbc/proceedings/2006/22_Welsh_NCBC2006.pdf)*
- *An ASHRAE Journal article titled Trend Analysis for Commissioning discusses automated trend analysis techniques as a troubleshooting tool for commissioning and diagnostic processes. (http://www.taylor-engineering.com/downloads/articles/ASHRAE%20Journal%20-%20Trend%20Analysis%20for%20Commissioning.pdf)*
- *An ASHRAE Journal article titled Universal Translator can be downloaded for free by ASHRAE members or for a modest cost by non-members from www.ASHRAE.org. This article provides an overview of the new free tool that can leverage trend data for commissioning of facilities and verification of energy*

savings. The tool was developed in conjunction with the Pacific Energy Center, where classes on its use and application are offered frequently.

- *The following articles published originally in Heating, Piping and Air Conditioning explore data logging and data loggers.*
  - *Selecting Data Loggers*
  - *Installation of Data Loggers*
  - *Commissioning Data Loggers*
  - *Data Logger Operation Tips*
  - *Visualize BAS Data; A Picture is Worth at Least a Thousand Words when Working with BAS Data*

  Data logging is one of the most powerful tools available in the commissioning toolbox for assessing integrated operation and interaction. All of these articles can be found on the HPAC web site at www.HPAC.com or via a search in the California Commissioning Collaborative web site at www.CACx.org

- *The following application best practice guidelines on data loggers and energy management systems are additional resources on these important commissioning tools.*
  - *Portable Data Loggers (http://www.peci.org/Library/PECI_DxMonitoring1_0302.pdf) provides a good overview of data logger technology and features.*
  - *Energy Management Systems (http://www.peci.org/Library/PECI_PracticalGuide1_0302.pdf) provides a good overview of energy management system features and options, especially in the context of using the system as a commissioning and operations tool.*
- *The Field Guide for Engineers blog on the Consulting and Specifying Engineer Magazine web site (www.CSEMag.com) frequently discusses data logging techniques.*

Commissioning Process for New and Existing Buildings – an Overview

This course will provide an overview of the commissioning process for new and existing buildings including the relationships between LEED®, Title 24 Acceptance Testing, and the role of Architects and Owners in the process. The content will be illustrated with case study examples from past and current projects in new and existing buildings and will also include links to publically available resources to allow the attendees to further pursue topics of interest. A recommended reading list will be developed for you to distribute to class attendees prior to the class to allow them to better prepare themselves for the content of the class.

Proposed Agenda:

- Commissioning: What Is It and Why Do We Need It?
- The Relationship between LEED®, Title 24 Acceptance Testing and Commissioning
- The Architect's and Owner's Role in the Commissioning Process
- The Relationship between Control Systems and the Commissioning Process
- New Construction Commissioning; Steps in the Process and Examples of its Application
- Existing Building Commissioning; Steps in the Process and Examples of its Application

Proposed Learning Points:

- Attendees will come away from the class with a general understanding of the commissioning process in new and existing facilities

- Attendees will come away from the class with a general understanding of the similarities and differences between LEED®, Title 24 Acceptance testing and a formal commissioning process.
- Attendees will come away from the class with an enhanced understanding of the value of the commissioning process, both in terms of resource savings as well as in terms of non-resource or non-energy benefits like improved performance, reliability, or production.

Commissioning VAV Boxes

This class will be based on the materials Jay and Tim developed previously for use last year supplemented with some new development work on my part targeted at commissioning pneumatic VAV boxes.

Controls Fundamentals

(SMUD class)

Developing a Fundamental Understanding of Control Systems and Their Application to HVAC Processes for Reliable, Efficient, Persistent Operation
This class will cover the fundamentals of HVAC controls in a manner that will allow the concepts to be applied across the boards, from discrete analog pneumatic or electronic systems to direct digital control systems. It will include a brief overview of HVAC system theory before presenting sensors, controllers, actuating systems and other control system components. Control logic will be presented in three formats: as narrative text, as line diagrams and as computer code. Other concepts covered include analog vs. digital signals, control loops, PID controllers and energy-saving control strategies. The class will utilize real-world examples and in-class demonstrations featuring the Pacific Energy Center's pneumatic demonstrators to illustrate the principles that are discussed

DDC Controls

Design and Commissioning Skills Class (Point Lists, Narrative Sequences, and System Diagrams)

This class is targeted at designers, commissioning providers and facilities engineers interested in understanding the skills necessary and resources available for developing point lists, narrative sequences, and system diagrams. This class will emphasize how these tools or skills, properly executed, can form the foundations for design and support it through construction document development, start-up, commissioning, and operation.

Design Review

Issues identified during a design review process can go a long way towards improving the performance, efficiency, and first cost of a project and maximize the benefits to be achieved. To that end, this class will demonstrate how to identify and resolve design issues.

- Design review is the time to capture intent: What better place to be to capture design intent information than in a room full of the folks who initiated the project and are developing the design documents?
- Design review is the time to capture savings: Many times, efficiency and first cost savings opportunities that can be easily realized while a project is still evolving during design become prohibitively expensive or impossible to achieve after the building and equipment are ordered or in place.
- Design review is the time to solve problems: A project that is integrated and coordination on paper during design paves the way for a coordinated construction process and integrated operation.

Design review can occur on a number of fronts in addition to a formal review of contract documents as a project evolves. The same principles and techniques can be applied by owners, operators, engineers, and contractors during the shop drawing review process – the divining line between ideas and concepts on paper and hard physical realities. Similarly, facilities engineering groups can find the techniques useful as they review turn-key proposals with vendors and negotiate price and features.

This class will focus on design review issues using case studies from actual projects to illustrate the concepts. The class will also include an interactive group exercise built around an actual turn-key proposal for replacement air handling equipment where-in the class attendees, with guidance from the instructor, will use readily available rules of thumb, information accessed from the internet, and free vendor selection software to assess the proposed equipment in light of the current realities for the loads it will serve. Laptops will be furnished by the PEC for multi-person groups. A resource list will be posted on the class website a several weeks prior to the class for those wishing to load the required software onto their personal laptops and work through the exercise with the class on an individual basis. Design intent, construction observation, and functional testing will also be touched upon as techniques to support the design review process and ensure that good ideas make it all the way to functioning realities.

Recommended pre-class reading: While not necessary, attendees will maximize the experience in the class by reviewing the following documents.

- Design Details, a design brief that can be downloaded at no cost from the Energy Design Resources web site.
- Design Review, a design brief that can be downloaded at no cost from the Energy Design Resources web site.
- Field Observation, a design brief that can be downloaded at no cost from the Energy Design Resources web site.
- HVAC Fundamentals for the Field, a PowerPoint® presentation available for download on the class web site. This presentation provides an overview of HVAC fundamentals in layman's terms to provide insight into the design and operational issues associated with HVAC systems for those who work with the systems in the course of their job but do not have a design or engineering background.
- Useful Equations, a PowerPoint® presentation available for download on the class web site. This presentation provides an overview of frequently used HVAC equations for calculating loads, flow rates, etc.

Economizer Operations

(SMUD)

Maintenance and Commissioning – Optimizing Your HVAC System

This class will cover the operation of an economizer cycle with an emphasis on how the proper operation of an HVAC system's economizer can significantly reduce a building's cooling requirements and thus its energy usage. The class will also focus on the related indoor environmental quality issues and other related operational issues and costs. The class will begin with an overview of why economizers are useful and the theory behind their application and operation and them move on to discuss commissioning, operations and maintenance issues including assessing performance, determining proper set points, and assessing economizer issues during design review and construction observation. The relationship to LEED® will also be emphasized where appropriate

Existing Building Cx 101 Class

In addition the class description we already have developed (I can't find), I would like to suggest we add the following pre-class reading recommendations to the description on the web site.

- *The ability to successfully commission building systems relies on a basic understanding of how they are to work and the fundamental principles behind them. Thus, the HVAC Fundamentals for the Field: Key Concepts & Calculations class scheduled for Tuesday March 17, 2009 at the Pacific Energy Center, and its related reading list will complement the information presented in this class, which will focus on the commissioning HVAC systems in existing buildings.*
- *The Existing Building Commissioning 101 class will have a technical focus rather than a process focus. But the attendees will find that having some familiarity with the existing building commissioning process will provide a valuable framework for the course content. The Commissioning Resource Center on PECI's website (http://www.peci.org/LgCommercial/resources.html#guidestools) provides links to existing and new building commissioning resources, including guidelines about the existing building commissioning process.*
- *Case studies can be powerful tools for gaining an in-depth understanding of how building specific conditions interact with a general commissioning process and specific technical issues to deliver benefits. The library on the California Commissioning Collaborative website (www.CACx.org) is full of case study materials. Attendees may find it desirable to visit the site and do a search on "case study" and then review selected topics of interest that turn up as a result of the search.*

Functional Testing Guide

The *Functional Testing Guide* class will include a field exercise centered on testing a pump or pumps serving the systems at the class location. To minimize development costs, the core lecture will be adapted from previously developed content that is in the public sector from a similar course presented by Pacific Gas and Electric at the Pacific Energy Center (PEC). With regard to the field exercise, I anticipate that we will use one or more of the pumping systems that you and I looked at when I taught the first RCx 101 class several months ago.

Heating Hot Water and Steam Systems: Design, Performance, and Commissioning Issues

This class is targeted at building operating engineers and uses an approach similar to what was described for the chilled and condenser water system class, this class will use the "System Concept" as a method to focus on integrated design and operation as a method to meet the heating needs of a facility as efficiently as possible. We have targeted this topic because even in a relatively mild climate like the Bay Area, energy consumption for heating can be a significant component of a building's operating cost, especially if the HVAC processes employed in the facility require reheat and/or must deal with large quantities of outdoor air. Integrated design and operation are important tools for optimizing these systems and as a result, this will be the over-arching focus for the class.

Proposed Agenda:

- Variable Flow and Constant Flow Pumping Systems
- Steam and Condensate Systems
- Hot Water System Control Issues and Strategies
- Steam System Control Issues and Strategies
- A Day in the Life of a Typical Steam and Heating Hot Water System
- Using Trend Data to Inform Equipment Selections for Upgrades and Improvements
- Assessing Power and Energy Consumption

Proposed Learning Points:

- Attendees will recognize that for heating water systems and steam systems, the integrated operation and efficiency of all of the elements of the system is just as important, or maybe even more important than the efficiency and characteristics of any given element.
- Attendees will recognize that for heating hot water and condenser water systems, the load profile that must be met by the system on both a daily and seasonal basis is likely to be more important that the design load condition in terms of determining how the system should be designed, controlled, and optimized.
- Attendees will recognize the important of trending and data logging and analysis for optimizing heating hot water and steam system performance and be acquainted with tool and techniques to help them move forward in applying these techniques.

HVAC Control Series: Principles of HVAC Control

HVAC Control Series: Optimal Sequences of Control for HVAC Systems

HVAC Control Series: Commissioning DDC Systems

This class is the final class in the 3 part series (are parts 1 & 2 the two above?) focused on control system design, implementation and operation issues. In this class the attendees will explore control system commissioning targets and techniques from design phase through implementation and ongoing operation. The class will include hands-on exercises where appropriate to demonstrate techniques using the resources and systems available at the Pacific Energy Center.

Proposed Agenda:

Design Phase Commissioning Targets and Techniques
The Control System Design Process

- Narrative Sequences
- System Diagrams
- Logic Diagrams
- Point Lists
- Specifications

The Commissioning Authorities Role in the Control System Design Process

- Design Review
- Addressing Diagnostic and Monitoring Requirements
- Incorporating Commissioning Requirements into the Project Specifications
    - Roles and responsibilities
    - Construction observation
    - Prestart and start-up requirements
    - Witnessing
    - Functional testing
    - Issue resolution
    - Documentation

- Training

Implementation Phase Commissioning Targets and Techniques
The Control System Construction Sequence

- Shop drawing development and review
  - Hardware submittal
  - Software submittal
  - Control integration and coordination meetings
- Construction observation and start-up preparation
  - Observing installation procedures
  - Relative vs. absolute calibration
  - Witnessing point to point checks and calibration
  - Witnessing start-up and prefunctional tests
- Functional performance testing
  - Hands-on vs. Hands-off approach
  - Forced response vs. natural response testing
  - Trend analysis
  - Component level, system level and building level testing
  - Sampling
  - Retesting
  - Off-season testing
- Documentation
- Training

Operational Phase Commissioning Targets and Techniques

- On-going trend analysis
- Re-testing and continual commissioning processes

Maintaining documentation

HVAC Design Fundamentals

HVAC Fundamentals for the Field: Key Concepts & Calculations

This class will look at the basic theory and related equations behind HVAC systems and endeavor to provide the participants with some insights into the design process and how the design processes and commissioning and operations processes are inter-related.

Topics to be touched upon include load assessment, psychrometrics, equipment sizing and selection concepts, and the potential long term construction and operation implications of design decisions. In addition the class description we already have developed, I would like to suggest we add the following pre-class reading recommendations to the description on the web site.

There are several publically available resources, listed below, which will be referenced in the course of the class. Attendees may find it beneficial to review these resources prior to the class to enhance their learning experience or to allow any questions that come up as a result of reviewing them to be discussed in the class.

- *Honeywell used to publish a book called Engineering Manual of Automatic Control, which in the industry is commonly called "the Honeywell gray manual". The book was used as a handbook/resource for Honeywell control engineers and, in addition to control theory, includes an overview of general HVAC principles and concepts in the first chapter and an overview of psychrometric principles in its second chapter. Both chapters present their information in clear terms that can be understood by someone with little if any prior background in HVAC. This publication is now available on-line in both a down-loadable .pdf format (http://%20http//customer.honeywell.com/techlit/pdf/77-0000s/77-E1100.pdf)or an interactive html format (http://www.buildingcontrolworkbench.com/).*
- *The Energy Design Resources web site (www.EnergyDesignResources.com) contains numerous design briefs on HVAC topics. In the context of the HVAC fundamentals class, the following briefs may provide additional insight into some of the topics targeted by the class.*
  - *Design for your Climate ((http://www.energydesignresources.com/Design/EnergyDetailing/tabid/91/articleType/ArticleView/articleId/111/Design-Briefs-Design-For-Your-Climate.aspx) looks at how climate conditions specific to a project's location can impact building design.*
  - *Design Details (http://www.energydesignresources.com/Design/EnergyDetailing/tabid/91/articleType/ArticleView/articleId/108/Design-Briefs-Design-Details.aspx) looks at how subtle details of pipe and duct system design can have significant impacts on first costs and operating costs.*
  - *Improving Mechanical System Energy Efficiency (http://www.energydesignresources.com/Design/IntegratedEnergyDesign/tabid/89/articleType/ArticleView/articleId/118/Default.aspx) looks at how taking an integrated design perspective from very early in a project's life cycle can yield big benefits in terms of HVAC system efficiency.*
  - *Integrated Design (http://www.energydesignresources.com/Design/IntegratedEnergyDesign/tabid/89/articleType/ArticleView/articleId/110/Design-Briefs-Integrated-Building-Design.aspx) provides additional insight into the benefits of integrating the design team and process.*
  - *Options and Opportunities (http://www.energydesignresources.com/Design/IntegratedEnergyDesign/tabid/89/articleType/ArticleView/articleId/2/Design-Briefs-Options--Opportunities.aspx) looks at how different energy efficiency measures can be applied to different building types and the results that will be achieved.*
  - *Building Simulation (http://www.energydesignresources.com/Design/IntegratedEnergyDesign/tabid/89/articleType/ArticleView/articleId/3/Design-Briefs-Building-Simulation.aspx) will provide some insight into how modeling techniques can be used to assess and optimize building performance during the design process.*
  - *Centrifugal Pump Application and Optimization (http://www.energydesignresources.com/Design/BuildingCommissioning/tabid/90/articleType/ArticleView/articleId/357/Default.aspx) will provide insights into the details of one of the HVAC system "workhorses" including how design parameters are reflected in the selection of equipment. While written in the context of pumps, in a broader context, the concepts are applicable to the selection and application of most HVAC equipment.*
- *Control systems are critical utility systems supporting the successful operation and performance of HVAC processes. The second chapter of the Control Design Guide (http://www.peci.org/ftguide/csdg/DG_Chapters/02-ControlSystemDesignProcess.htm#2_1_Introduction)*

will provide some insight into the control system design process from the perspective of the three key players; the Owner, the Designer, and the Control Contractor.

- *HVAC designs and systems are interactive by their very nature. The Functional Testing and Design Guide chapter titled Integrated Operation and Control (http://www.peci.org/ftguide/ftg/IntegratedOperation/1_Introduction.htm) explores HVAC system integration and interaction as well as the commissioning process by looking at the commissioning process as it occurs in a hypothetical student activities center located in the Midwest after it has been through a renovation cycle.*

The class will include interactive exercises to reinforce some of the concepts and will require the use of the PEC laptops. The laptops will need to have the equipment selection software we typically use loaded on them so the students can work with different equipment selection programs and other free software to gain insight regarding using these tools in the field environment.

Integrated Interactions: Commissioning Case Studies and Lessons Learned

The class will be structured around a series of case studies from commissioning and retrocommissioning projects and will focus on issues in one HVAC system or subsystem can ripple out and impact performance in other systems due to the highly interactive and integrated nature of HVAC systems and the buildings they serve. The class will also highlight the techniques used to assess and resolve the issues targeted in the case studies and will include several interactive exercises designed to reinforce some of the concepts. A proposed course description for the web site follows:

Buildings and their system are highly interactive by nature. To a large extent, the commissioning process is about integrating interactive elements to provide repeatable, reliable, and robust performance and operation. This class will use a case study format to explore building and system interactions from past commissioning projects and identify the techniques used to evaluate and resolve the challenges they presented to the commissioning team. In some instances, the theory behind the root cause will also be touch upon.

There are several publically available resources, listed below, which will be referenced in the course of the class. Attendees may find it beneficial to review these resources prior to the class to enhance their learning experience or to allow any questions that come up as a result of reviewing them to be discussed in the class.

- *The Functional Testing and Design Guide chapter titled Integrated Operation and Control (http://www.peci.org/ftguide/ftg/IntegratedOperation/1_Introduction.htm) explores the topic by looking at the commissioning process as it occurs in a hypothetical student activities center located in the Midwest after it has been through a renovation cycle.*
- *The Functional Testing and Design Guide test guidance document titled System Recovery from Power Failure (http://www.peci.org/ftguide/ftg/Test_guidance/Tests/TG07-Power_Failure_Recovery.doc) looks at one of the more critical system building system integration issues; the integration of the mechanical systems with the electrical system that powers them.*
- *Commissioning and Envelope Leakage: Using HVAC Operating Strategies to Meet Design and Construction Challenges (available at http://resources.cacx.org/library/ via a search on the title or key word), a paper published at the 2004 ACEEE Summer Study explores the interactions that can occur as a result of envelop leakage and its interaction with the building occupants, systems, and ambient environment.*
- *The following articles published originally in Heating, Piping and Air Conditioning explore data logging and data loggers.*
  - *Selecting Data Loggers*
  - *Installation of Data Loggers*
  - *Commissioning Data Loggers*

- *Data Logger Operation Tips*
- *Visualize BAS Data; A Picture is Worth at Least a Thousand Words when Working with BAS Data*

Data logging is one of the most powerful tools available in the commissioning toolbox for assessing integrated operation and interaction. All of these articles can be found on the HPAC web site at www.HPAC.com or via a search in the California Commissioning Collaborative web site at www.CACx.org

- *The following application best practice guidelines on data loggers and energy management systems are additional resources on these important commissioning tools.*
  - *Portable Data Loggers (http://www.peci.org/Library/PECI_DxMonitoring1_0302.pdf) provides a good overview of data logger technology and features.*
  - *Energy Management Systems (http://www.peci.org/Library/PECI_PracticalGuide1_0302.pdf) provides a good overview of energy management system features and options, especially in the context of using the system as a commissioning and operations tool.*
- *The Field Guide for Engineers blog on the Consulting and Specifying Engineer Magazine web site (www.CSEMag.com) frequently discusses integration and interaction issues.*
- *Good system integration in the field starts with good system integration on the drawing board. There are several resources on the Energy Design Resources web site that explore this angle including the following:*
  - *Numerous design briefs on various integrated design topics may be found under Integrated Energy Design. (http://www.energydesignresources.com/Design/IntegratedEnergyDesign.aspx)*
  - *The EDR Charette allows the user to investigate how different design options will impact building energy consumption in an interactive, on-line format. (http://www.energydesignresources.com/Resources/SoftwareTools/EDRCharrette.aspx)*
- *Related to the preceding, a training class on design review is being offered in Oakland on Friday, May 15, 2009 (INSERT LINK HERE WHEN THE SITE IS UP). Design review is a powerful commissioning tool for, among other things, ensuring that critical system elements are integrated on the drawing board, paving the way for a smoother construction, start-up, and operation process.*

Introduction to Controls

The class will cover the fundamentals of HVAC controls in a manner that will allow them to be applied from discrete analog pneumatic or electronic systems to direct digital control systems. It will include a brief overview of HVAC system types and components before presenting sensors, controllers, actuating systems and other control system components. Control logic will be presented in three formats: as narrative text, as line diagrams and as computer code. Other concepts covered include analog vs. digital signals, control loops, PID controllers and energy-saving control strategies. The class will utilize real-world examples and in-class exercises featuring pneumatic demonstrators with the principles illustrated applicable to a building's DDC system.

On Demand Material Development

This is a new concept we have been discussing as a way to eliminate the need to cover fundamental information for many of our classes and "level the playing field" in terms of attendee preparedness prior to the class. Ideally, if this process succeeds, we will be able to focus more of the class time on advanced topics and things like calculation and analysis techniques.

The list of On-Demand modules proposed in the next section is based on what we currently believe it will take to support the classes proposed for the spring semester. However, I believe this list will also serve as a strong foundation from this point forward, which can be expanded upon as we identify the need or identify new class topics.

In general terms, I believe each module will consist of a number of video clips created using Camtasia to capture PowerPoint materials or provide screen captures of other resources and techniques like Excel Spreadsheets, data logger software, or other free resources. They may also include video clips from field situations like the clip we made to illustrate the relationship between motor speed and load and illustrate slip. In general term, the clips will look very much like the example I sent you for the clip I have on You Tube that walks through a troubleshooting problem via trend analysis using Excel®.

Over the course of the next month, as a pilot project, I plan to convert the slides I have on Induction Motor Theory into an example of what this technique would look like for a PowerPoint® based presentation and will send that to you as soon as it is available. This will be a good pilot because;

- It's a relatively short topic but includes animation and a video element (the one we shot of the PEC chilled water pump) and,
- It's a complicated subject that is part of both the proposed *Pump Fundamentals* module as well as the *Fan Fundamentals* modules.

As allude to earlier in this section, I believe each module will actually be sub divided into a series of clips. There are several reasons for subdividing the modules.

1. Not everything will be conveyed in the same media. For instance, while the bulk of the material will be derived from my existing PowerPoint® presentations, in some instances, simply opening a spreadsheet and walking through it will better convey the concept in contrast with using slides that show screen shots of the spreadsheet.
2. Smaller modules mean smaller file sizes, especially if we choose to keep the resolution high. This will facilitate downloading and/or on-line play for students who have older computers or limited bandwidth in their internet connections.
3. Smaller modules mean that the recording sessions can be broken down into more manageable segments. My experience has been that working with a recording session vs. a live audience is harder to do because of the lack of feedback, direct or indirect, from the audience. I think shorter sessions will make some of the issues that come up in this regard more manageable.
4. Smaller modules mean faster edits. My experience with Camtasia thus far (and I suspect this would be true for any video capture and editing package) is that it is time consuming to work with and edit large files. Thus, smaller modules make for more manageable editing sessions.
5. Smaller modules mean less effort will be required to re-record a session that does not turn out well. This is really a subset of the preceding point.

Operating Your Facility with an Eye toward Energy Conservation and Sustainable Operations

This class will be new development targeted at building operating engineers and will rely on some of the on demand courses included in this proposal for support. In general terms, the course will endeavor to empower facilities engineers to become more proactive in monitoring how their facilities use energy and other resources and making them more efficient and sustainable. By the nature of their work, facility operators are intimately connected to the energy and resource consumption patterns in their facilities. Thus, they are also in a good position to have a significant and lasting impact with regard to improving the way their facility uses resources.

This class is intended to provide facility operators with some of the tools they need to move down the path towards more efficient operating strategies and provide them with examples of ways to use these tools to

immediately begin to identify and capture savings. The content will include case studies illustrating how the techniques that are discussed have been used in existing building to generate savings. Interactive exercises illustrating some of the concepts and techniques are also planned.

Proposed Agenda:

- Monitoring Utility Consumption to Identify Opportunities and Ensure the Persistence of Improvements
- Using Simple Tests, Observations, and Common Sense to Identify Savings Opportunities
- Using Data Loggers and Control System Trends to Identify Opportunities and Ensure the Persistence of Improvements
- Developing Documentation, Purchasing, and Training Standards to Support Efficient Operations
- Projecting Savings for Targeted Opportunities

Proposed Learning Points

- Attendees will recognize that energy and resource efficiency have a lot to do with day to day operating practices and will be exposed to techniques they can use to improve their facilities efficiency using low-cost/no-cost techniques and practices and/or by leveraging standard operations and maintenance expenditures.
- Attendees will learn about the many free resources available to them to facilitate their efforts at efficient sustainable operation.
- Attendees will be exposed to fundamental calculations that they can use to estimate the savings potential for measures they identify.

Optimal Sequences of Control for HVAC Systems

This class will build on the concepts covered in the *Principles of HVAC Control* class and will focus on sequences of operation appropriate for small and medium commercial facilities (for instance, small package units and heat pumps versus chiller sequences). These sequences have been integrated into Title 24, the California Energy code, and can yield significant energy savings if incorporated into existing facilities with legacy controls; thus the focus for the class. The class will use narrative text, line diagrams and computer code to illustrate these sequences.

Pump Troubleshooting Design Brief

(AEC)

The design brief content will include case studies illustrating and reinforcing the key concepts. Where possible, these case studies will be built around the pumping systems and equipment in the CTAC facility. However, if the systems and equipment are inappropriate for the concepts to be illustrated, or the necessary information can not be readily obtained in a timely fashion, the case studies will be based on examples from other projects.

Pumps: Design, Performance and Commissioning Issues

This class will cover centrifugal pump application and optimization and pump system troubleshooting from a field perspective. The class will start by exploring pump theory and construction and then move to motor theory and the interactions that occur between a pump and its motor as the loads on the pump change. From this foundation, the remainder of the class will focus on pump and system interactions, with an emphasis on parallel pump applications and how pump tests can be use to assess performance, troubleshoot operating

problems, and identify optimization opportunities. Many of the principles discussed will be illustrated by mini case-studies based on actual field experiences. Interactive exercises involving the pumping systems in the PEC are anticipated, pending class size and weather conditions. Class content will be drawn from a number of resources including *Centrifugal Pump Application and Optimization* and *Pump System Troubleshooting*, both of which are design briefs that can be found on the *Energy Design Resources web site* (www.energydesignresources.com). A recommended reading list will be developed for you to distribute to class attendees prior to the class to allow them to better prepare themselves for the content of the class.

Proposed Agenda:

- Introduction and Overview of Pumps and Piping Systems and the Optimization Opportunities they Often Contain
- Pump Theory
- Motor Theory
- Pumps and Systems
    - Constant Flow vs. Variable Flow Systems
    - Open vs. Closed Systems
    - Piping Systems Details that Impact Pump Performance
    - Pump Testing as a Diagnostic for Troubleshooting and Optimization

Resources for the Resourceful

This class will cover the wealth of no-cost resources available from the internet and manufacturers that can be used to support building design and commissioning processes. The afternoon session will consist of hands-on experience with some of the resources for the PEC attendees, demonstrating the resource features and illustrating how they might be applied in the design office or in the field.

Retrocommissioner's Retrospective on Retrofits

(SMUD)

This class wills use a case study format to look at the impact of design details on the success (or lack of success) of HVAC projects. Specifically, the case study format will be used to illustrate:

- How the problem was identified
- What the implications of the problem were in terms of performance, efficiency sustainability, maintainability, etc
- How the problem was corrected
- The results of the correction, where available, and
- The theory behind the problem and its solution.

Topics will include duct and pipe installation details, fan and pump application details, control system details, envelope details and power system details. Where possible, I will try to develop hands-on class-room exercises related to the materials to help attendees apply the concepts and further their understanding of the topic. While the class will focus on field issues encountered in retrocommissioning and operations experiences the information presented will also be of interest to those involved with new construction because getting the

details right in the first place is on the critical path to preventing problems and delivering efficient, sustainable HVAC systems and processes

Retrocommissioning and HVAC Fundamentals for the Field

(SMUD)

Developing and documenting design intent is a key element of any commissioning process. Unfortunately, many projects never have their design intent documented and the field personnel charged with operating and optimizing the systems must forensically assess the intent behind the system they are dealing with. Having some knowledge of the design process, how a design evolves, how equipment selections are made and how these decisions translate into a functional (or dysfunctional) system can be a valuable asset in such an endeavor. This class will begin with an overview of HVAC fundamentals in layman's terms to show how the design of an HVAC system evolves from concept to equipment selections, distribution system configurations, and selection of supporting utility equipment and systems. The second portion of the class will provide an overview of retrocommissioning skills and tools that can be used to scope a facility and identify potential retrocommissioning opportunities and begin to assess their value. Where possible, hands-on classroom exercises will be used to help attendees to apply the concepts that are discussed further their understanding of the topic. While the class will be somewhat technical in nature, the goal is to provide the technical content at a level that can be useful to operators, facility engineers, program managers and others who are working out in the field with buildings and building systems but do not have a design background

RCx 101: Identifying and Assessing Common Retrocommissioning Opportunities

Specifying Direct Digital Controls

System Diagrams, Point Lists & Sequences

Top 10 Cx Issues

(SMUD)

Using Design Review, Submittal Review and Construction Observation to Enhance your Commissioning Process and Save Resources and First Cost (this looks to be about the same as the Design Review Course)

Issues identified during a design review process can go a long way toward improving the performance, efficiency, and first cost of a project and maximizing the benefits to be achieved.

- Design review is the time to capture intent. What better place to be to capture design intent information than in a room full of the team members who initiated the project and are developing the design documents?
- Design review is the time to capture savings. Many times, efficiency and first cost savings opportunities that can be easily realized while a project is still evolving during design become prohibitively expensive or impossible to achieve after the building and equipment are ordered or are in place.
- Design review is the time to solve problems. A project that is integrated and coordinated on paper during design paves the way for a coordinated construction process and integrated operation.

Design review can occur on a number of fronts in addition to a formal review of contract documents as a project evolves. The same principles and techniques can be applied by owners, operators, engineers, and

contractors during the shop drawing review process - the dividing line between ideas and concepts on paper and hard physical realities. Similarly, facilities engineering groups will find the techniques useful as they review turn-key proposals with vendors and negotiate price and features.

While the focus of this class will tend to be on HVAC related issues, the class will touch on related architectural and electrical issues such as access, coordination and the ripple effects that can occur when equipment is right sized as a result of the design review process.

The class will be divided into a morning and afternoon session and attendees are welcome to attend either or both, depending on their level of interest. The morning session will consist of a broader perspective, less technical overview of the topic including:

- A discussion of where to target review and observations processes in the design-build-operate time for best benefit,
- A discussion of the types of documentation that should be targeted for review, and
- Case studies illustrating the benefits achieved by applying the review and observation processes to actual projects

The afternoon session will take on a more technical focus by using a workshop approach built around a turn-key proposal for replacement air handling equipment wherein the class attendees, with guidance from the instructor, will use readily available rules of thumb, information accessed from the Internet, and free vendor selection software to assess the proposed equipment in light of the realities for the loads it will serve.

We will furnish laptops for group hands-on participation during the workshop. We will also post a resource list on the class website several weeks prior to the class for those wishing to load the required software onto their personal laptops and work through the exercise with the class on an individual basis.

Recommended pre-class reading: While not necessary, attendees, especially workshop attendees, will maximize the experience in the class by reviewing the following documents that can be downloaded from the Energy Design Resources Website (www.EnergyDesignResources.com):

- Design Details
- Design Review
- Field Observation

In addition, a PowerPoint presentation will be available for download on the class Web site on the topic of HVAC Fundamentals for the Field, a class previously presented at the Pacific Energy Center and scheduled for presentation on Tuesday March 17, 2009 this semester. This presentation provides an overview of HVAC fundamentals in layman's terms to provide insight into the design and operational issues associated with HVAC systems for those who work with the systems in the course of their jobs but do not have a design or engineering background. Also available for download on the class Web site closer to the time of the class will be Useful Equations, a PowerPoint presentation. This presentation provides an overview of frequently used HVAC equations for calculating loads, flow rates, etc.

As indicated in the description, the afternoon exercise will require the use of the PEC laptops. The laptops will need to have the equipment selection software we typically use loaded on them so the students can work with different equipment selection programs and other free software to gain insight regarding using these tools in the field environment. They will also need to have internet access to allow the attendees to access manufacturer’s catalog data from the web, or we will need to preload that data so that it is available without web access. We will also need to preload the sample turn-key proposal and other related materials to ensure that everything the attendees need for the exercise is available to them on the laptops.

VAV Systems: Design, Performance and Commissioning Issues

This class will look at the theory and operational issues associated with Variable Air Volume (VAV) systems from a field perspective. The class will start by exploring the temperature control process at the zone level and how the requirements associated with this process lead to the evolution of variable air flow as a design concept. The zone temperature control discussion will then be expanded to a discussion of HVAC system loads and their variable nature, which is the primary driver behind the operating profile a VAV system sees. Building from this foundation, the class will then focus on the various types of terminal units and air handling unit configurations found in VAV systems and how the operating requirements of a VAV system impact their selection, installation, operation and control. Many of the principles discussed will be illustrated by mini case-studies based on actual field experiences. Interactive exercises involving the air systems in the PEC are anticipated, pending class size and weather conditions. Class content will be drawn from a number of resources including the *Functional Testing Guide* (www.ftguide.org) and the *Advanced Variable Air Volume Systems Design Guide* (www.energydesignresources.com). A recommended reading list will be developed for you to distribute to class attendees prior to the class to allow them to better prepare themselves for the content of the class.

Proposed Agenda:

- Introduction and Overview of VAV Systems: Why Vary Airflow in an HVAC System?
- Building HVAC Loads and Variables
- VAV Terminal Equipment
  - Fundamental Operating Principles
  - The Relationship Between VAV Systems, Minimum Flow Settings, and Reheat
  - Design, Installation, Control and Operating Issues
- VAV Air Handling Systems
  - Common System Configurations
  - Duct Systems and VAV Operation
  - Return and Relief Fans and VAV Operation
  - Economizers and VAV Operation
  - Filters and VAV Operation
  - Design, Installation, Control and Operating Issues

VAV Terminal Unit