Continuous Commissioning® Process

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Continuous Commissioning® Process

- Continuous Commissioning (CC®) is the process of optimizing building energy and plant energy systems to reduce energy consumption, improve comfort, and increase productivity
- Continuous Commissioning and CC are registered trademarks of the Texas Engineering Experiment Station (TEES), the Texas A&M University System, College Station, Texas

Outline of Presentation

1. Evolution of Continuous Commissioning Process
2. Summary of Applications
3. Energy Systems Laboratory Info
4. CC Case Studies
   - Terrell State Hospital
   - Matheson Courthouse – Salt Lake City
   - Prairie View A&M University
5. CC Costs and Savings
6. CC Assessment Process – 1st Steps
7. Continuous Commissioning Guidebook for Federal Energy Managers
8. Conclusions, Q&A

Evolution of Continuous Commissioning Process

- LoanSTAR – Loans to Save Taxes and Resources (approved in 1988)
- $98.6 Million Capital Retrofit Fund for Energy Efficiency Improvements
- DOE Demonstration Project (retrofits had to be metered and monitored for verification of energy savings)
- Texas A&M's Energy Systems Lab was selected as the M&V subcontractor

Evolution, cont'd

- Hourly data (electrical, NG, chilled water, steam, hot water, and some submetering) were coming into Energy Systems Lab
- Developed analysis methodologies to determine savings – IPMVP and ASHRAE 14P
- Had hourly data on hundreds of LoanSTAR buildings—Large, building energy consumption relational database

Evolution, cont'd.

- Began analyzing the hourly data for operational improvements, i.e., systems which could have improved operation schedules or be shut off completely
- Called these O&M improvements (~1992)
- In 1993, we began the development of air-side models to analyze performance

Evolution, cont'd.

- Started going into buildings to make operational improvements
- Commissioned the retrofitted buildings in LoanSTAR and made additional operational improvements
- Additional savings averaging 20% of utility bills were achieved (over and above the retrofit savings!)

Summary of Applications of Continuous Commissioning

Can be applied to:

- Buildings retrofitted for energy efficiency
- Existing buildings as a stand-alone process
- New (or nearly new) buildings as a stand-alone process
- Buildings/plants undergoing retrofits as an integral part of the retrofits, i.e., a CC Energy Conservation Measure

Energy Systems Laboratory

A research laboratory specializing in:

- Energy management and conservation
- Building Continuous Commissioning
- Plant Continuous Commissioning
- Building metering and monitoring
- Energy savings analysis
- Electric utility deregulation
- Indoor air quality (mold, moisture, CO_2)
- Emissions calculations from energy efficiency

Energy Systems Laboratory, cont'd.

Personnel

- 36 full-time staff
- 7 faculty
- 45 undergraduate and graduate students

Energy Systems Laboratory, cont'd.

Facilities

- Fan testing and certification facility
- Calibration laboratory (flow meters, electrical sensors, pressure, temperature, and humidity)
- Psychrometric chambers for air conditioning and heat pump testing and research
- Extensive computer facilities
- Thin film photovoltaics test facility (in work)

Continuous Commissioning Activities

- Presented 16 one and two day commissioning workshops
- Commissioned over 165 buildings, three central plants, three thermal storage facilities
- Currently conducting Continuous Commissioning services at Texas A&M University, TAMIU Laredo, Prairie View A&M University, Alamo Community College District San Antonio, and State of Utah buildings

Continuous Commissioning Activities, cont'd.

- Currently working on a licensing agreement to transfer the Continuous Commissioning process to private sector
- Several patents pending on CC process

Case Studies

1. Terrell State Hospital (commissioned older, retrofitted facility)
2. State of Utah – Matheson Courthouse (fairly new, modern building)
3. Prairie View A&M University (includes CC as an ECM in a retrofit project)

Continuous Commissioning of a Retrofit Project—Terrell State Hospital, Terrell, Texas

Facility Information

- Building: 20 major buildings with a total floor area of 676,000 square feet
- Chiller system: 5 chiller plants connected to a 7000 ton-hr thermal storage system
- AHUs: 80
- Modern Control System

Special Issues

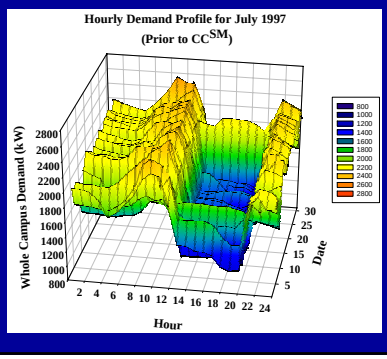
- Old facility
- Operating staff is short of manpower
- Comfort problems exist in most of the buildings
- Thermal storage system operation is unstable
- Any modifications are subjected to pre-approval by operating staff

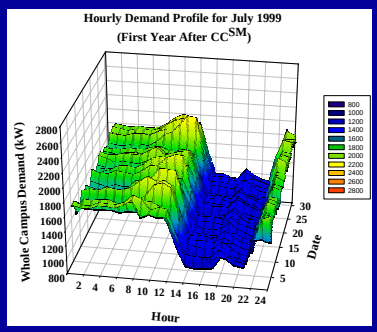
Retrofit Results:

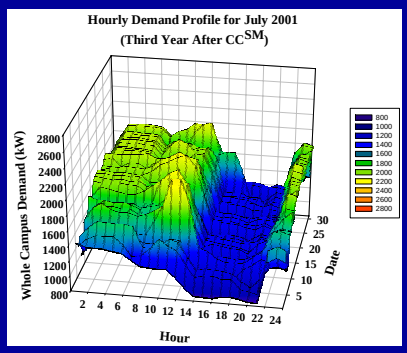
- Achieved only 55% of savings projected by design engineer
- Thermal storage system had to turn on a chiller during utility peak period
- Client could not repay loan from utility savings
- SECO asked ESL to investigate for possible commissioning opportunity

Findings:

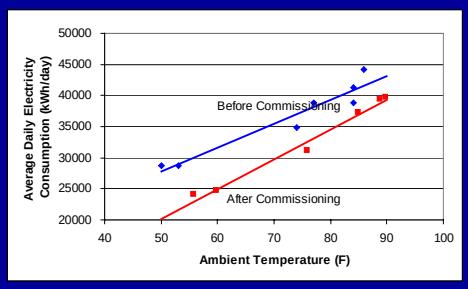
- Some controls hardware in place, but not connected
- Some controls hardware missing
- Lack of training of staff on new system
- No attempt to fix obvious HVAC problems within buildings
- Algorithms programmed into Controls System were not specific to facility
- Thermal storage charging/discharging not optimized



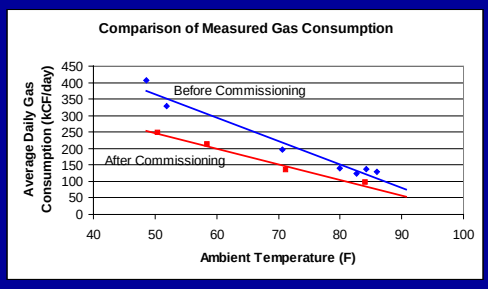




Comparison of Campus Electricity Consumption



Comparison of Campus Gas Consumption



Post-Retrofit Commissioning Results

- Brought savings to 95% level in 1st year
- Optimized control systems operation
- Optimized chilled water tank charging and operation
- Calibrated sensors and identified hardware problems, both for maintenance staff and controls vendor to fix
- Achieved additional savings in 2nd year of CC to bring total savings to about 105% of audit-estimated savings

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- First year savings after CC (7/99- 06/00): $175,112
  - $34,096 for demand
  - $88,832 for electricity
  - $55,736 for gas
- Demand costs: $7.63/kW M
- Energy costs: $0.037/kWh
- Gas costs: $2.40/MMBtu

Summary

- Comfort improved
- Thermal storage system performance improved
- Measured savings: $175,000/yr in first year

State of Utah – Matheson Courthouse

(CC of an existing, modern building)

- CC assessment conducted in February ’01
- Contract completed in October ’01
- CC started in January ’02
- Bulk of CC completed in November ’02, but process is ongoing

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Matheson Courthouse Retro-Commissioning Progress Report to DFCM 8

May 2003

by: Dr. Dan Turner, Song Deng (ESL), Kevin Healy, Mike Butler (DFCM), Jim Hood (UEO)

Matheson Courthouse

BUILDING DESCRIPTION

- Matheson Courts Complex
- COVERED AREA : 420,000 ft^2
- CONDITIONED AREA: 370,000 ft^2
- 37 courtrooms, offices, holding cells, 3 level underground parking

Matheson Courthouse

Installed HVAC Equipment

- One (1) 400 ton and one (1) 770 ton chiller
- Six (6) single duct, VAV AHUs, with hot water terminal reheat
- Two (2) 500 hp hot water boilers
- Modern DDC building automation system

Matheson Courthouse – Energy Information

- 2001 utility bills were $400,000 ($300,000 for electricity, $100,000 for gas)
- Energy Cost Index = $1.08 per square foot per year, based on conditioned area

Matheson Courthouse – CC Team

- Engineer from Utah Energy Office, Department of Natural Resources
- Controls Specialist from Utah Department of Facilities Construction and Management
- Building Facilities Manager
- Two engineers from Energy Systems Laboratory

Matheson Courthouse – CC Findings (From CC Assessment and Detailed Investigations)

- Several CO_2 sensors were bad, including one which had failed at a reading of 2000 ppm
- Several AHU temperature sensors were off and in need of replacement/recalibration
- About 70% of the VAV boxes were in need of recalibration or had broken flow stations or dampers
- Two boilers were operating on high fire
- Two pumps were normally operating when one pump could carry the load

Matheson Courthouse – CC Findings, cont'd.

- Glycol de icing system was not programmed correctly
- Building start p/shut down sequence was not optimal
- A few maintenance problems (dampers out of adjustment, leaking valves) were identified
- Outside air temperature sensor was not reading correctly and RH sensor was giving false outputs

Matheson Courthouse – CC Findings, cont'd.

- Chiller sequence was not optional
- Duct static pressure sensors were reading too high
- Building static pressure sensors were out of calibration
- Chilled water pressure sensor was not a ΔP sensor but a static pressure sensor

CC Findings, cont'd.

- Insulation was missing around one of the AHUs, which allowed outside air to mix with building return air
- Exhaust air dampers would not close completely or sometimes failed to open

Matheson Courthouse – CC Measures Implemented

Sensor Issues

1. Replaced (2) CO_2 sensors and recalibrated the third
2. Recalibrated temperature sensors
3. Recalibrated duct static pressure sensors
4. Recalibrated building static pressure sensors
5. Replaced OA temperature and humidity sensor
6. Recalibrated all 500 plus VAV boxes (done by TAB contractor)
7. Recommended a ΔP sensor be installed for chilled water loop (to be implemented)

Matheson Courthouse – Operational Changes Implemented

1. On boilers, changed to one boiler operation, starting on low or medium fire
2. Revised two pump operation to one pump operation on systems where one pump can carry the load
3. Glycol loop operation had an error in programming which allowed the Glycol system to come on anytime RH was above 80%, regardless of temperature

Matheson Courthouse – Operational Changes Implemented, cont'd.

4. Chiller start up sequence in spring allowed all chillers, cooling towers, pumps to run, which created an electrical demand spike and start up sequence was modified
5. Programming logic allowed both chillers to run during changeover from small to large chiller, which was changed
6. Early morning start up of building was inefficient, which wasted a great deal of energy. A "semi-occupied" mode was created to optimize building start up

Matheson Courthouse – Maintenance Issues Implemented

1. Dampers were adjusted to close as completely as possible
2. Two (2) leaking valves were repaired
3. Insulation was added to one (1) AHU to seal off outside air
4. Sticking isolation valve on small chiller was repaired
5. Exhaust dampers were adjusted and programming logic was changed to ensure dampers were closed when exhaust fans were off

Matheson Courthouse – Optimization Measures Implemented

1. A cold deck temperature reset schedule was implemented for each AHU, based on outside air temperature
2. Hot water temperature was lowered to 155-160°F (the lowest temperature the boiler controller could go). A recommendation was made to purchase a new controller which could be programmed to have a reset schedule with OAT

Matheson Courthouse – Optimization Measures Implemented, cont'd.

3. Duct static pressures were reset according to OAT. Also a semi-occupied mode was established which also reset duct static pressure
4. Airflow settings were changed on some VAV boxes, both for occupied and semi-occupied modes. During periods of low building occupancy, outside airflow was reduced.
5. Pending – shut off both boilers in summer

Matheson Courthouse – Results of Continuous Commissioning

Model savings, based on 2001 prices, weather normalized

- $80,000 annual savings (60% gas, 40% electricity)

Actual Savings for 2002

- $116,000 (both gas and electricity were somewhat cheaper than baseline prices)

Actual ECI for 2002 = $0.77 per square foot/year (2001 ECI was $1.08 per square foot/year)

Simple payback was 1.2 years, based on outside labor/contractors. Over 700 operating hours were eliminated by creating a new start-up sequence and shutdown sequence.

Matheson Courthouse - Conclusions

- Continuous Commissioning at Matheson was a team success
- A second building commissioning effort is underway in Utah
- Energy office wants to expand initiative statewide with a team of Utah staff, private industry, and the ESL.

Continuous Commissioning as an ECM in an Energy Efficiency Capital Retrofit Project – Prairie View A&M University

Prairie View A&M University Energy Project (LoanSTAR Project)

- Engineering firm conducted investment grade audit for capital retrofits
- ESL concurrently conducted CC audits
- Modeled and simulated energy consumption of 16 major campus buildings as part of the CC audit (1st project in LoanSTAR program allowing CC as an ECM)
- Original intent was a $5 million loan

Prairie View A&M, cont'd.

- When savings and ECMs were identified, project simple payback was under 8 years
- With a lower payback, customer wanted to get two new chillers and we were asked to revise project to include additional chillers and stay within a 10-year payback required by LoanSTAR
- Final project involved two loans totaling $4.7M and $1.7M each, with a combined payback of 9.4 years

PVA&M ECMs

ECM	Simple Payback, yrs
Lighting retrofits	6.0
Replace two chillers	19.8
Repair steam system	7.2
Install motion sensors	7.3
Expand chilled water loop	8.4
Convert to primary/ secondary pumping	9.0
Replace DX systems	13.0
Upgrade DDC EMCS	13.7
Continuous Commissioning	3.0

Project Cost = $6,436,460
Simple Payback = 9.4 years

CC Measures at PVA&M University

- Hot and cold deck temperature resets
- Elimination of unnecessary simultaneous heating and cooling
- Air and water balancing
- Duct static pressure resets
- Sensor calibration/repair
- Improved start/stop/warm up/shutdown schedules
- Improved chiller and boiler plant operation
- Retrofit commissioning

Project Status

- LoanSTAR project is combined with major campus renovations in three phases
- Phase A (~9 buildings) includes lighting, EMCS, motion sensors, primary/secondary loop conversion is at 100% design phase
- Phase B is at 50% design phase
- Metering hardware has been installed or calibrated/verified in first 4 buildings to be commissioned
- CC has begun in first three major buildings

Project Summary

- 1st LoanSTAR project where CC is an ECM, along with other energy efficiency measures
- CC represents roughly 1/3 of project savings, with a payback of 3 years (including CC, metering installation, meter calibration, M&V, training, one year's CC follow up, project administration)
- Energy projects are coupled with major campus renovation projects, which creates unexpected coordination problems

PVA&M Project Challenges

- Energy projects are only part of major campus renovations
- Design firm is not the original engineering firm that performed the energy audits
- "Phased" approach requires ESL engineers to commission on a "piece meal" basis
- Much more coordination and planning is required, i.e., 25% review, 50% review, etc., and we expect even more coordination will be required during construction

Conclusions

The CC process has been successfully applied

- After buildings received energy retrofits
- To existing buildings with no retrofits
- To new (or nearly new) buildings
- As an ECM in major energy retrofit projects

Conclusions, cont'd.

- While CC savings results vary from building to building, overall average savings are 15 25%, regardless of the applications
- Using CC as an ECM in an energy conservation project is one of the fastest payback items, which allows longer payback items to be purchased
- By properly commissioning the retrofits, the owner gets a capital energy project that will meet the owner's requirements, as well as a project which saves energy

Continuous Commissioning®

-Savings & Costs

Buildings	Savings ($/kft^2/yr)	Costs (hr/kft^2)
Hospitals	$430	4.74
Lab/Offices	$1,260	3.68
Class/Offices	$430	2.26
Offices	$220	3.29
Schools	$170	3.36
Average	$540	3.59

Metering & Reporting Costs Per Building

Approach	Metering	Reporting	Total
Utility Bill		$15,000	$15,000
Short Term Measured Data	$5,000	$5,000	$10,000
Long Term With Existing Meters	$4,000	$3,500	$7,500
Long Term With Dedicated Meters	$17,000	$3,500	$20,500

Big Picture of Continuous Commissioning Savings

- Over 165 buildings commissioned since 1993
- Cumulative measured savings through August 2002 – about $60 million
  - LoanSTAR- $30 million
  - Texas A&M- $22 million
  - Brooke Army Medical Center- $1.5 million
  - Others- $6.0 million

Steps in the Continuous Commissioning® Process

- Initiate a commissioning assessment
- Usually 1-3 days on site, depending on the size and complexity of the building(s)

For the Continuous Commissioning® Assessment

Prior to the Visit

- Need mechanical systems drawings
- Controls schedules
- Chiller/boiler plant equipment sizes, pump info
- Floor layout
- One year of utility data, if available (gas, electric, any purchased utilities)

During the On-Site Assessment

- Need access to mechanical rooms
- Need time on BAS to review control settings, schedules
- Prefer to have a member of operations staff dedicated to us for the visit

  - Should know where mechanical rooms are and have access to them

  -Know locations of sensors

During the Assessment, cont'd.

- We will measure supply air, cold deck, hot deck (if applicable) CW temps, static pressure, cfm, OA, for major AHUs
- We will spot check space temps, RH, CO_2 levels within the building
- We will note any comfort problems, O&M issues, sensors out of calibration
- If requested by client, we will also identify potential capital retrofit measures

Results of CC Assessment

Provide an implementation report which will:

- Identify potential CC measures
- Estimate savings from CC
- Estimate CC cost
- Discuss comfort issues and observed problems
- Identify any O&M or safety problems
- Recommend level of metering/submetering, if applicable
- Identify potential capital retrofit measures (optional)

Continuous Commissioning Guidebook for Federal Energy Managers

- Prepared by Liu, Claridge, Turner
- Delivered to FEMP/DOE in October 2002
- Should be available for distribution by FEMP soon

Continuous Commissioning Workshop

At Energy 2003 on Thursday

Seats are still available

Questions on CC Process?