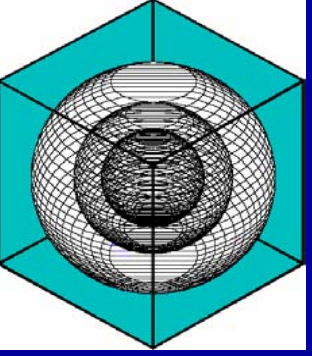

Commissioning Existing Buildings

By

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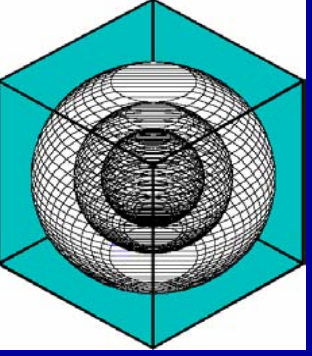
Texas A&M University System

College Station, Texas

FFC Government/Industry Forum on Building Commissioning

Washington, D.C.

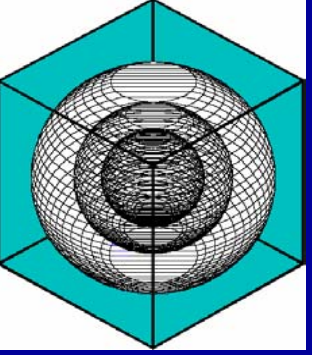
October 9, 2003



Continuous Commissioning® Process

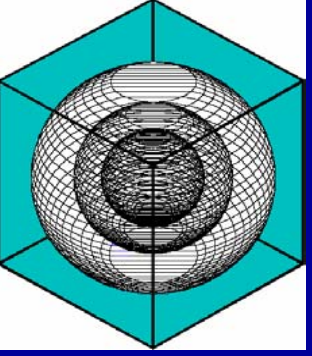
- Continuous Commissioning (CC^{SM}) is the process of optimizing building energy and plant energy systems to reduce energy consumption, improve comfort, and increase productivity

- Continuous Commissioning is a registered trademark of the Texas Engineering Experiment Station (TEES), the Texas A&M University System, College Station, Texas



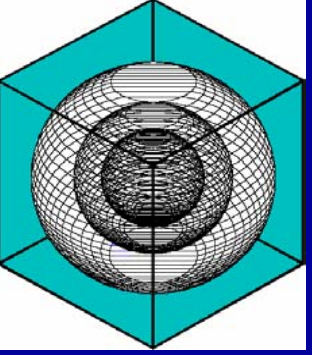
Outline of Presentation

1. Background 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



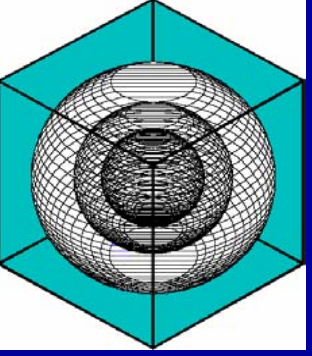
Background of Continuous Commissioning Process

- 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



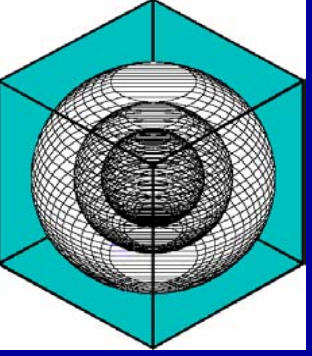
Background, cont'd

- Hourly data (electrical, natural gas, chilled water, steam, hot water, and some submetering) were coming into Energy Systems Lab
- Developed analysis methodologies to determine savings (prior to International Performance Measurement and Verification Protocols and ASHRAE Guideline 14)
- Had hourly data on hundreds of LoanSTAR buildings—Large, building energy consumption relational database



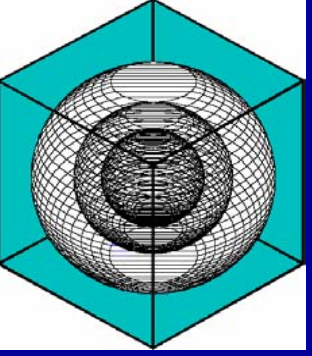
Background, cont'd

- 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 building models to analyze performance



Background, cont'd

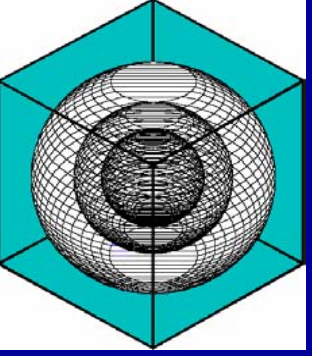
- Started going into buildings to make operational improvements
- Commissioned the retrofitted buildings in LoanSTAR and made additional operational improvements
- Additional savings averaging 20% of utility bills were achieved (over and above the retrofit savings!)



Summary of Applications of Continuous Commissioning

Can be applied to:

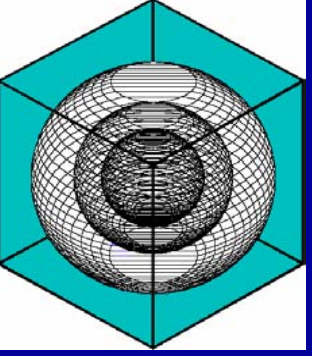
- **Commissioning of building retrofits for energy efficiency**
- **Existing buildings as a stand-alone process**
- **New (or nearly new) buildings as a stand-alone process**
- **Buildings/plants undergoing retrofits as an integral part of the retrofits, i.e., a CC Energy Conservation Measure**



Energy Systems Laboratory

A research laboratory specializing in:

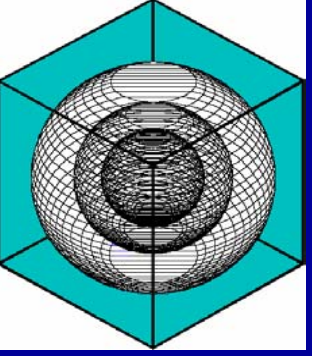
- Energy management and conservation
- Building Continuous Commissioning
- Plant Continuous Commissioning
- Building metering and monitoring
- Energy savings analysis
- Electric utility deregulation
- Indoor air quality (mold, moisture, CO_2)
- Emissions calculations from energy efficiency



Energy Systems Laboratory, cont'd

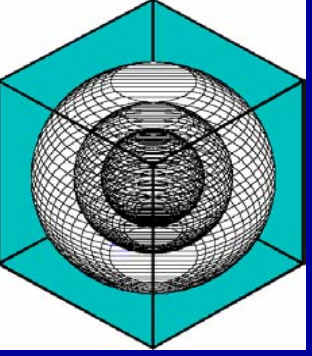
Personnel

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



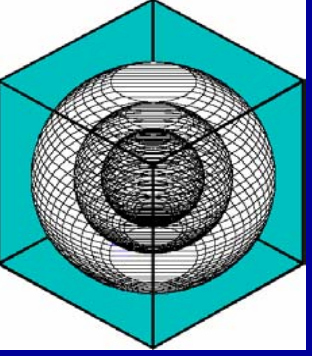
Continuous Commissioning Activities

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

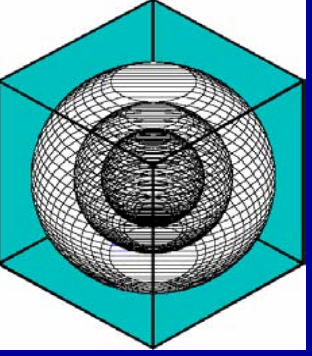


Case Studies

1. Terrell State Hospital (commissioned older, retrofitted facility)
2. State of Utah – Matheson Courthouse (fairly new, modern building)

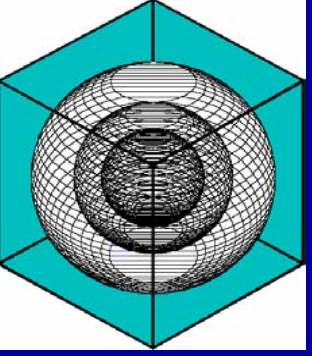


Continuous Commissioning of a Retrofit Project—Terrell State Hospital, Terrell, Texas



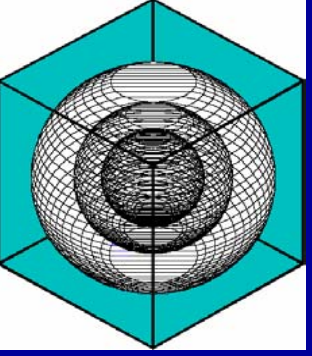
Facility Information

- **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**



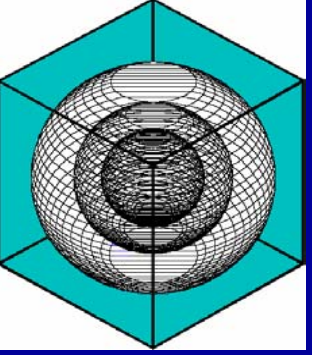
Special Issues

- Old facility
- Operating staff is short of manpower
- Comfort problems exist in most of the buildings
- Thermal storage system operation is unstable



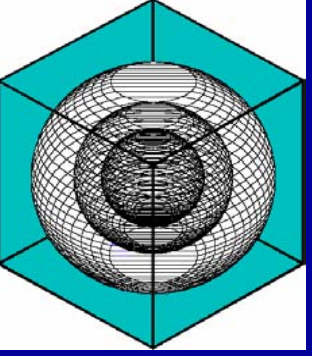
Retrofit Results:

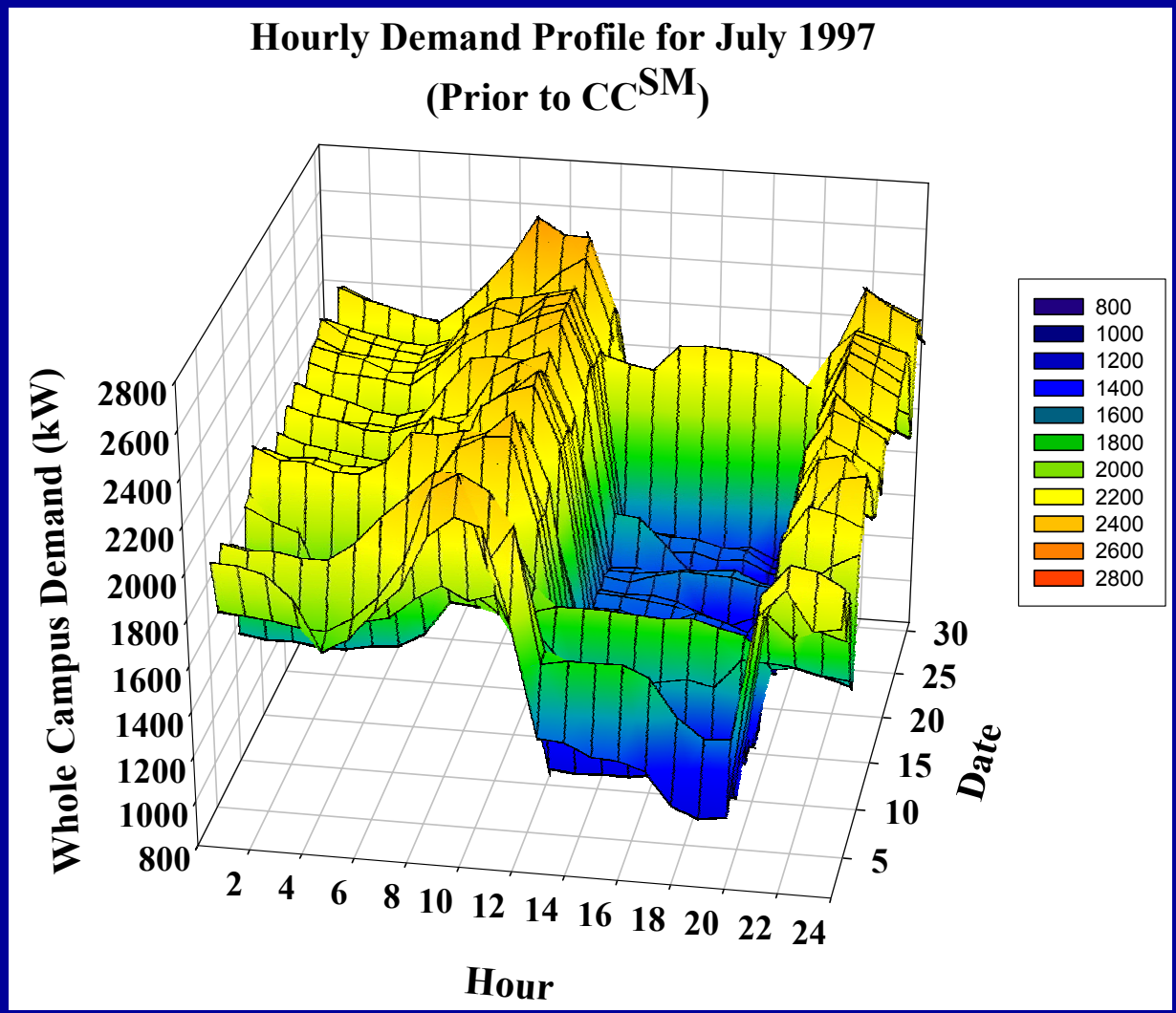
- Achieved only 55% of savings projected by design engineer
- Thermal storage system could not carry the load, and a chiller had to be turned on during utility peak period
- Client could not repay loan from utility savings
- State Energy Conservation Office and client asked ESL to investigate for possible commissioning opportunity

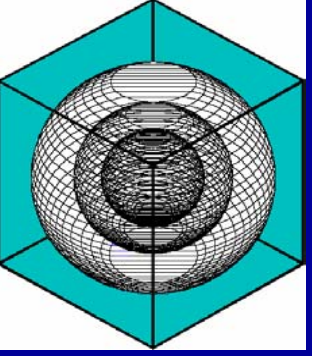


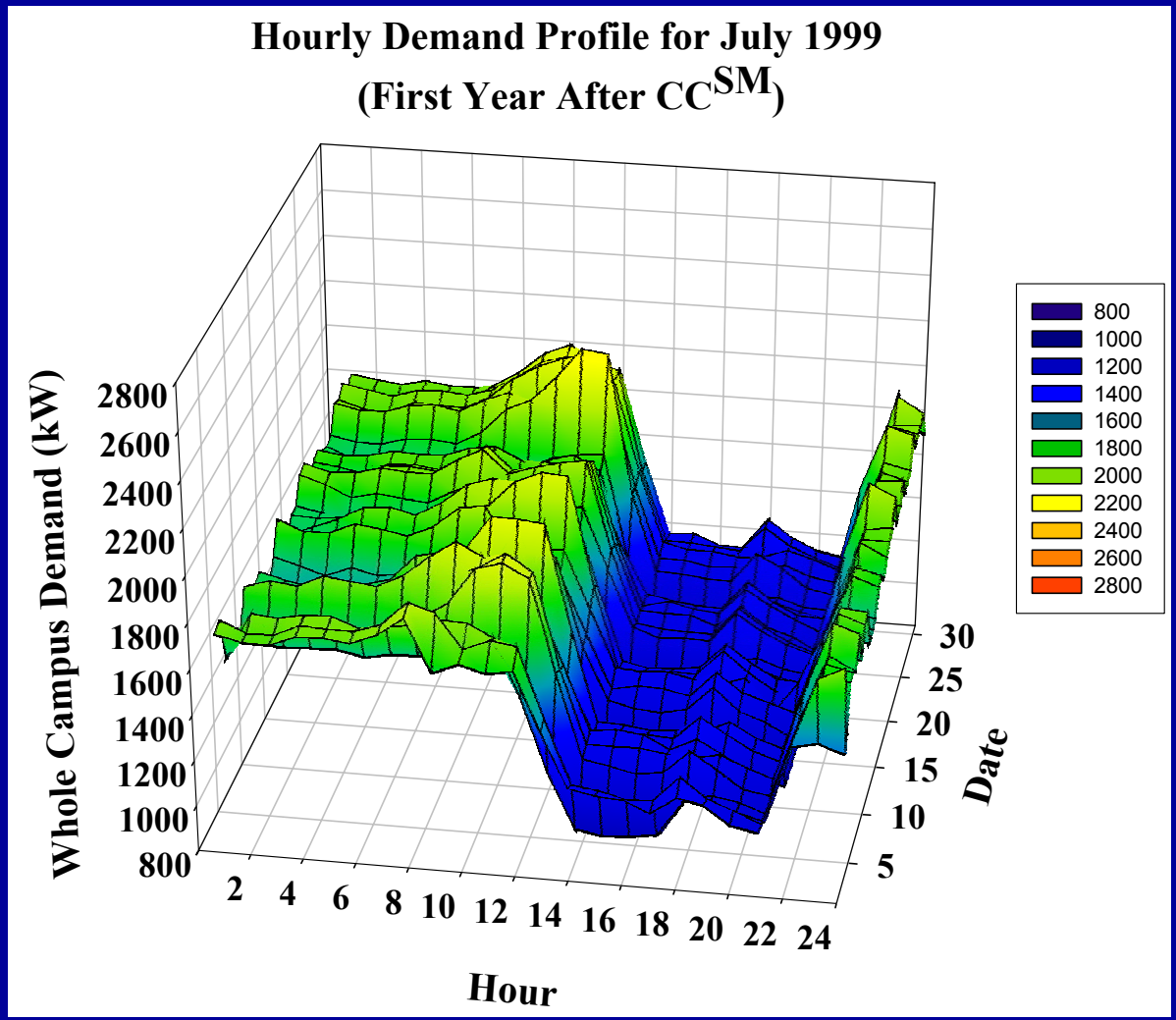
Findings:

- 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




Hourly Demand Profile for July 1997
(Prior to CC^SM)
Whole Campus Demand (kW)
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
2
4
6
8
10
12
14
16
18
20
22
24
Hour
30
25
20
15
10
5
Date
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800




Hourly Demand Profile for July 1999
(First Year After CC^SM)
Whole Campus Demand (kW)
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
2
4
6
8
10
12
14
16
18
20
22
24
Hour
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800
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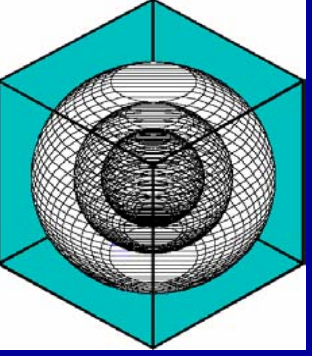
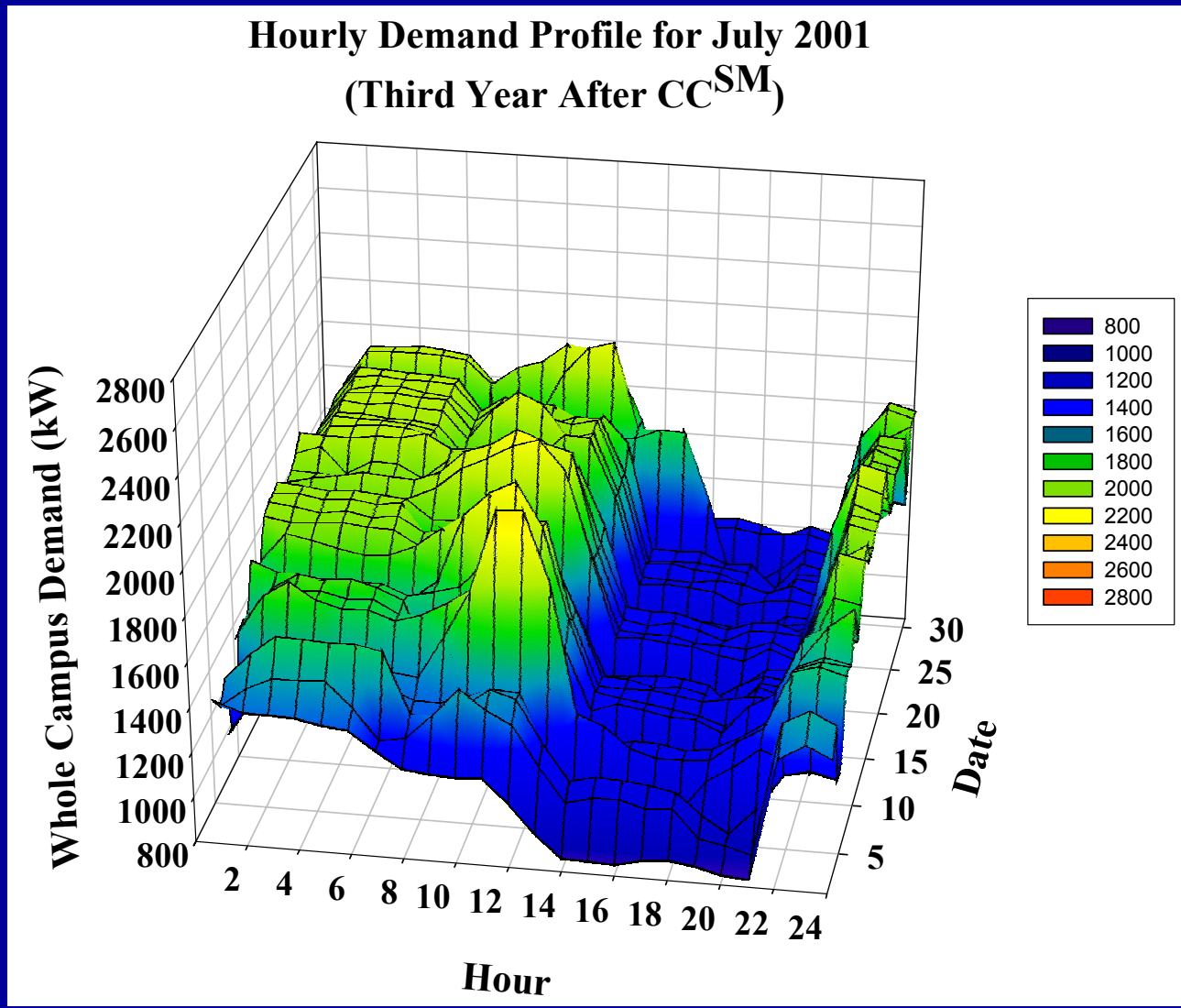
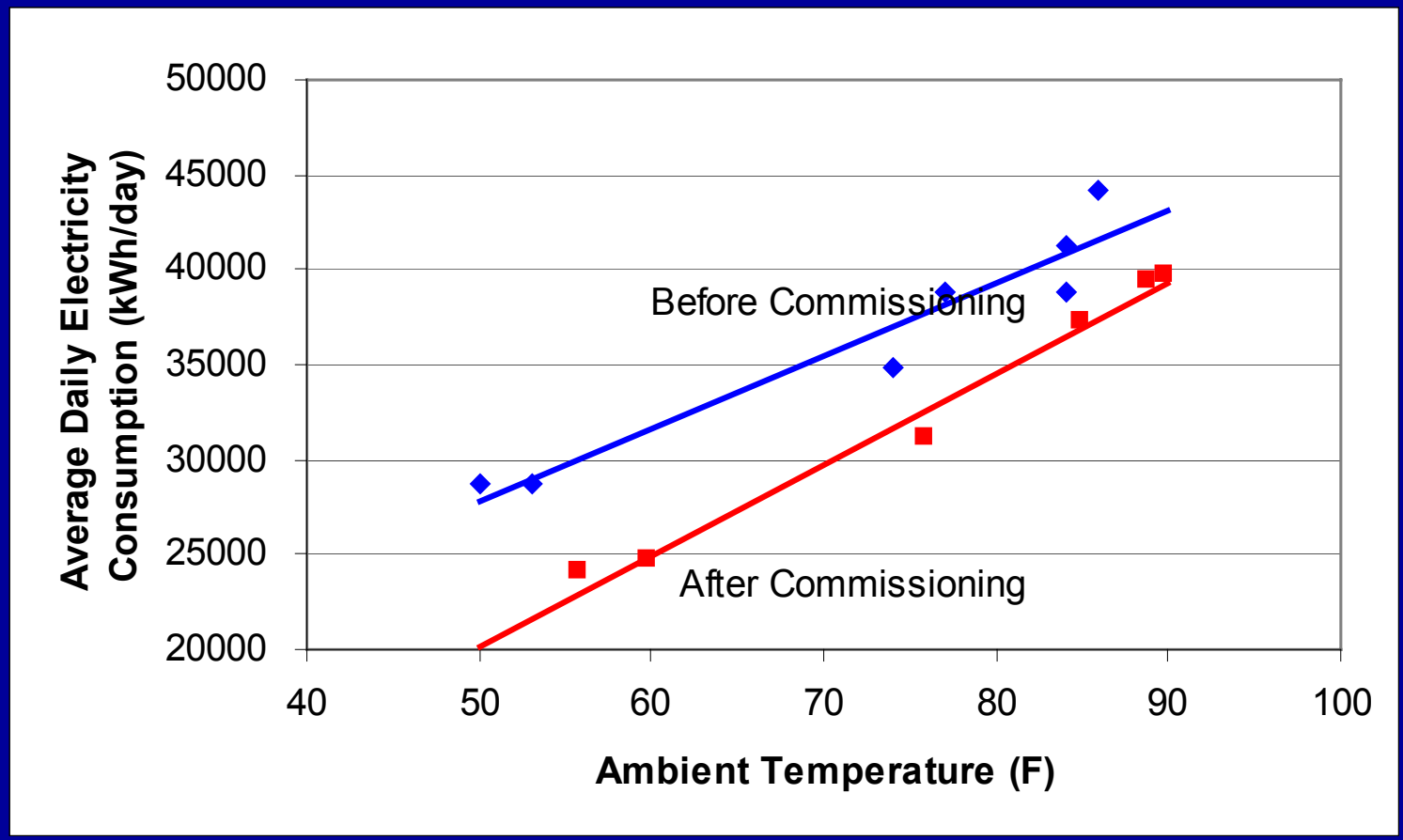
2200
2400
2600
2800

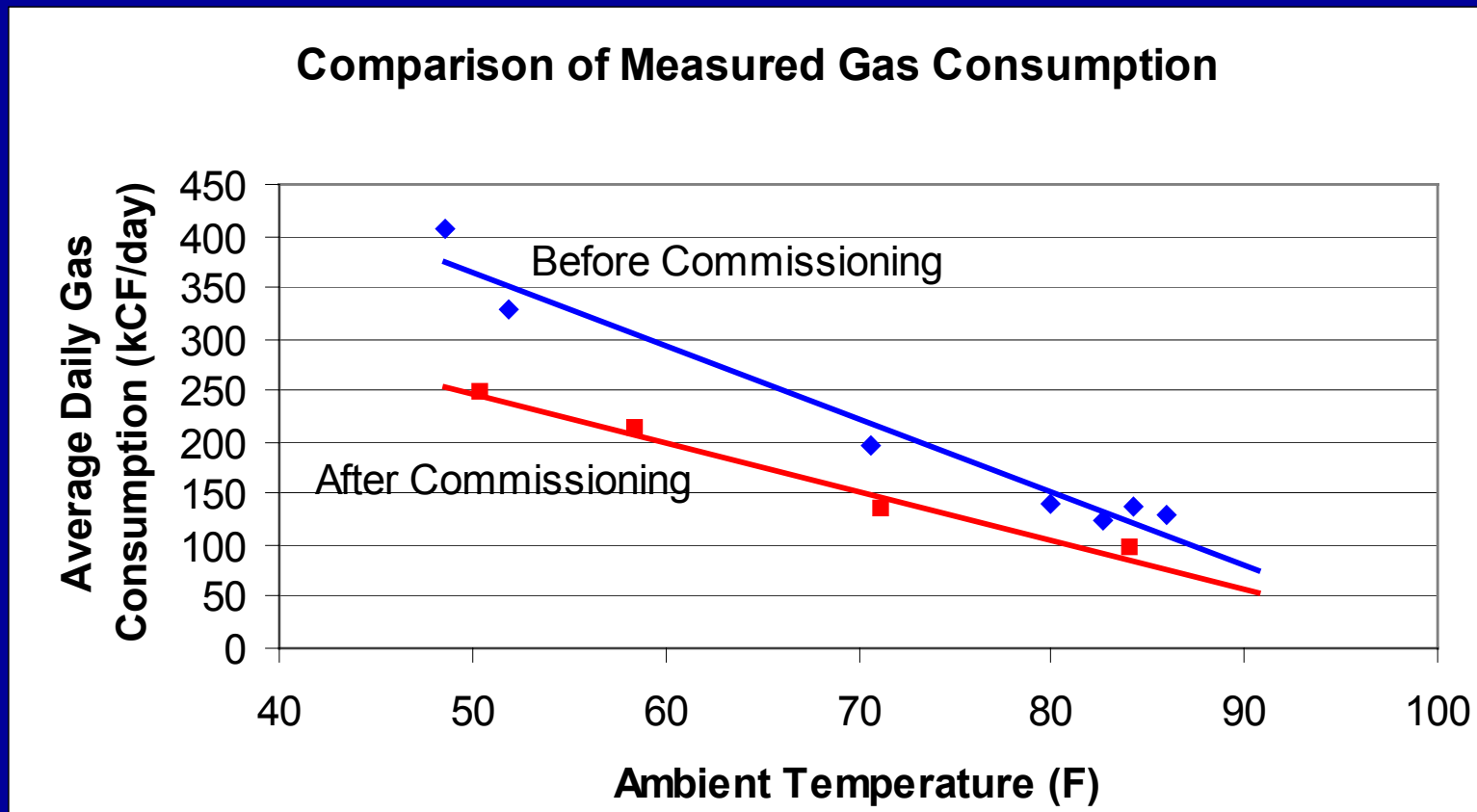


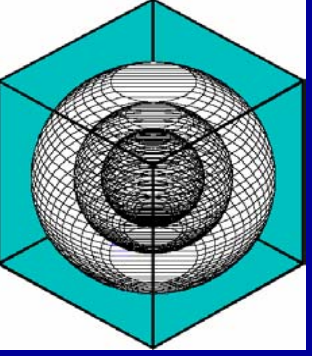

Hourly Demand Profile for July 2001
(Third Year After CC^SM)
Whole Campus Demand (kW)
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
2 4 6 8 10 12 14 16 18 20 22 24
Hour
30
25
20
15
10
5
Date
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Comparison of Campus Electricity Consumption



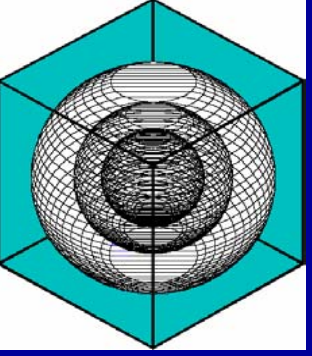
Comparison of Campus Gas Consumption



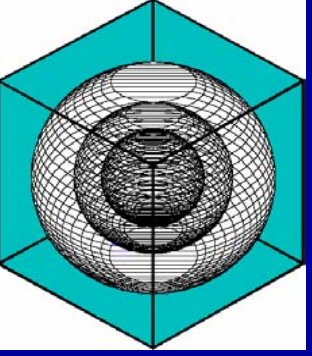


Post-Retrofit Commissioning Results

- 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

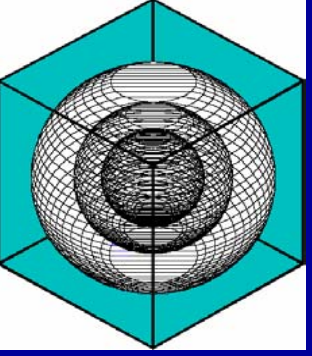


- **First year savings after CC (7/99 - 06/00): $175,112**
  - **$34,096 for demand**
  - **$88,832 for electricity**
  - **$55,736 for gas**
- **Demand costs: $7.63/kW-Mo**
- **Energy costs: $0.037/kWh**
- **Gas costs: $2.40/MMBtu**



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**

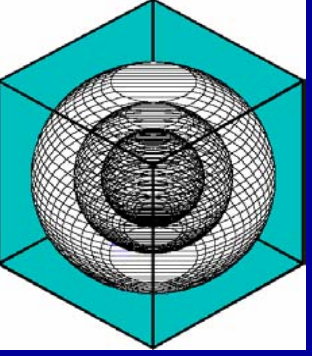
Matheson Courthouse Retro-Commissioning Progress Report to DFCM 8 May 2003

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

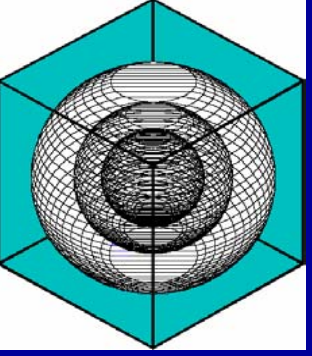
- 2001 utility bills were $400,000 ($300,000 for electricity, $100,000 for gas)
- Energy Cost Index = $1.08 per square foot per year, based on conditioned area

Matheson Courthouse – CC Team

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

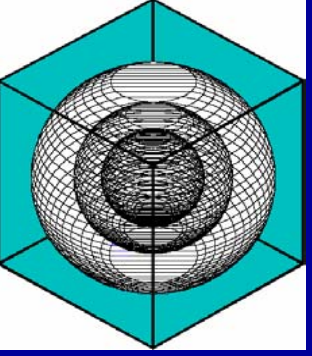
Matheson Courthouse – CC Findings (From CC Assessment and Detailed Investigations)

- 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



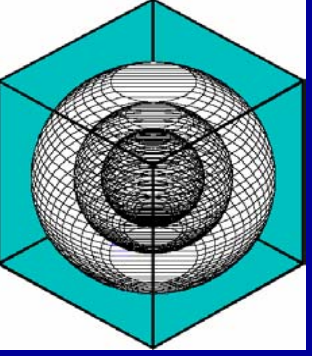
Matheson Courthouse – CC Findings, cont'd.

- Glycol de-icing system was not programmed correctly
- Building start-up/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



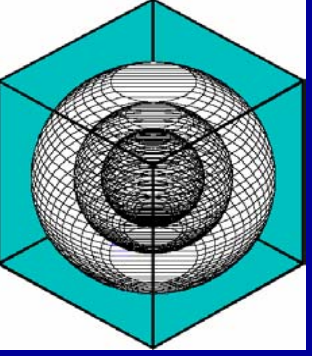
CC Findings, cont'd.

- 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

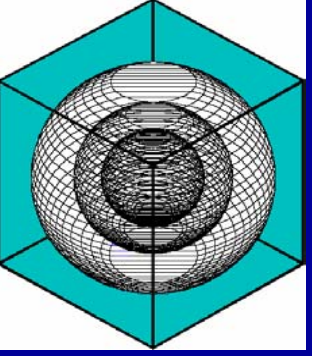
1. Dampers were adjusted to close as completely as possible
2. Two (2) leaking valves were repaired
3. Insulation was added to one (1) AHU to seal off outside air
4. Sticking isolation valve on small chiller was repaired
5. Exhaust dampers were adjusted and programming logic was changed to ensure dampers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

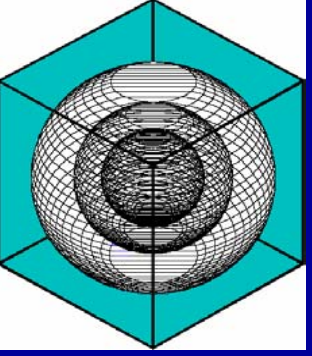
- Actual Savings for 2002

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

- Actual ECI for 2002 = $0.77 per square foot/year

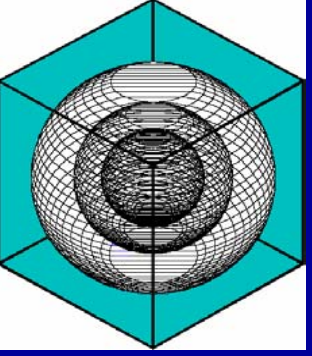
  (2001 ECI was $1.08 per square foot/year)

- 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.



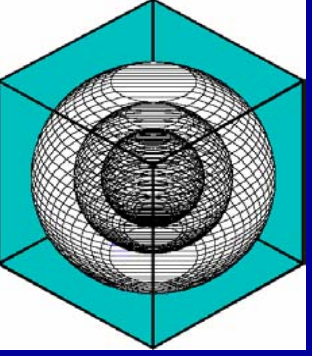
Matheson Courthouse - Conclusions

- 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.



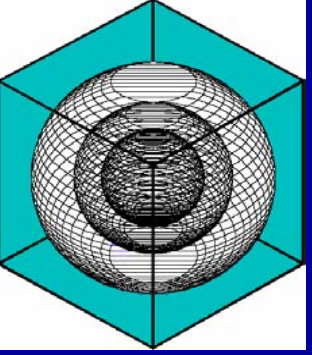
Costs for Continuous Commissioning

- Typically 30¢ to 60¢ per square foot, depending on the type of building and complexity
- Prefer to have interval metering on the building/facility, both gas and electric. Metering costs are $3,000 to $20,000 per building, depending on number of feeds, thermal metering, etc.
- Sometimes a modern building automation system can be used for limited metering



Savings from Continuous Commissioning

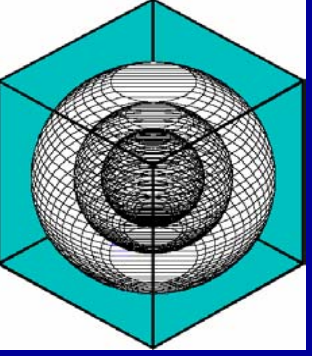
- Average savings are 10% to 25% of utility bills
- Simple paybacks typically from 1 to 3 years
- Some paybacks are less than 6 months



Continuous Commissioning®

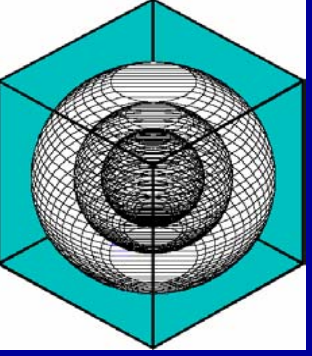
-*Savings & Costs*

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



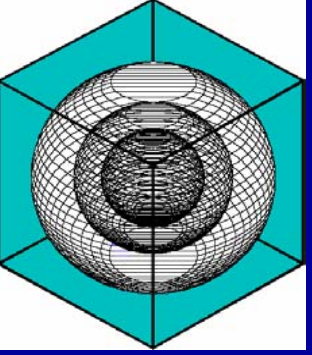
Summary

- Continuous Commissioning is one of the most cost effective efficiency measures that can be implemented
- Potential savings of 10 to 25% of annual utility bills
- Simple paybacks of 1-3 years



Federal Facilities Commissioned

- **Brooke Army Medical Center, San Antonio**
  ($300,000 annual savings)
- **NASA Dryden Flight Research Center**
  ($41,500 annual savings for 2 buildings)
- **Pending Contracts**
  - **Walter Reed Army Institute of Research**
  - **Fort Sill, OK, Reynolds Army Community Hospital**
  - **Brooke Army Medical Center – follow-up contract**



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