Commissioning New Facilities

The What, Why and How's of the Process

FASBO Energy Managers
Central Florida Chapter of AEE
FSPMA Energy & Environment

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Commissioning Purpose

To **AVOID**:

"***A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements***" **- ASHRAE Guideline 0-2005**

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Commissioning Process

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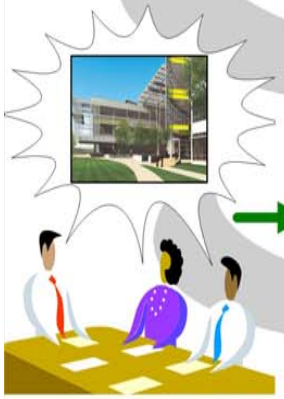
OPR Development & Documentation | BOD Review & Verification | Design Document Review | Submittal Review | Construction Phase Inspections, Testing

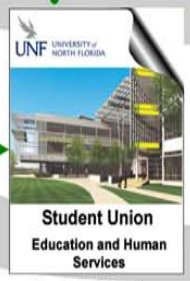
Technology Transfer To Owner.

Warranty & Seasonal Follow-Up.

Continuous Commissioning.



UNF Owner's Project Requirements



Basis of Design

OPRs

Design Drawings

OPRs

Submittals

OPRs

Prefunctional Checksheets

OPRs

Functional Tests

OPRs

OPRs

Specifications

OPRs

Student Union
Education and Human Services

Systems Manual

Operations and Maintenance Manual

Master Equipment List

Record Drawings

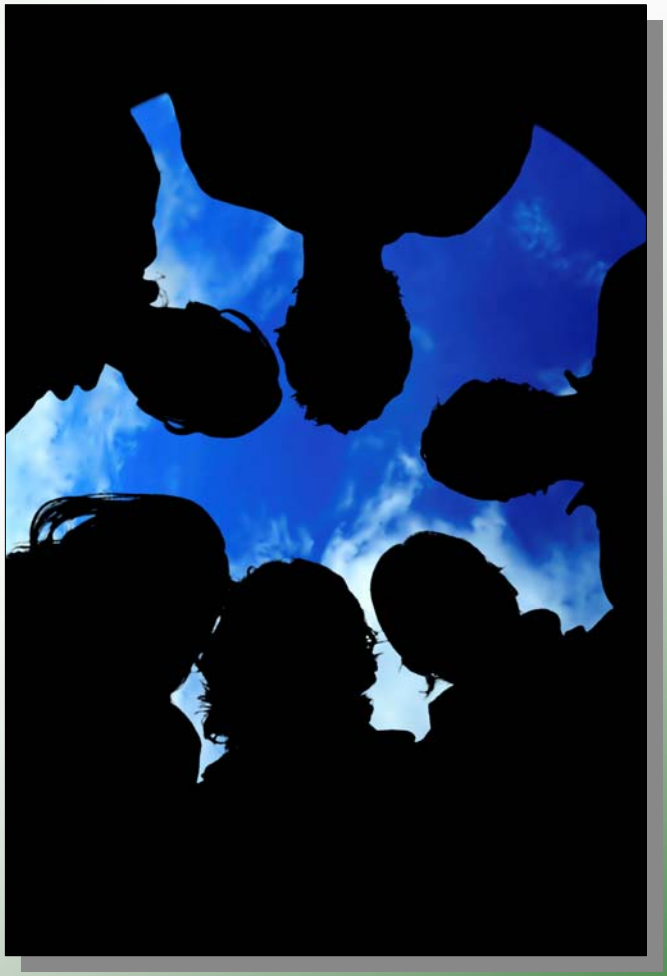
Training Videos

Warranties

Verifying Owner Project Requirements (OPRs)

Who are the “Owners”

- School Board
- Occupants/ Tenants
  - Faculty
  - Students
- Energy Managers
- Operations Personnel
- Maintenance Personnel
- Facility Managers
- Parents



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LEED Commissioning Process

- Review Owner's Project Requirements (OPR)
- Review Basis of Design (BOD)
- Peer Review Design Documents.
- Create Commissioning Plan.
- Commissioning Specifications.
- Develop Pre-functional Checksheets.
- Review Contractor Submittals.
- Functional\ Performance Testing.
- Develop Systems Manual.
- Verify Training Requirements.
- 10 Month Warranty Follow-up.

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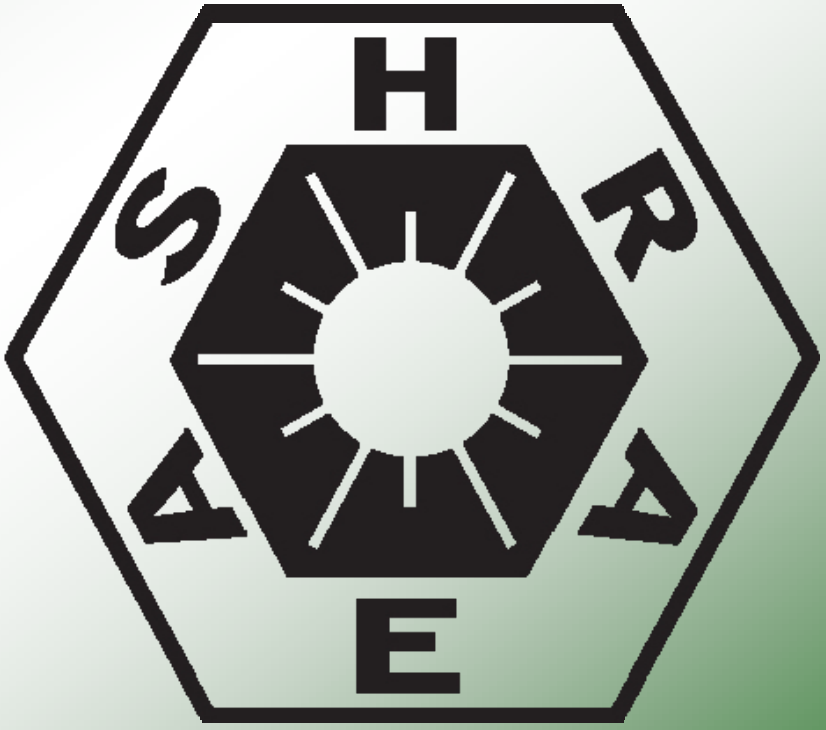
ASHRAE Guideline 0-2005

- Cx Authority Leads Process
- Develop OPR's with Owner
- Identify Coordination Items
  - Prefunctional vs Factory Rep. Startup
  - Spec. Tests vs Functional
- Witness Tests
  - Factory Tests
  - Field Tests
- Review Record Drawings
- Lessons Learn Workshops
- Document Rev. Management



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What are Owner Project Requirements

- LEED Requirements
- Indoor Environmental Quality
  - Temperature
  - Humidity
  - Air Quality (CO2, Filters)
  - Building Pressurization
- System Performance
  - Supply Temps (Air, Water)
  - Equipment/ System Efficiencies
  - Equipment/ Occupancy Schedules
- Security and Safety
- Owner Design Standards
- State Requirements for Educational Facilities (SREF)
- **Establish and DOCUMENT Goals**

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Indoor Environmental Quality

- ASHRAE Article 10/2006 – "*Research Report of Effects of HVAC on Student Performance*"

Effects on Children

The detailed results of the experiments have been submitted to ASHRAE's *HVAC&R Research* journal.[11,12] They show that increasing the outdoor air supply rate and reducing moderately elevated classroom temperatures significantly improved the performance of many tasks, mainly in terms of how quickly each pupil worked (speed) but also for some tasks in terms of how many errors were committed (% errors, the percentage of responses that were errors). The improvement was statistically

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System Performance

- Reduced Energy Costs
- Lower Carbon Footprint
- Chiller Efficiency
- Overall Plant Efficiency
- Increased Equipment Life
- Lower Life-Cycle Costs

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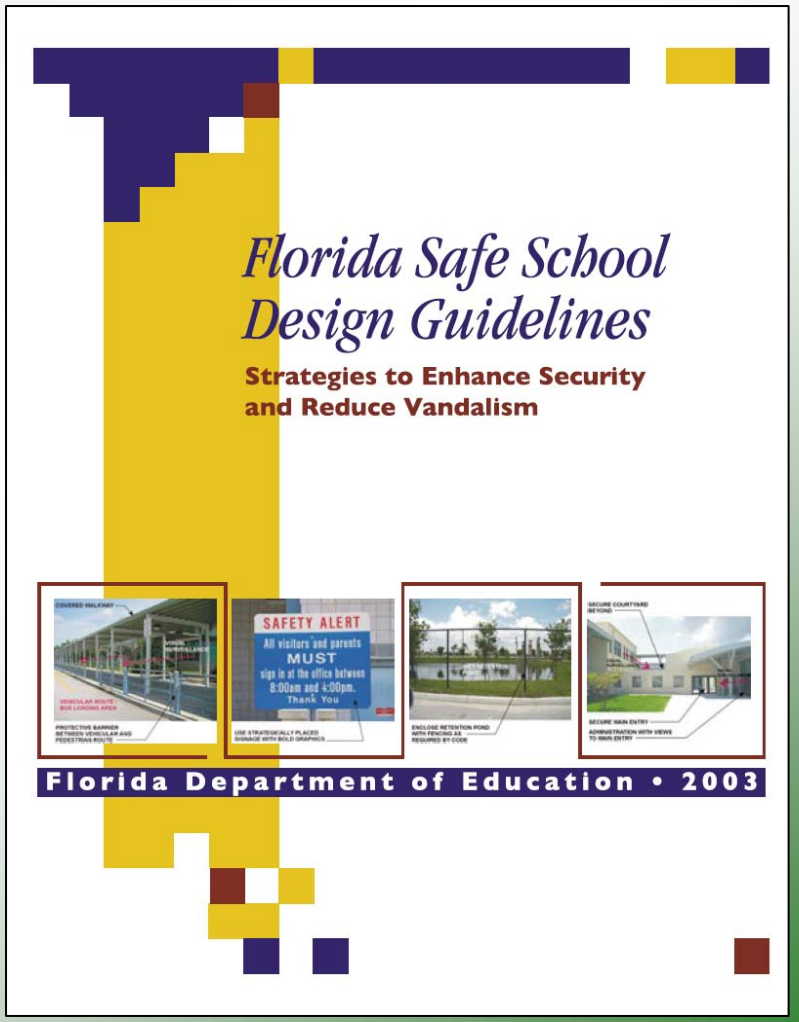
Security and Safety

- Students
- Teachers
- Public
- Reduce Costs from Vandalism

"*This work is applicable to Florida schools and community colleges, and these Guidelines illustrate – through text and drawings – how school architects, facility managers, risk managers, planners, and others can translate these crime prevention ideas into action. This guide also is intended to serve school resource officers, school administrators, and the general public as well.*"



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Commissioning Process Tasks

- Review Owner's Project Requirements (OPR)
- Review Basis of Design (BOD)
- Peer Review Design Documents.
- Create Commissioning Plan.
- Commissioning Specifications.
- Develop Pre-functional Checksheets.
- Review Contractor Submittals.
- Functional\ Performance Testing.
- Develop Systems Manual.
- Verify Training Requirements.
- 10 Month Warranty Follow-up.

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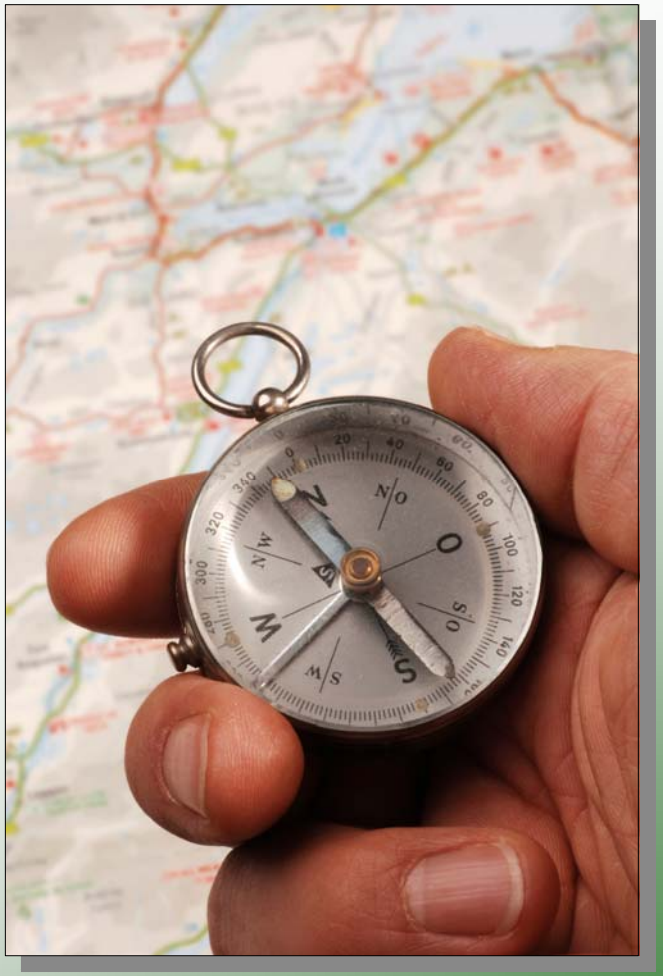
Commissioning Plan

- Provide Direction to Project Team
- Mirror Specifications
- Coordinate Scheduling Information
- Updated Throughout Project
- **Establish Work Flow**



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Commissioning Specifications

- Task List/ Description
- Commissioned Systems Lists
- Testing Requirements
- Sample Documentation
- Per Discipline
- **Identify Roles and Responsibilities**

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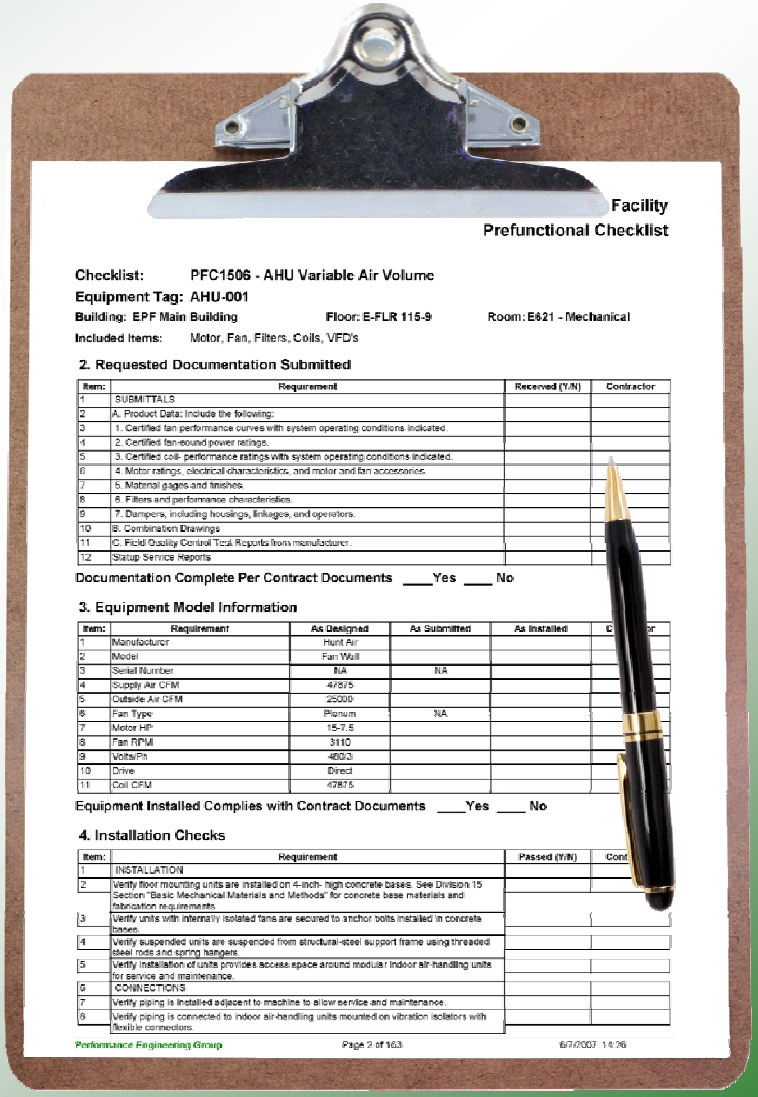
Pre-functional Checksheets

- Must be Complete Prior to Functional Test
- Verifies the Following:
  - Documentation Submittals
  - Equipment Model Info.
  - Receipt/ Installation Quality
  - Operational Items
  - Related Control Points
- Developed by CxA
- Executed by Subs
- Reviewed by CxA



Facility
Prefunctional Checklist

Checklist: PFC1506 - AHU Variable Air Volume
Equipment Tag: AHU-001
Building: EPF Main Building **Floor:** E-FLR 115-9 **Room:** E621 - Mechanical
Included Items: Motor, Fan, Filters, Coils, VFD's

2. Requested Documentation Submitted

Item:	Requirement	Reserved (Y/N)	Contractor
1	SUBMITTALS		
2	A. Product Data: Include the following:		
3	1. Certified fan performance curves with system operating conditions indicated.		
4	2. Certified fan-sound power ratings.		
5	3. Certified coil- performance ratings with system operating conditions indicated.		
6	4. Motor ratings, electrical characteristics, and motor and fan accessories.		
7	5. Material gages and finishes.		
8	6. Filters and performance characteristics.		
9	7. Dampers, including housings, linkages, and operators.		
10	B. Combination Drawings		
11	C. Field Quality Control Test Reports from manufacturer.		
12	Startup Service Reports		

Documentation Complete Per Contract Documents ___Yes ___ No

3. Equipment Model Information

Item:	Requirement	As Designed	As Submitted	As Installed	C...r
1	Manufacturer	Hunt Air			
2	Model	Fan Wall			
3	Serial Number	NA	NA		
4	Supply Air CFM	47875			
5	Outside Air CFM	25000			
6	Fan Type	Plenum	NA		
7	Motor HP	15-7.5			
8	Fan RPM	3110			
9	Volts/Ph	460/3			
10	Drive	Direct			
11	Coil CFM	47875			

Equipment Installed Complies with Contract Documents ___Yes ___ No

4. Installation Checks

Item:	Requirement	Passed (Y/N)	Cont
1	INSTALLATION		
2	Verify floor mounting units are installed on 4-inch- high concrete bases. See Division 15 Section "Basic Mechanical Materials and Methods" for concrete base materials and fabrication requirements.		
3	Verify units with internally isolated fans are secured to anchor bolts installed in concrete bases.		
4	Verify suspended units are suspended from structural-steel support frame using threaded steel rods and spring hangers.		
5	Verify installation of units provides access space around modular indoor air-handling units for service and maintenance.		
6	CONNECTIONS		
7	Verify piping is installed adjacent to machine to allow service and maintenance.		
8	Verify piping is connected to indoor air-handling units mounted on vibration isolators with flexible connectors.		

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Submittal Review

2. Requested Documentation Submitted

Item:	Requirement	Received (Y/N)
1	SUBMITTALS	
2	A. Product Data: Include the following:	
3	1. Certified fan performance curves with system operating conditions indicated.	
4	2. Certified fan-sound power ratings.	
5	3. Certified coil- performance ratings with system operating conditions indicated.	
6	4. Motor ratings, electrical characteristics, and motor and fan accessories.	
7	5. Material gages and finishes.	
8	6. Filters and performance characteristics.	
9	7. Dampers, including housings, linkages, and operators.	
10	B. Combination Drawings	
11	C. Field Quality Control Test Reports from manufacturer.	
12	Statup Service Reports	

Documentation Complete Per Contract Documents ____Yes ____ No

3. Equipment Model Information

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7	Motor HP	15-7.5		
8	Fan RPM	3110		
9	Volts/Ph	480/3		
10	Drive	Direct		
11	Coil CFM	47875		

Equipment Installed Complies with Contract Documents ____Yes ____ No

- Part of Check Sheet
  - Database Application
  - Easy to See Discrepancies
- Form Helps Verifies:
  - Documentation Reqs.
  - Equipment Model
- Additional Review
  - Dimensions
  - Capacity
  - Discipline Coordination

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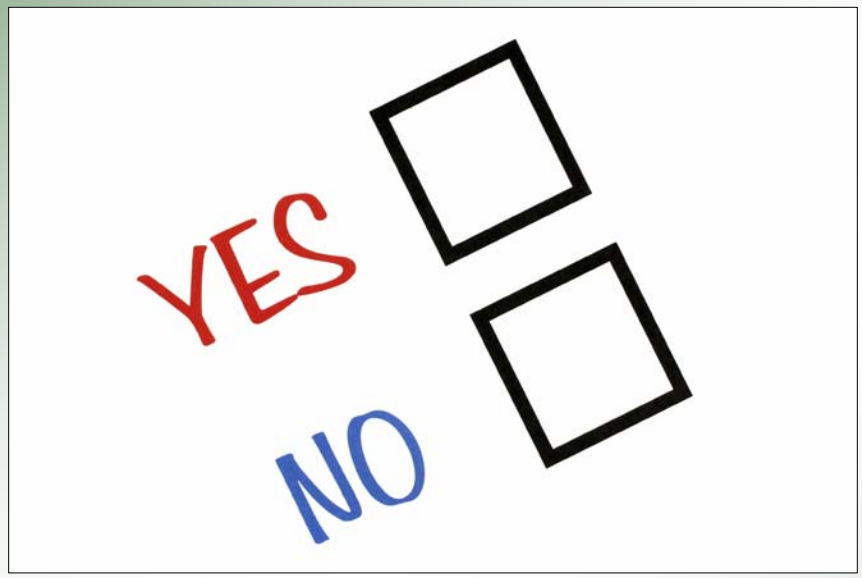
Functional/ Performance Tests



- Typically Based on Sequence of Operations
- Includes Performance Testing
  - Efficiencies (kW/ ton)
  - Capacities (tons)
  - Sound Levels
- Equipment Interlocks
- Inter-System Testing
  - Life-Safety/ HVAC
  - Emergency Power/ Lighting
- Opportunity to Document:
  - Critical Setpoints
  - PID Settings
  - Operating Schedules

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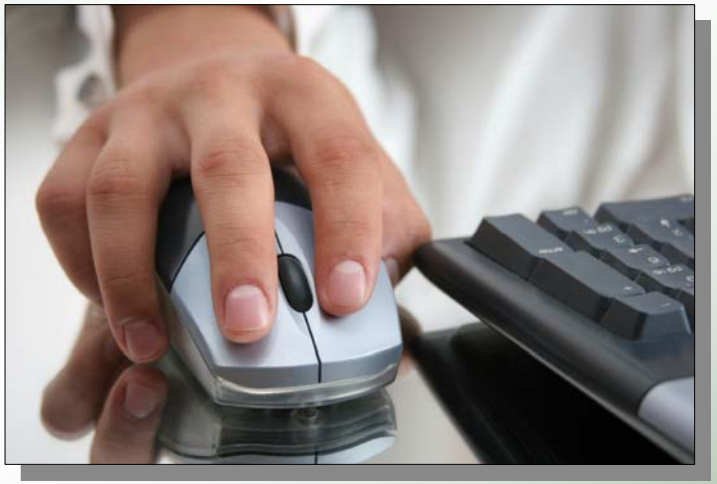
Technology Transfer

- Systems Manual
- Training Verification
- Operations and Maintenance Manual
- Commissioning Forms Templates
- Record Drawings
- Master Equipment List
- **Begin Transfer Day 1**
  - **O&M Following Submittal**
  - **Involve Operations Personnel Early**



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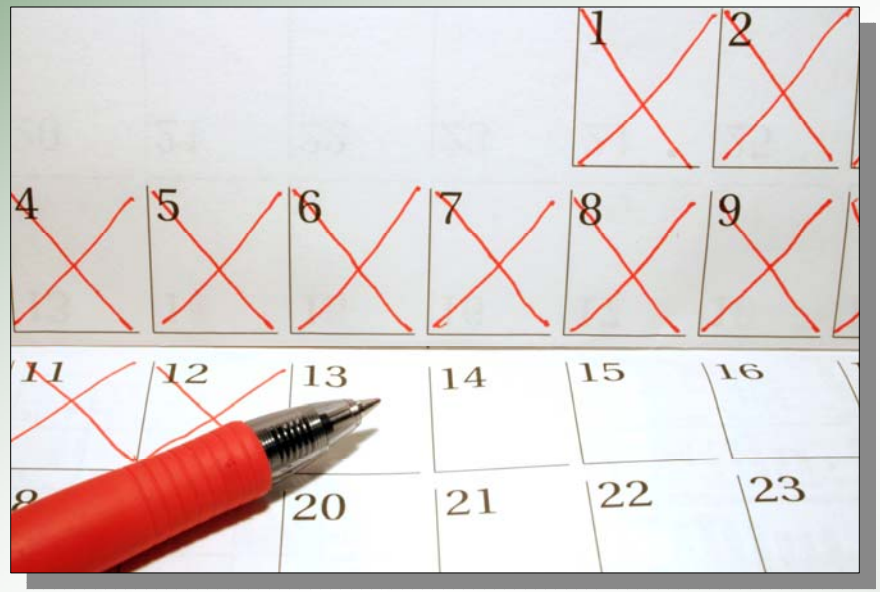
Warranty/ Seasonal Follow-up



- Interview Personnel
  - Discuss Operations
  - Evaluate Training Needs
- Seasonal Testing
  - As Needed
- Check Warranties
  - Claim Submissions Req.
- Review Utility Bills
  - Compare to EnergyStar
  - Compare to OPR
- **Review Trend Data**
  - **Identify Issues**
  - **Develop Resolution**
  - **Optimization**

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Benefits-Savings

Savings From Commissioning		
Building Type	**$ Savings**	**Energy Savings**
110,000 ft^2 office	$.11/$ft^2$/yr ($12,276/yr)	279,000 kWh/yr
22,000 ft^2 office	$.35/$ft^2$/yr ($7,630/yr)	130,800 kWh/yr
60,000 ft^2 high-tech manu.	$.20/$ft^2$/yr ($12,000/yr)	336,000 kWh/yr

Costs from Tenant Discomfort	
Payroll costs	$150/$ft^2$/year
Productivity lost to complaint time	$.10/$ft^2$/year

Source: http://www.oregon.gov/ENERGY/CONS/BUS/comm/commsave.shtml

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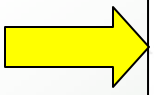
Benefits-Example CCOC

- Fewer warranty call backs
- Fewer tenant complaints
- Extended equipment lifecycles
  - Minimized cycling and hunting
  - Improved maintenance
  - Trended data provides baselines for comparison
  - Better skill at troubleshooting and addressing problems
- Improved system reliability

"*A new process of designing and commissioning high-performance prototype office buildings has evolved rapidly at the state's Department of Management Services (DMS)…*

Lower maintenance costs. Built-in access to technology that is adaptable to future developments. And high-performance energy efficiency. ***Our total energy costs are 90 cents a square foot per year. That's less than half of the comparable cost for the whole South.***"

Bill Lindner- Secretary, Florida Department of Management Services - 3/4/1996
http://www.p2pays.org/ref/17/16987.htm



Commissioned buildings save money, officials say

TALLAHASSEE — A super-efficient $50 million office complex that opened in the spring shows how "commissioning" state buildings can save utility costs, Florida officials said yesterday.

Energy use at the six-building Satellite Office Complex during peak summer air-conditioning demand was 2.48 watts per square foot. Four other typical state office buildings around Tallahassee averaged 4.74 watts.

Efficient design causes part of the savings, but part is from commissioning the buildings like a Navy ship, said Department of Management Services Secretary William Lindner. That involves checking on energy performance, quality of light, whether air conditioning responds and how other systems function while construction is still under way and then fixing any problems.

Lindner will describe the system at the Florida Design Initiative Roundtable, a two-day convention of architects, engineers and builders opening today in Orlando.

Times Union, Jacksonville FL - 9/28/95

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Costs-Cx Authority

Estimated Commissioning Costs	
Commissioning Scope Estimated Cost	**Range**
Whole building (controls, electrical, mechanical) **Commissioning from design through acceptance**	**0.5-1.5% of total construction cost**
HVAC and automated controls system only	**1.5-2.5% of mechanical contract**
Electrical system only	**1-1.5% of electrical contract**
Various energy-efficiency measures	**53,000 ft^2 avg. $.08-$.64* ft^2** **102,000 ft^2 avg. $.13-$.43** ft^2**

***$.23 avg. cost for 16 buildings**
****$.28 avg. cost for 7 buildings**

From the Oregon Department of Energy:
http://www.oregon.gov/ENERGY/CONS/BUS/comm/commcost.shtml

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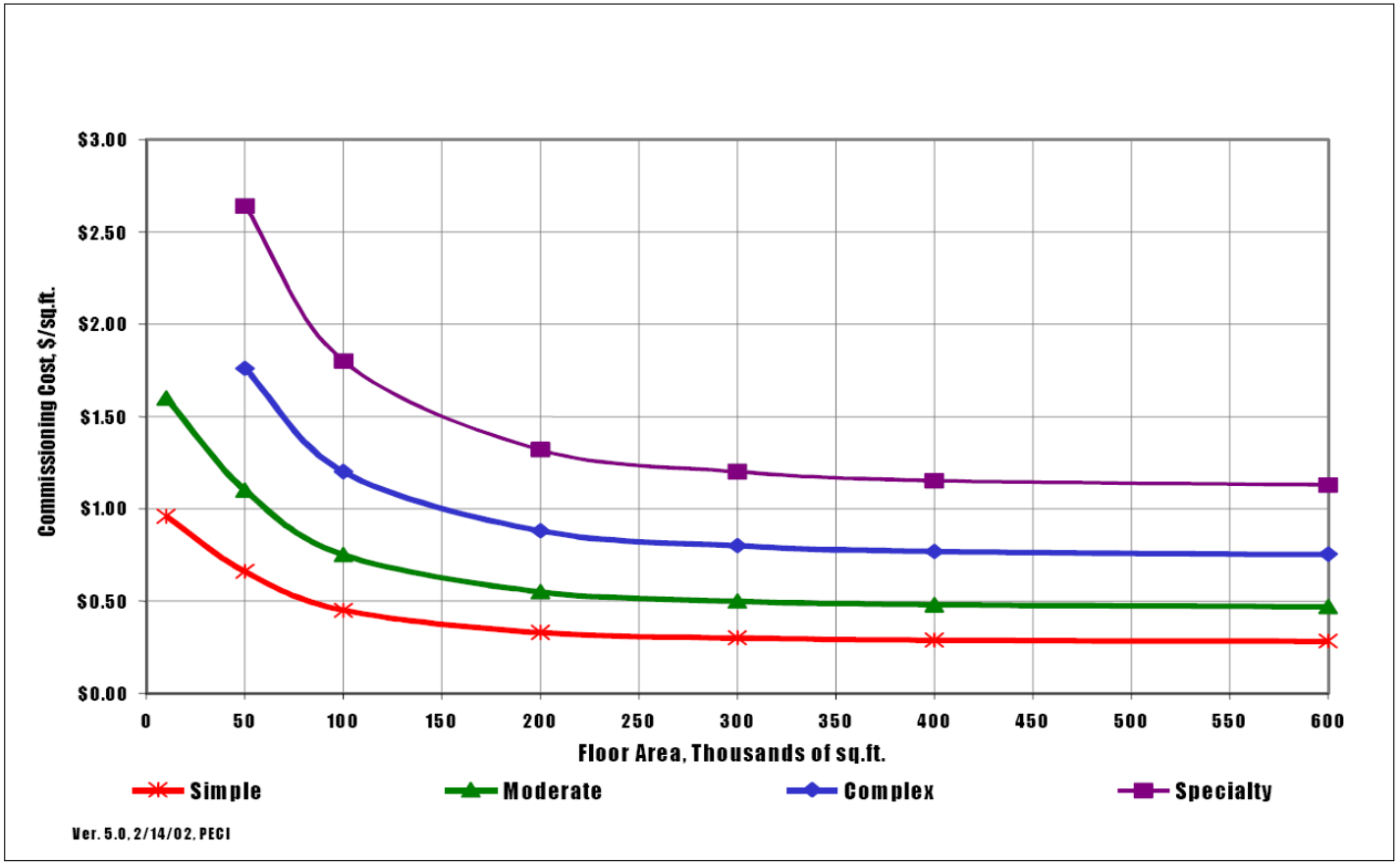
Costs-Cx Authority



Portland Energy Conservation, Inc.
"*Commissioning of Smaller Green Buildings-Expectations vs. Reality.*"
http://www.peci.org/library/PECI_SmallGreenCx1_1002.pdf

Simple = office buildings, classrooms, packaged equipment and controls; common systems, fewer pieces of equipment.
Moderate = more complex office, classroom with some labs, more control strategies, fewer packaged equipment; more systems (fire, emergency power, etc.).
Complex = Moderate plus most of floor area in complex systems (hospitals, labs, operating rooms, clean rooms, fume hoods or other non-HVAC systems are commissioned such as electrical quality, transformers, security, communications, etc.
Specialty = Very complex facilities

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LEED Cx Costs

Building	Total Sq.Ft. (in thousands)	Cx Cost/ Sq.Ft.
Office, showroom	10-20	$ .32
Elementary School	40-50	$ .37
Office	50-60	$ .58
Gallery, meeting rooms	50-60	$ 1.00
Restaurant	20-30	$ 1.30
Office	30-40	$ 1.35
Restaurant, office	1-10	$ 1.78
Dormitory, classrooms, dining hall	30-40	$ 1.95
Office	10-20	$ 2.00
Municipal facility	10-20	$ 2.25
Visitor center, laboratory, exhibition space	50-60	$ 3.19

Portland Energy Conservation, Inc.
"*Commissioning of Smaller Green Buildings-Expectations vs. Reality.*"
http://www.peci.org/library/PECI_SmallGreenCx1_1002.pdf

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Costs - Other

- Sub-contractors
  - Labor to Support Cx
  - Pre-functional Checksheets
  - Additional Documentation
  - Functional Testing Support
  - Change Order if Not in Specifications
  - Cx Meetings
- Contractor may Claim
  - More Scope to Manage
  - Extra Effort Same Schedule

Commissioning Payback

	All		Existing buildings			New construction		
	Total	Sample size	Total	Median per project	Sample size	Total	Median per project	Sample size
Number of projects	175	175	106		106	69		69
Number of buildings[1]	224	175	150	1.4	106	74	1.1	69
Number of states	21	175	15		106	15		69
Total project floor area, million square feet	30.4	175	22.2	0.151	106	8.2	0.07	69
Year built				1978	78		1996	59
Total new-building construction costs, millions of dollars[2]						1,514	10.2	58
Number of deficiencies identified	6,805	120	3,500	11	85	3,305	26	35
Commissioning cost as a fraction of total building-construction cost (excluding non-energy benefits), percent							0.6	65
Total commissioning costs (excluding non-energy impacts[3])								
Thousands of dollars	16,984	171	5,223	34	102	11,760	74	69
Dollars per square foot				0.27	102		1.00	69
Total savings[3]								
Thousands of dollars per year[4]	8,840	133	8,022	45	100	818	3	33
Dollars per square foot per year[4]				0.27	100		0.05	33
Whole-building energy-cost savings, percent[5]				15	74			
Simple payback time, local energy prices, years				1.0	99		5.6	38
Simple payback time, standardized U.S. energy prices, including some cases with non-energy impacts, years[6]				0.7	59		4.8	35

Notes:
[1]Actual values likely higher. For the many data sources that did not specify number of buildings, the authors stipulated one.
[2]All costs in this table are in inflation-corrected 2003 dollars.
[3]Payback time should not be inferred from these two rows, as sample sizes are different.
[4]Total based on inflation-corrected local energy prices. Median based on inflation-corrected standardized energy prices.
[5]Percentage savings generally are not available for new construction.
[6]In a number of cases, commissioning costs were partly or fully offset by resultant first-cost savings.

"*The most cost-effective results--both in terms of depth of savings and payback times--occurred among energy-intensive facilities, such as hospitals and laboratories. Less cost-effective results were most frequent in smaller buildings.* ***Energy savings tended to rise with the comprehensiveness of commissioning***."

Source: HPAC Magazine
"*The Cost-Effectiveness of Commissioning*"
http://eetd.lbl.gov/emills/PUBS/PDF/Cx/Cx_HPAC.pdf

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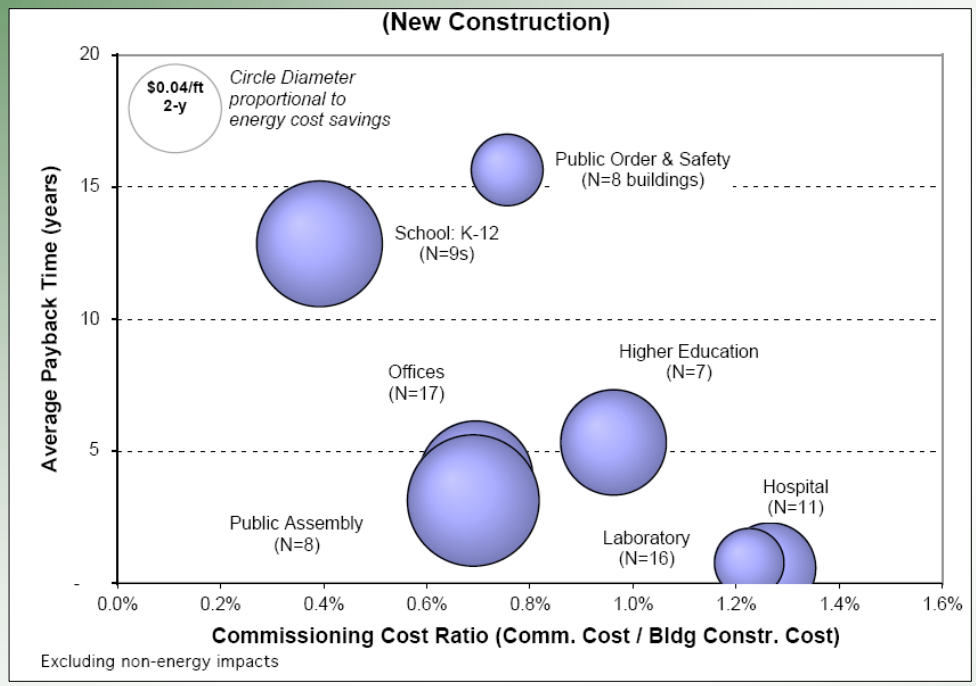
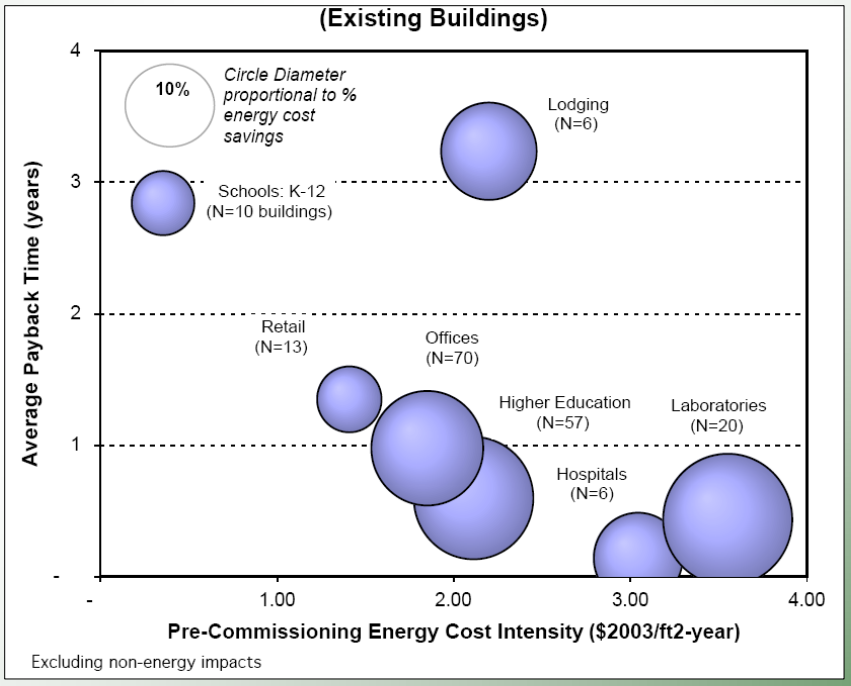
Payback: Building Types





Source: "*THE COST-EFFECTIVENESS OF COMMERCIAL-BUILDINGS COMMISSIONING***"**
Lawrence Berkeley National Laboratory, Portland Energy Conservation Inc.,
Energy Systems Laboratory, Texas A&M University
http://eetd.lbl.gov/emills/PUBS/PDF/Cx-Costs-Benefits.pdf

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Quality Cx: Optimization

- Sequence of Operations
  - Provide More Detail
  - Leverage Equipment Efficiencies
  - Recommend Points
- Setpoints
  - Supply Temperatures
  - Supply Pressures
- Schedules
  - Match Tight to Tenant Use
  - Verify Optimum Starts
  - Segregate Space Types

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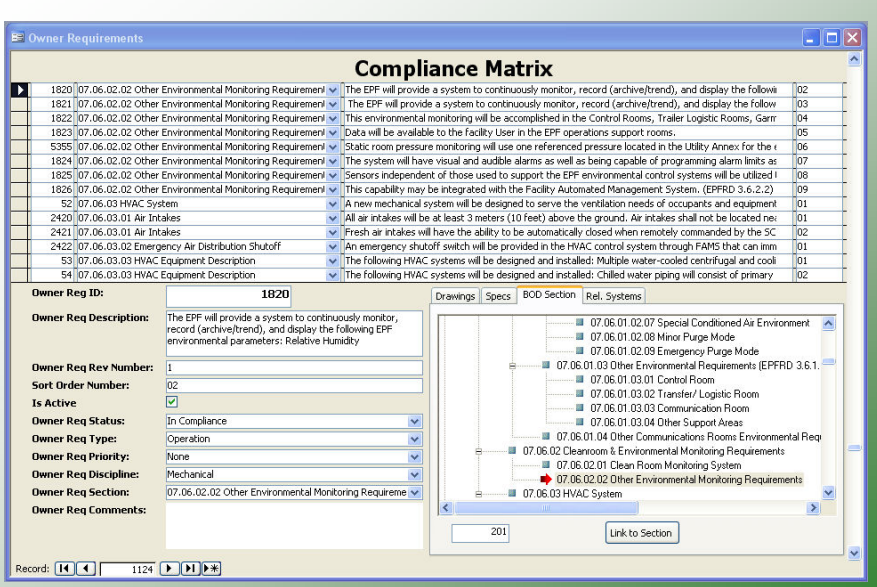
Quality Cx: Information Management

- OPR Tracking
- Components
- Drawings
- Specifications
- Functional Tests
- Prefunctional Checksheets
- Issues
- Revision Mgmt



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http://www.pegengineering.com/fasbo.htm

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