Commissioning New Facilities

The What, Why and How's of the Process

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

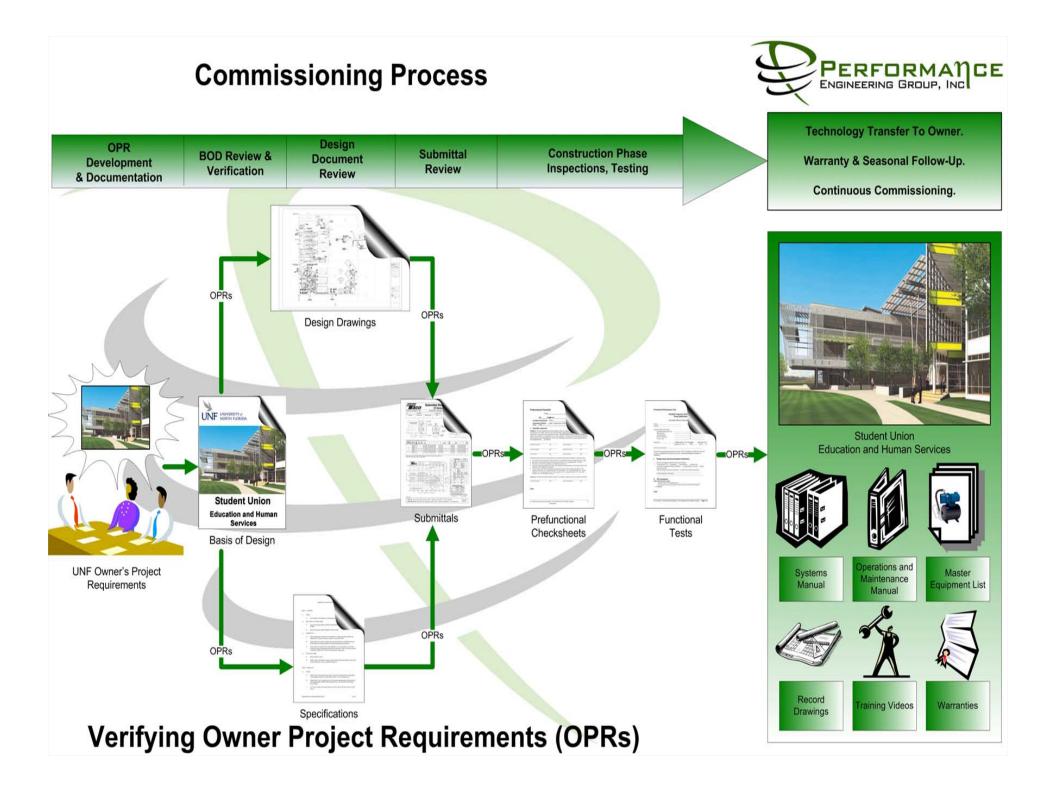


Commissioning Purpose



"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 <u>Owner's Project Requirements</u>" - ASHRAE Guideline 0-2005





Who are the "Owners"

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





LEED Commissioning Process

- Review Owner's Project Requirements (OPR)
- Review Basis of Design (BOD)
- <u>Peer</u> 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.





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





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

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



System Performance

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







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, <u>facility managers, risk</u> <u>managers, planners</u>, 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."



Florida Safe School Design Guidelines

<mark>Str</mark>ategies to Enhance Security and Reduce Vandalism



Commissioning Process Tasks

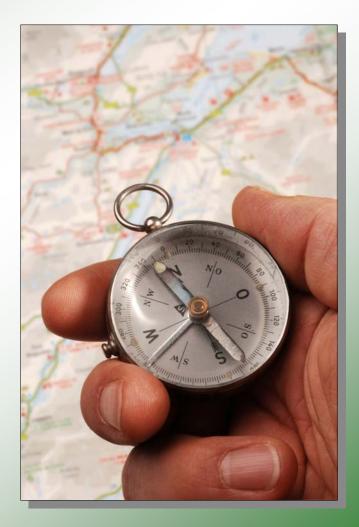
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Commissioning Plan

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





Commissioning Specifications



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



Pre-functional Checksheets

- Must be <u>Complete</u> 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



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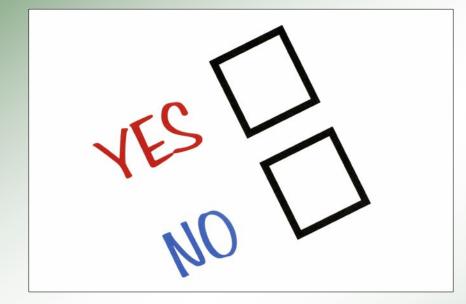
Submittal Review

Item:		Received (Y/N		
1	SUBMITTALS			
2	A. Product Data: Include the following			
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4	2. Certified fan-sound power ratings.			
5	3. Certified coil- performance ratings			
6	4. Motor ratings, electrical characteri			
7	Material gages and finishes.			
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9	7. Dampers, including housings, links			
10	B. Combination Drawings			
11	C. Field Quality Control Test Reports			
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- Part of Check Sheet
 - Database Application
 - Easy to See Discrepancies
- Form Helps Verifies:
 - Documentation Reqs.
 - Equipment Model
- Additional Review
 - Dimensions
 - Capacity
 - Discipline Coordination



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



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







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



Benefits-Savings

Savings From Commissioning					
Building Type	\$ Savings	Energy Savings			
110,000 ft ² office	\$.11/ft²/yr (\$12,276/yr)	279,000 kWh/yr			
22,000 ft ² office	\$.35/ft²/yr (\$7,630/yr)	130,800 kWh/yr			
60,000 ft ² high-tech manu.	\$.20/ft²/yr (\$12,000/yr)	336,000 kWh/yr			

Costs from Tenant Discomfort				
Payroll costs	\$150/ft²/year			
Productivity lost to complaint time	\$.10/ft²/year			

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



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 highperformance 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 superefficient \$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

Costs-Cx Authority

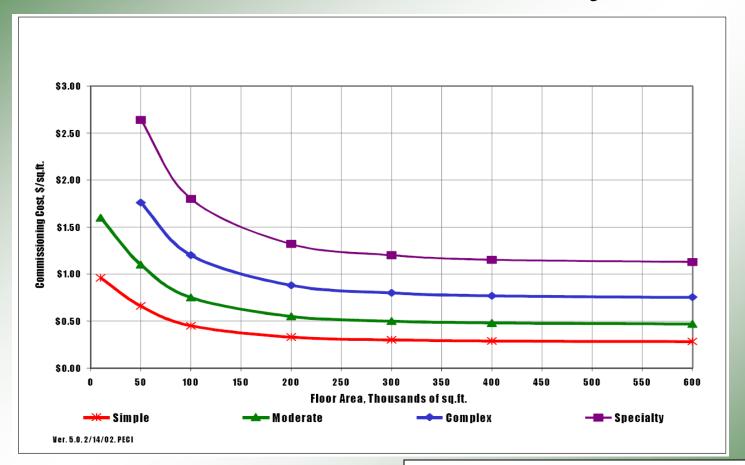
Estimated Commissioning Costs				
Commissioning Scope Estimated Cost	Range			
Whole building (controls, electrical, mechanical) Commissioning from design through acceptance	0.5-1.5% of total construction cost			
HVAC and automated controls system only	1.5-2.5% of mechanical contract			
Electrical system only	1-1.5% of electrical contract			
Various energy-efficiency measures	53,000 ft² avg. \$.08-\$.64* ft² 102,000 ft² avg. \$.13-\$.43** ft²			

*\$.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



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

LEED Cx Costs

	Total	Cr. Cost/
Building	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,	50-60	\$ 3.19
exhibition space		

Portland Energy Conservation, Inc.

"Commissioning of Smaller Green Buildings-Expectations vs. Reality." http://www.peci.org/library/PECI_SmallGreenCx1_1002.pdf



Costs - Other



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



Commissioning Payback

	A	All Existing buildings		New construction		ction		
	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 Dollars per square foot	16,984	171	5,223	34 0.27	102 102	11,760	74 1.00	69 69
Total savings ³ Thousands of dollars per year ⁴ Dollars per square foot per year ⁴	8,840	133	8,022	45 0.27	100 100	818	3 0.05	33 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

¹Actual values likely higher. For the many data sources that did not specify number of buildings, the authors stipulated one.

2All costs in this table are in inflation-corrected 2003 dollars.

³Payback time should not be inferred from these two rows, as sample sizes are different.
⁴Total based on inflation-corrected local energy prices. Median based on inflation-corrected standardized energy prices.

⁵Percentage savings generally are not available for new construction.

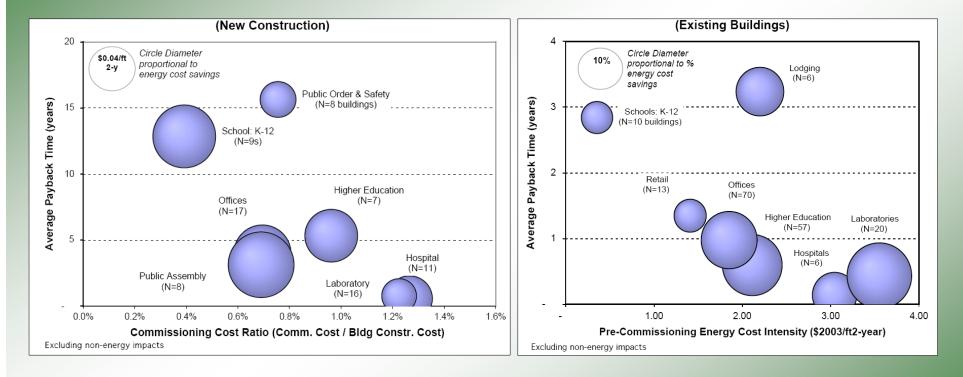
6In a number of cases, commissioning costs were partly or fully offset by resultant first-cost savings



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

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

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



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





Quality Cx: Information Management

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



BOD/ EWR	Components	Drawings	Issues
BOD/ EWR Compliance	Components	Drawings	Issues
Basis of Design Report	Component Report Filter	Drawing Report Filter	Issue Report (Detailed)
EWR 127-1 Report	System Tree Reports		Issue List (Summary)
Specifications	Prefunctional Checklists	Specification Tests	Functional Tests
Specifications	PFC Data Entry PFC Templates	Test Templates	Functional Test Template
Specifications Report Filter	Prefunctional Checklist Form	Test Templates Report Filter	Functional Test Forms

		Compliance Matrix	
1820 07.06.02.02 Other	Environmental Monitoring Requirement 🗸	The EPF will provide a system to continuously monitor, record (archive/trend), and display the followi	02
1821 07.06.02.02 Other	Environmental Monitoring Requirement 🗸	The EPF will provide a system to continuously monitor, record (archive/trend), and display the follow	03
		This environmental monitoring will be accomplished in the Control Rooms, Trailer Logistic Rooms, Garr	04
		Data will be available to the facility User in the EPF operations support rooms.	05
		Static room pressure monitoring will use one referenced pressure located in the Utility Annex for the (06
		The system will have visual and audible alarms as well as being capable of programming alarm limits as	07
		Sensors independent of those used to support the EPF environmental control systems will be utilized I	08
		This capability may be integrated with the Facility Automated Management System. (EPFRD 3.6.2.2)	09
52 07.06.03 HVAC Sys		A new mechanical system will be designed to serve the ventilation needs of occupants and equipment	01
2420 07.06.03.01 Air Int		All air intakes will be at least 3 meters (10 feet) above the ground. Air intakes shall not be located near	01
2421 07.06.03.01 Air Int		Fresh air intakes will have the ability to be automatically closed when remotely commanded by the SC	02
		An emergency shutoff switch will be provided in the HVAC control system through FAMS that can imm	01
53 07.06.03.03 HVAC		The following HVAC systems will be designed and installed: Multiple water-cooled centrifugal and cool	01
54 07.06.03.03 HVAC	and the second se	The following HVAC systems will be designed and installed: Chilled water piping will consist of primary	02
Owner Reg ID:	1820	Drawings Specs BOD Section Rel. Systems	
Owner Req Description:	The EPF will provide a system to continu record (archive/trend), and display the I environmental parameters: Relative Hun	following EPF 07.06.01.02.07 Special Conditioned Air Enviro midity 07.06.01.02.08 Minor Purge Mode 07.06.01.02.09 Emergency Purge Mode	
Owner Req Rev Number:	1	07.06.01.03 Other Environmental Requirements (EPFI	RD 3.6.1.
Sort Order Number:	02	07.06.01.03.01 Control Room	
Is Active		07.06.01.03.02 Transfer/ Logistic Room	
Owner Reg Status: In Compliance		07.06.01.03.03 Communication Room	
			atal Dam
Owner Req Type: Operation		07.0E.02 Cleanson 1 Environmental Monitoring Rog instants	
Owner Req Priority:	None	O7.06.02 Clean Boom Monitoring System O7.06.02.01 Clean Room Monitoring System	
Owner Req Discipline:	Mechanical	OT.06.02.02 Other Environmental Monitoring Requirer	ents
Owner Req Section:	07.06.02.02 Other Environmental Monit		3
Owner Req Comments:			>
		201 Link to Section	

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

