Chapter 9:
Commissioning the Building

- *Commissioning Process Overview*
- *Commissioning Activities and Documentation*

LANL

Chapter 9

Commissioning the Building

Commissioning Process Overview

Commissioning is a process – a systematic process of ensuring that a building performs in accordance with the design intent, contract documents, and the owner's operational needs. Commissioning is fundamental to the success of the whole-building design process. Due to the sophistication of building designs and the complexity of building systems constructed today, commissioning is necessary, but not automatically included as part of the typical design and contracting process.

Commissioning is* critical *for ensuring that the building design is successfully constructed and operated.

Any type of building will benefit from a commissioning effort. Commissioning is even more important in energy-efficient buildings to ensure that they perform as intended to maintain comfort. Also, HVAC equipment in better-performing buildings may require advanced control strategies. But commissioning goes beyond the traditional HVAC elements. More and more buildings rely on the integrity of the envelope to ensure comfort.

Commissioning can also evaluate claims about the construction materials such as durability and VOC emission content. It can improve power quality for the overall building by verifying that electrical building support and

Warren Gretz

Rooftop cooling equipment inspection with building owner representative, facility engineer, and installer.

Building commissioning:

- Is a systematic and designed process coordinated by a commissioning authority or team.
- Includes documentation, verification procedures, functional performance tests, validation, and training.
- Is performed specifically to ensure building operation in accordance with design intent and construction documents.
- Starts with the conceptual phase and continues through design and construction to a minimum of one year after construction completion.

Building commissioning implementation:

- Begins early in the design process.
- Necessitates special bidding requirements during contractor selection.
- Coordinates the static and dynamic testing that acceptance is based on.
- Finishes with staff training and warranty monitoring.

Building systems to be commissioned include:

- Mechanical (heating, ventilating, air-conditioning, and refrigeration)
- Electrical
- Lighting
- Life safety
- Plumbing
- Building envelope and interior finish materials
- Laboratory-specific processes

Building commissioning is more than:

- Construction observation (punch list)
- Start-up
- Testing, adjusting, and balancing (TAB)
- Final punch-out and acceptance
- Post-occupancy re-tuning

These activities are among the individual steps in the systematic process of commissioning, but by themselves these activities cannot meet the goals of building commissioning.

laboratory equipment performs as specified. It is important that the products specified for the building meet the manufacturer's claims and are appropriate for the project.

While commissioning is critical before and during initial occupancy, use and changes over time require that systems be evaluated on an ongoing basis. *Continuous commissioning,* or recommissioning at planned inter-

Robb Williamson

Checking air flow in a displacement ventilation system diffuser. Dirty or clogged air filters are a common commissioning finding. Not only do dirty filters reduce air handler efficiency, they also can affect occupant comfort and health.

vals, ensures that the building operates as efficiently as possible while meeting comfort and functional needs throughout the life of the building. Continuous commissioning goes beyond traditional building operation and maintenance just as initial commissioning differs from testing, adjusting, and balancing. Continuous commissioning involves scheduled and rigorous retesting of building systems to ensure that they continue to operate optimally.

Building commissioning has emerged as the preferred method of ensuring that building systems are installed and operated to provide the performance envisioned by the designer.

– *Continuous Commissioning Guidebook, U.S. Department of Energy*

Benefits of building commissioning include:

- Energy savings and persistence of savings
- Improved thermal comfort with proper environmental control
- Improved indoor air quality
- Improved operation and maintenance with documentation
- Improved system function that eases building turn-over from contractor to owner
- Consistent system function when the building turns over from one operator to another

The Laboratory already uses project documentation relevant to commissioning including:

- Quality Assurance Project Plans
- Construction Management Plans
- Test and Inspection Plans
- Acceptance Test Procedures
- O&M Manuals

Building commissioning coordinates these plans and manuals and leverages their benefits through a systematic and integrated process.

The Cost of Commissioning

Energy, water, productivity, and operational savings resulting from commissioning offsets the cost of implementing a building commissioning process. Recent studies indicate that on average, operating costs of a commissioned building range from 8–20% below that of a non-commissioned building. The one-time investment in commissioning at the beginning of a project results in reduced operating costs that will last the life of the building. In general, the cost of commissioning is less than the cost of NOT commissioning. Continuous commissioning is an enhancement to O&M that typically makes facility operations and management more efficient.

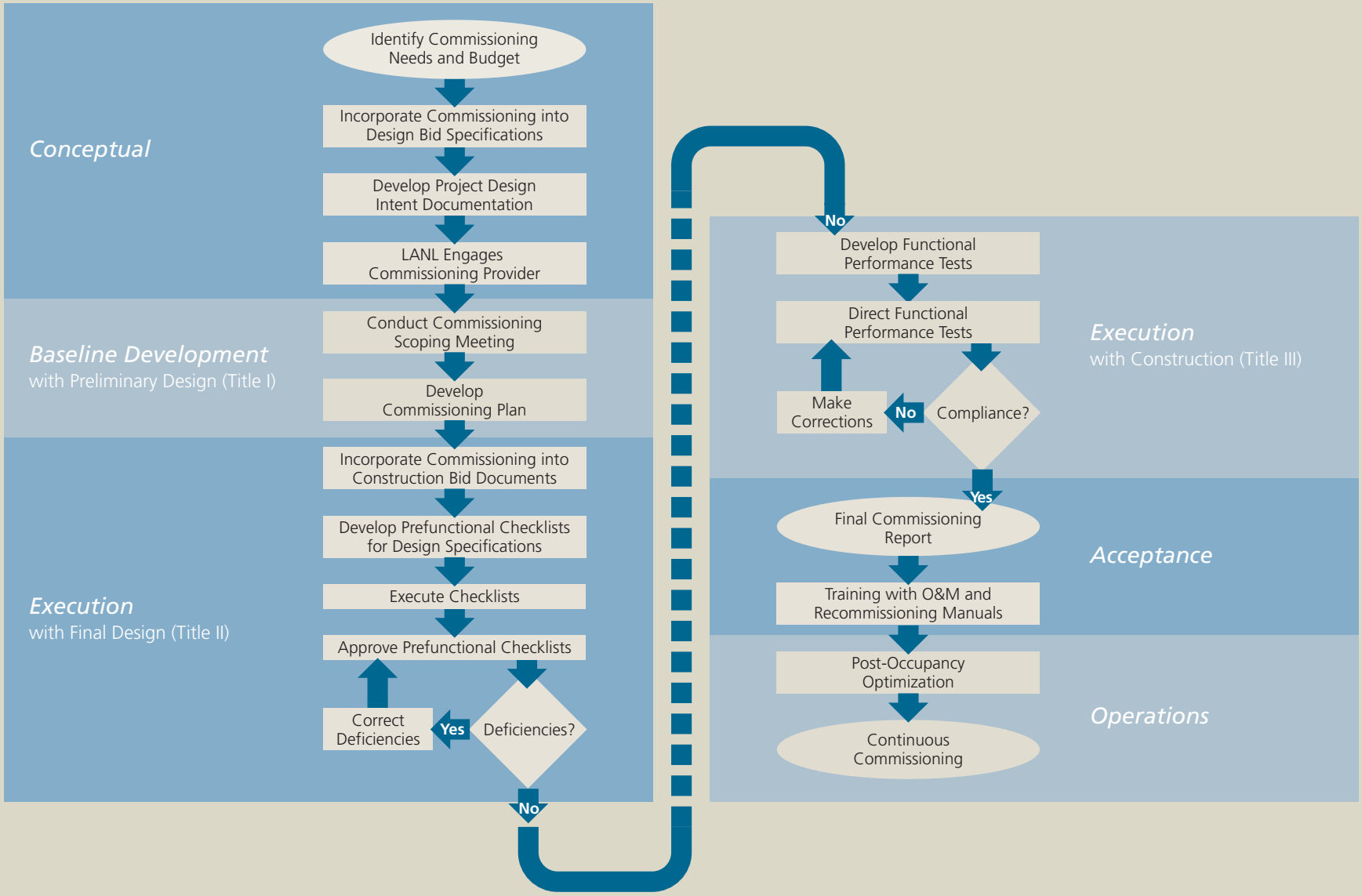
The cost of commissioning is dependent upon many factors, including a building's size and complexity, and whether the project consists of new construction or building renovation. In general, the cost of commissioning a new building ranges from 0.5–1.5% of the total construction cost. For an existing building, never before commissioned, the cost of retro-commissioning can range from 3–5% of total operating cost.

Costs of Commissioning, New Construction

Commissioning Scope	*Estimated Cost*
Entire building (HVAC, Controls, Electrical, Mechanical)	0.5–1.5% of total construction cost
HVAC and Automated Control System	1.5–2.5% of mechanical system cost
Electrical Systems	1.0–1.5% of electrical system cost
Energy Efficiency Measures	$0.23–0.28 per square foot

Source: Building Commissioning Guide. Version 2.2. 1998. DOE/GSA.

Commissioning Process Flow Chart Across the LANL Project Development Process



Commissioning ideally occurs through all phases of a building project (see figure on the opposing page). The process begins by identifying commissioning needs in the conceptual design phase and then designating a commissioning provider. While it is beneficial to have a third-party commissioning authority for more comprehensive design and construction review, it is acceptable for a project to use a qualified member of the design team as the commissioning agent.

The commissioning provider serves as an objective advocate of the owner, directs the commissioning process, and presents final recommendations to the owner regarding the design and performance of commissioned building systems. The commissioning provider introduces standards and strategies early in the design process and then ensures implementation of selected measures by clearly stating target requirements in construction documents. The commissioning provider then verifies that the minimum performance targets have been met after construction completion. In addition, the commissioning provider should provide guidance on how to operate the building at peak efficiency as part of a continuous commissioning manual.

Robb Williamson

End-use metering provides a good indication of how sub-systems are operating in a building. Sub-meters are recommended for HVAC, lighting, and plug loads. Recording and tracking this information is useful for evaluating the start-up and efficiencies of sub-metered systems.

Warren Gretz

Temperature sensors must be calibrated against known standards to ensure that monitoring results and actual comfort conditions match.

Commissioning Activities and Documentation

- ***Owner's Requirements.*** List and describe the owner's requirements and basis of design intent with performance criteria and goals.
- ***Commissioning Plan.*** Create the commissioning plan as early in the design phase as possible, including the management strategy and list of all features and systems to be commissioned.
- ***Design Review.*** Review plans at designated points in the design process to verify that the design is consistent with the owner's intent and goals.
- ***Bid Documents.*** Integrate commissioning requirements in the construction bid and contract documents. Designate the Construction Specifications Institute (CSI) Construction Specification Section 01810 in Division 1 for general commissioning requirements. Use the unassigned Sections 01811 through 01819 to address requirements specific to individual systems. Notify mechanical and electrical subcontractors of Division 15 and 16 commissioning requirements in Sections 15995 and 16995.
- ***Prefunctional Checklists.*** Develop prefunctional checklists for specifications of each piece of equipment identified in the commissioning plan.
- ***Functional Performance Test Procedures and Checklists.*** Develop functional performance test procedures or performance criteria verification checklists for each of the systems identified in the commissioning plan.
- ***Commissioning Report.*** Complete a commissioning report for each identified component, equipment, system, or feature, including results of prefunctional checklists, installation observation, start-up and checkout, operation sampling, functional performance testing, and performance criteria verification.
- ***Training.*** Assemble written verification that training was conducted for appropriate personnel on all commissioned features and systems.

Examples of Components and Systems to Target for Functional Performance Testing:

Mechanical and Electrical

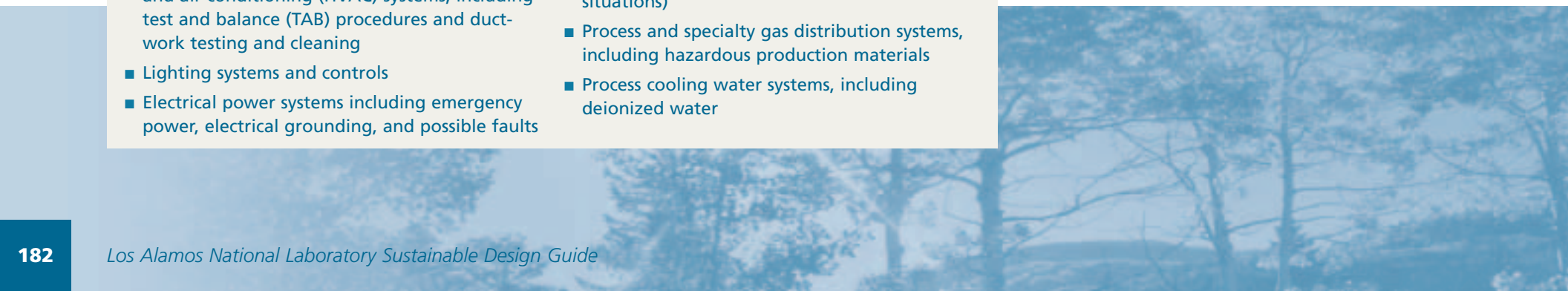
- Central building automation systems, including linkages to remote monitoring and control sites
- Air supply and exhaust systems and controls
- Fume hoods and laboratory air pressurization
- Central plant systems (boilers, chillers, pumps, cooling towers, controls, etc.)
- All equipment of the heating, ventilating and air conditioning (HVAC) systems, including test and balance (TAB) procedures and duct-work testing and cleaning
- Lighting systems and controls
- Electrical power systems including emergency power, electrical grounding, and possible faults

Building Envelope

- Interior and exterior light and shade management devices
- Window glazing
- Infiltration air leakage

Laboratory

- Life-safety systems and toxic-gas monitoring systems (verify that HVAC systems are interlocked and operate per code under emergency situations)
- Process and specialty gas distribution systems, including hazardous production materials
- Process cooling water systems, including deionized water



- ***Operation and Maintenance Manuals.*** Review operation and maintenance manuals for completeness, including instructions for installation, maintenance schedules and procedures, replacement, and start-up; replacement sources; parts lists; special tools; performance data; and warranty details.
- ***Recommissioning Management Manual.*** Develop an indexed recommissioning management manual with components such as guidelines for establishing and tracking benchmarks for whole building energy use and equipment efficiencies, recommendations for recalibration frequency of sensors, list of all user adjustable set-points and reset schedules, and list of diagnostic tools.
- ***Post-Occupancy Optimization Report.*** Complete a commissioning report at the close of the warranty period verifying that the identified systems and features of the building are performing as intended through the heating, cooling, and swing seasons. Identify any issues with recommended resolutions.

est Activities:

- Verify all pieces of equipment perform according to manufacturers' specifications.
- Measure temperatures and flow rates from all HVAC devices and compare to specifications.
- Calibrate all sensors to a known standard.
- Review the sequence of start-up operations.
- Verify controls are providing the correct interaction between equipment and systems.
- Determine energy efficiency of major systems and equipment relative to design specifications and at variable loads.

Mike Ketcham

Light sensors must be calibrated and control sequences validated properly to dim and shut-off light fixtures when adequate natural light is available.

Robb Williamson

A National Park Service staff member verifies the operation of an Energy Management Control System. Calibration of sensors and verification of program sequencing is essential to creating a building that operates properly.

Building flush-out

Consider a building flush-out period after construction completion and prior to occupancy to reduce possible indoor air quality contamination. This involves running the mechanical system with tempered 100% outside air for an extended period of time (two weeks). Flushing out the building may be particularly important when high VOC- and particle-emitting construction materials, furnishings, interior finishes, and cleaning agents have been applied. Change all ventilation air filters as a final step of building flush-out.

Craig Miller, DOE

Visual inspection can provide clues for diagnosing HVAC system performance problems. For example, filters full of construction dust and water on the floor of a mechanical room indicate issues that need to be corrected.

Case Study:

Commissioning at the Nicholas C. Metropolis Modeling and Simulation Center at the Strategic Computing Complex

The Metropolis Center general contractor, Hensel Phelps, retained a third-party commissioning agent, Testmark Associates of Golden, Colorado. Testmark participated in the general review. They reviewed and had some input into plans for chilled water schematics and sequences and mechanical/electrical systems.

Subsequently, there were bimonthly commissioning meetings to address issues as they arose during construction, to plan coordination for building start-up, and to review safety procedures. Testmark placed two full-time staff on site to carry out standard testing procedures during construction. These tests were ongoing throughout summer months. Commissioned systems included chilled water, heating water, ventilation systems (including air handlers, variable air volumes, and exhaust fans), main switches, building substations, power panels, lighting controls, electrical receptacles, i.e. all mechanical/electrical systems and equipment. Before Testmark completed its contract, it conducted a 24-hour baseline analysis during winter months to ensure that systems were functioning within the expected design and operating parameters. Testmark's contract did not call for revisits. Due to security concerns, it is necessary for LANL to carry out all future testing and recommissioning procedures. Testmark provided a comprehensive procedure manual with manufacturer specifications for that purpose.

Systems Integration Issues

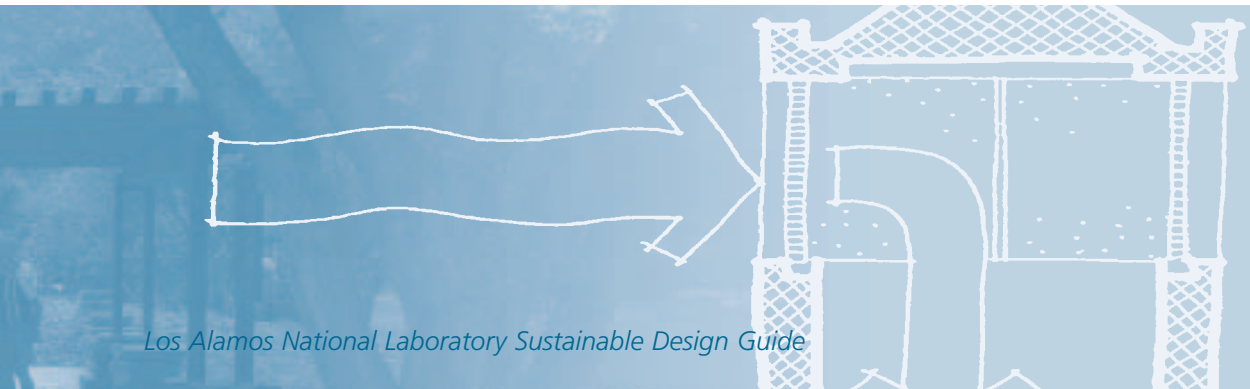
- ☐ The commissioning process is a mechanism to ensure that the interface between the trades is working properly. It affects all dynamically operated components, equipment, systems, and features, as well as the environmental performance aspects of selected static materials and systems.
- ☐ Additional commissioning supplements fundamental commissioning and focuses on review of the building design and construction documents to identify areas for improvement as well as recommissioning of building systems after occupancy.
- ☐ Address the commissioning process during pre-bid or pre-construction conferences as well as at design and construction meetings.
- ☐ The construction contractor should understand that a third-party will be evaluating their work for compliance with the specifications. If design review is included within the commissioning scope, the design team also will be asked to provide plans and specifications and to respond to questions and concerns. These expectations must be made clear early in the process so that the designers and contractors are prepared to assist and provide appropriate documentation.
- ☐ Coordinate functional performance test measurement devices with those required as part of the energy management control system and any long-term continuous measurement and verification objectives to either double check instrument readings or to reduce redundancy of equipment.

The bottom line is that commissioning improves a building's value… Systems that function properly use less energy, experience less down time, and require less maintenance, thereby saving money for building owners.

– Building Commissioning: The Key to Quality Assurance, *U.S. Department of Energy*

Warren Gretz

Perform functional tests at design, intermediate, and minimum flow conditions on variable frequency drive motors controlling variable flow hydronic systems.



	Standard Practice/	*Better*	*High Performance*
Commissioning Activities	◯ Federal and local codes for quality assurance	*PLUS:* ◯ Commissioning plan, functional performance testing, and commissioning report	*PLUS:* ◯ Comprehensive review of design and contractor submittals throughout the entire construction process
Commissioning Provider	◯ None	◯ Contract for commissioning agent as part of design or construction team	◯ Contract for third-party commissioning authority
Operation Documentation	◯ Construction as-built drawings and warranty documentation	*PLUS:* ◯ Comprehensive O&M manual and preventive maintenance plan	*PLUS:* ◯ Recommissioning management manual
Last Construction Process Step	◯ Final contractor punch-out	◯ Final commissioning report after staff training and building flush-out	◯ Near-warranty end or post-occupancy review (i.e., 10 months into 12-month warranty period)
Continuous Commissioning	◯ Reactive approach: examination of systems only when problems are reported	◯ Active approach: effective maintenance with performance testing as resources allow	◯ Proactive approach: scheduled recommissioning of all systems on a periodic basis

References

"Building Commissioning Guide." Version 2.2. 1998. DOE/GSA. ***www.eren.doe.gov/femp/techassist/bldgcomgd.html***

"ASHRAE Guideline 1-1996: The HVAC Commissioning Process." American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), 1996.

"An Integrated Approach to Building Commissioning – Professional Development Seminar." ASHRAE, 1999.

"What Can Commissioning Do For Your Building?" PECI. ***www.peci.org/cx/overviews.html***

"Commissioning to Meet Green Expectations." PECI. ***www.peci.org/cx/CxGreen.pdf***

Proceedings of the Annual National Conference on Building Commissioning. 1993–2002. PECI. ***www.peci.org/ncbc/proceed.html***

"Leadership in Energy & Environmental Design Reference Guide." Version 2.0. U.S. Green Building Council, 2001.

"Sustainable Building Technical Manual." Public Technology, Inc., 1996.

"Sustainable Design Report for Los Alamos National Laboratory's Strategic Computing Complex." LA-UR-01-5547. ***http://emeso.lanl.gov/useful_info/publications/SCC_SD.pdf***

Additional Resources

"Model Commissioning Plan and Guide Specifications." Version 2.05. ***www.eren.doe.gov/femp/techassist/bldgcomgd.html***

"Commissioning for Energy Efficiency." DOE Office of Energy Efficiency and Renewable Energy. ***www.eren.doe.gov/buildings/comm_energyeff.html***

E-design Online Commissioning Archives 1996-2000. ***www.state.fl.us/fdi/edesign/news/main/commiss.htm***

Diagnostics for Building Commissioning and Operation ***http://eetd.lbl.gov/EA/IIT/diag***

"Building Commissioning; The Key to Buildings that Work." *Environmental Building News.* Vol. 9, No. 2 (February 2000).

Oregon State Energy Office ***www.energy.state.or.us/bus/comm/bldgcx.htm***

Building Commissioning Association ***www.bcxa.org***