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BUILDING TECHNOLOGIES PROGRAM

A Guide to Building Commissioning

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Pacific Northwest NATIONAL LABORATORY

Commercial Building Initiative

BUILDING TECHNOLOGIES PROGRAM

A Guide to Building Commissioning

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A Guide to Building Commissioning

Many building owners want to save money by reducing their energy bills. Building commissioning is one more way for building owners and facility managers to save energy by helping ensure that the building's systems and equipment are installed and work correctly—and efficiently.

Commissioning is the process of verifying that a building's heating, ventilation, and air conditioning (HVAC) and lighting systems perform correctly and efficiently and according to the design intent and owner's project requirements. The commissioning process for new construction integrates the traditionally separate functions of design, construction, and operation by bringing the project team together during each phase of the project. Existing building commissioning investigates, analyzes, and optimizes the performance of existing building systems by identifying and implementing measures to improve their performance. Without commissioning, system and equipment problems can result in higher than necessary utility bills and unexpected and costly equipment repairs. Poor indoor environmental quality can result in tenant complaints and turnover.

There are many benefits associated with commissioning your building, including:

- Verifying equipment and controls function correctly
- Identifying and correcting sub-optimal operating conditions
- Identifying associated opportunities for energy savings

These tangible benefits are why commissioning is a requirement for buildings pursuing the popular Leadership in Energy and Environmental Design (LEED) certification, and why building codes are gradually adopting commissioning activities into code.

Considering a building that is not commissioned will cost 8 to 20 percent more to operate than one that is commissioned, the payback of commissioning can be relatively quick, and on average, the cost of performing commissioning is paid back in less than 5 years from energy savings alone[2]. When considering the other benefits of commissioning (fewer project delays, requests for information, and construction call backs; increased equipment life; fewer maintenance problems; better operator training), total cost of ownership of your building can go down and the entire cost of commissioning your building may be offset, resulting in an immediate payback.

A study of six new construction projects found that commissioning reduces change orders by 87 percent and contractor callbacks by 90 percent, thus reducing the total construction cost by an estimated 4 to 9 percent[1].

A study of 60 commercial buildings found that:

- Over 50 percent suffered from control problems
- 40 percent had problems with HVAC equipment
- 33 percent had sensors that were not operating properly
- 15 percent of the buildings studied were actually missing specified equipment[3]

A case study of a 6,700ft^2 data center provides a good illustration of this scenario. Energy efficient equipment was installed and controls strategies were implemented with an anticipated energy savings of 15 percent of total energy usage. Once the measures were implemented and actual energy usage was measured, it was determined that energy usage in fact went up. Subsequent commissioning of the facility identified the causes of the lost savings: unanticipated interaction between equipment and system operation. Once these causes were identified and the problems resolved, realized energy savings actually increased to 19.2 percent and 26 percent for peak demand[5].

If you have already realized the benefit of commissioning you are not alone. The number of commissioned buildings is on the rise as building owners are motivated to save costs by making their properties more efficient. An increasing number of tools, resources, and programs are becoming available to assist in the commissioning process as well. As an additional incentive to building owners, funding for commissioning activities is available as energy utilities are introducing incentive programs to help bring down the cost. Even insurance companies are customizing insurance products to commissioning, with the understanding that it is a risk-management opportunity.

This commissioning guide is intended to be a resource, as well as a call to action, for building owners and facility managers who want to verify their buildings are not only operating as originally intended, but also as efficiently as possible. Commissioning of new construction and major renovations is the primary focus of this guide, although commissioning of existing buildings will be discussed briefly as well.

What Is Commissioning?

Commissioning, often abbreviated as "Cx," is more than just an energy saving strategy. It is also a quality control process that ensures the design, installation, and operation of equipment meets the owner's requirements and any associated deficiencies are corrected. According to a comprehensive study on commissioning by the Lawrence Berkeley National Laboratory, commissioning can also be considered a risk management strategy that should be an integral part of the design and construction of your building. It helps ensure you get what you pay for when constructing or retrofitting a building, and it detects and corrects problems that would eventually surface as far more costly maintenance or safety issues[4]. The Building Commissioning Association (BCA) describes building commissioning as "a quality based process with documented confirmation that building systems are planned, designed, installed, tested, operated and maintained in compliance with the owner's project requirements."

While new construction commissioning focuses on ensuring new systems are fully integrated, tested, and function properly, existing building commissioning identifies deficiencies of existing systems and equipment and makes recommendations to improve performance and ensure efficient operation. Although commissioning focuses on the functionality of individual pieces of equipment, its primary focus is on the interfacing between equipment, components and systems. It is easy to assume that energy savings can be estimated with simple "off the shelf" methods and that promised energy savings will always materialize from simply installing more efficient equipment. But this assumption is not always true. As equipment, system design, and controls become more sophisticated, the likelihood of design errors and sub optimal operation greatly increases, confirming the importance of commissioning modern buildings and systems.

Commissioning is a systematic process that includes design review, installation verification, proper system start-ups, functional performance tests, operations and maintenance (O&M) training, and complete documentation of the HVAC systems. It serves the owner's best interests by delivering a building with systems that perform per the owner's project requirements (OPR), project basis of design and construction documents.

Types of Commissioning

There are two primary types of commissioning: new construction and existing building.

New Construction Commissioning

Commissioning of new construction can be more comprehensive than existing building commissioning because it involves a thorough review process during the design phase of your project, as well as comprehensive evaluation, testing, training, and documentation during the construction, occupancy, and initial operations phases. Waiting until the construction phase to begin commissioning your new building eliminates the tremendous opportunity of including the commissioning agent and commissioning activities in the pre-design and design phase of the project. Engaging the commissioning agent in the pre-design phase can reduce design deficiencies and enable development of the necessary documentation before the design phase begins. Like new construction commissioning, major retrofit commissioning is a comprehensive approach to ensuring new equipment and systems are integrated and tested thoroughly when they are added to existing systems. It begins before the design phase and continues on past the acceptance phase of the project.

Existing Building Commissioning

Existing building commissioning includes recommissioning and retrocommissioning. Recommissioning refers to performing commissioning activities on an existing building that had once been commissioned, either during construction or at some time after initial occupancy. The term retrocommissioning refers to performing commissioning on a building that had never been commissioned. Ongoing commissioning, continuous commissioning™ and monitoring based commissioning are other terms that can more specifically describe the umbrella term "existing building commissioning."

As with commissioning new construction, commissioning existing buildings can provide tremendous benefits such as reducing energy use, improving building operation and occupant comfort, and increasing equipment life. These benefits can be achieved in several ways:

- The process can return the building's equipment to its original and intended operation. The need for this can be the result of years of accumulated deferred maintenance.
- Building commissioning can result in an update to the building's systems to accommodate new tenants, renovations, or new building uses for which the building was not originally designed. It is common to repurpose a building without making the necessary changes to the building HVAC and lighting systems.
- Commissioning existing buildings can take a deeper look at building operations and find ways to optimize equipment and system performance.

PEAK DEMAND

Peak demand is a term used in describing a period in which electrical power is provided for a sustained period at a significantly higher than average supply level. Peak demand fluctuations may occur on daily, monthly, seasonal and yearly cycles. For an electric utility company, the actual point of peak demand is a single half hour or hourly period which represents the highest point of customer consumption of electricity.

MAJOR RETROFIT COMMISSIONING

Similar to New Building Commissioning, Major Retrofit Commissioning involves five major phases: Planning Phase, Design Phase, Installation Phase, Acceptance Phase, and Post-Acceptance Phase. When commissioning is incorporated into the retrofit project, owners are more likely to receive the expected energy savings from the retrofit[6].

HIDDEN COSTS OF NOT COMMISSIONING

Two buildings analyzed in detail found that almost half of the deficiencies identified during commissioning would in the future manifest as higher repair and maintenance costs. Similarly, about one in ten deficiencies would have resulted in shortened equipment life, adversely impacted occupant productivity, or increased energy costs.

Another report found over 500 deficiencies at four Detroit elementary schools. Correcting the problems avoided $100,000 in repair costs. Foregone energy savings amounted to an additional $110,000.

A third report found that by commissioning 10 schools in California's Folsom Unified School District, 32 percent of the issues identified would have increased operations and maintenance costs, 37 percent comfort and indoor air quality, 6 percent safety, and 26 percent energy[7].

Because the process for commissioning existing buildings varies significantly from the process for new construction, it will not be discussed in greater detail in this guide. For more detailed information about existing building commissioning, please reference the following resources available for building owners:

- Building Commissioning Association Best Practices in Commissioning Existing Buildings: https://netforum.avectra.com/temp/ClientImages/BCA/b352902a-e491-4609-80ef-dc1bf6c8f6af.pdf
- California Commissioning Collaborative Guide for Existing Buildings: www.cacx.org/resources/documents/CA_Commissioning_Guide_Existing.pdf
- California Commissioning Collaborative Toolkit for Existing Buildings: www.cacx.org/resources/rcxtools/index.html
- Environmental Protection Agency's Retrocommissioning Guide for Building Owners: www.peci.org/documents/EPAguide.pdf

Benefits of Commissioning

Today's HVAC systems must be energy efficient and meet high indoor air quality and comfort standards. At the same time they need to be cost effective. System designs meeting these demands typically have many components, sub-systems and controls and are designed and installed on short timelines and by multiple contractors. These factors can result in poor coordination between the multiple designers and contractors and can produce HVAC systems with installation deficiencies that result in improper operation and shortened equipment life. Building commissioning is a systematic process that addresses these problems. The key benefits of buildings commissioning include:

- **Construction cost savings** resulting from fewer change orders and project delays. Identifying issues early during the design review process results in less post occupancy corrective work, and improved operation and reliability of equipment.
- **Ongoing energy savings** that result from preventing sub-optimal operating conditions of equipment and control sequences and verifying proper equipment sizing.
- **Non energy and "intangible" benefits** such as improved project team communication, improved staff training, systems manuals, and complete Operations and Maintenance (O&M) documentation.

Construction Cost Savings

When commissioning starts during the pre-design phase of a new construction project, the result can be significant construction related cost savings. Deficiencies identified during the design phase, rather than on the job site, are much less expensive to resolve. Also, early design review can avoid common problems like oversized equipment and incorrect or incomplete sequences of operation. These common issues can go unnoticed without the commissioning agent's thorough review of the design documents and operational sequences.

The commissioning process also employs effective communication strategies between all team members. Throughout the project, the commissioning team tracks and resolves issues by focusing attention on these issues at frequently held commissioning meetings. Improved communication throughout the design and construction process results in fewer change orders, claims, project delays, shorter building turn over transition period and less post occupancy corrective work. Several studies investigating the impact of choosing *not* to commission your building have been done and demonstrating the impact identifying deficiencies during the commissioning process can have on a building.

Ongoing Energy Benefits

Identifying design issues that may lead to inefficient system operation and wasted energy is one way commissioning can result in ongoing energy benefits. Prior to occupancy, functional testing helps resolve equipment problems and controls programming deficiencies that would result in ongoing inefficient operation as well as increased maintenance costs. It is easy for the project team to focus their attention on short construction timelines, trying to obtain the necessary permits for occupancy. This can result in system operational deficiencies being overlooked. These deficiencies can go undetected for years, negatively affecting building control, energy use, equipment reliability, and occupant comfort. Once your building is in service, building staff may not have the time or expertise to correct these persistent issues, or may only be able to address the symptoms without fixing the real problem. Functional testing prior to occupancy is critical to preventing this scenario and ensuring equipment and systems are operating correctly and efficiently.

In 2004, Lawrence Berkeley National Laboratory estimated $18 billion per year of potential savings from commissioning throughout the United States. Simply addressing the top 13 faults in commercial buildings alone has a potential savings of $3.3 - $17 billion per year[8].

A study that included 643 buildings across the U.S. suggests that correcting the deficiencies found during the commissioning process resulted in 16 percent median whole-building energy savings in existing buildings and 13 percent in new construction, with payback times of 1.1 years and 4.2 years, respectively. It also found that projects that incorporated a thorough commissioning process attained nearly twice the overall median level of savings and five times the savings of the least thorough projects[9].

Energy savings of new building commissioning can be significant. Since they depend on several factors, including building type, location, and the scope of the commissioning process, they are usually presented as a range. A comprehensive study found the value of energy savings from commissioning to range from $0.02 - $0.19/sqft, and the value of non-energy savings resulting from commissioning to range from $0.23 - $6.96/sqft[10], as shown in the table below.

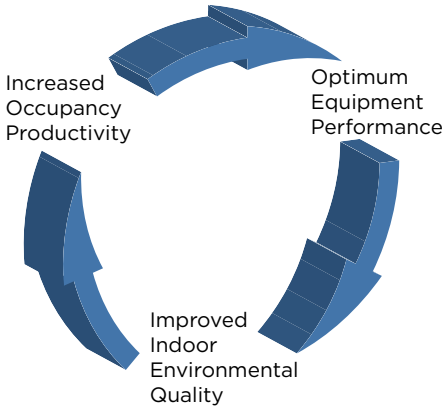
Savings from Commissioning		
Description	**Range of Values**	**Expected Annual Savings for a Theoretical 100,000 sq. ft. Building**
Value of Energy Savings	$0.02 - $0.19/sq. ft.	$2,000 - $19,000
Value of Non-Energy Savings	$0.23 - $6.96/sq. ft.	$23,000 - $696,000

Through proper commissioning these savings can actually increase over time. This may seem counterintuitive, but studies have found that when commissioning includes training, and in some cases, installation of permanent metering and feedback systems, improvements in system performance can persist for years after commissioning. This finding should reassure building owners that new-construction commissioning can be very durable, and that outcomes will result in savings for the lifetime of the building.

Finally, optimized system operation and right sized equipment has the additional energy benefit of peak demand reductions in energy use. Utility companies pass along a charge to customers based on their peak energy demand, which is the maximum energy use of the building throughout the year. This typically occurs in the summer on the hottest day of the year when a building is in full cooling mode.

Top 13 Faults in Commercial Buildings
Duct Leakage
HVAC system operates continuously during unoccupied period
Lighting system illuminating space during unoccupied period
HVAC system improperly balanced
Improper refrigerant charge
Economizer dampers operating incorrectly
Insufficient evaporator airflow
Improper controls setup / commissioning
Control component failure or degradation
Software programming errors
Improper controls hardware installation
Air-cooled condenser fouling
Valve leakage

Examples of commissioning are available in case studies found online at *www.cacx.org/resources/ commissioning.php.*



THE BOTTOM LINE

Commissioning improves a building's asset value. Properly functioning buildings with reliable equipment kept in good condition are worth more than uncommissioned buildings[11].

- Commissioned systems and equipment retain their value longer.
- There is a higher demand for comfortable, healthy working space that promotes productivity.
- Systems that function properly use less energy, experience less downtime and require less maintenance, which save building owners money.

Case in point—A newly constructed 16-story office tower in downtown Portland, OR sold in early 2011 for an unprecedented $353 per sqft, breaking the previous record of $309 per sqft for the area. The First & Main building is LEED Platinum certified and was fully commissioned under the enhanced commissioning LEED criteria.

This charge is based on the infrastructure that has to be in place to provide enough electricity to meet the peak demand requirement. System inefficiencies and oversized equipment can increase the amount of energy a building consumes, increasing its peak demand. A lower peak demand means a lower charge by the utility company.

Non-Energy and "Intangible" Benefits

A report by the Lawrence Berkeley National Laboratory indicates that in new construction, non-energy benefits from commissioning are cited as the primary motivator for commissioning. These benefits include ensuring equipment performance, improved indoor environmental quality, and increased occupant productivity[12].

Improved indoor air quality, improved lighting and temperature control issues, and better building pressure control contribute to the quality of a building's indoor environment by improving the health, comfort and productivity of its occupants. The consequences of poor indoor environmental quality can be serious. Temperature, lighting, and ventilation problems can make occupants uncomfortable, lowering their ability to work effectively. In some cases these issues can make employees sick. Incorrect building pressurization can result in poor indoor air quality as well since pressure effects the migration of toxins, odors, and moisture between spaces. Proper commissioning addresses all of these issues by ensuring:

- Proper ventilation air is provided
- Proper filtration is provided
- Lighting controls are functioning properly
- Light levels are adequate and as specified in design documents
- Temperature sensors are calibrated and functioning properly
- Pressure sensors are calibrated
- Proper building pressure is maintained

Commissioning Costs

The cost of commissioning is different for each project, and depends on the project's size, complexity, and the scope of the commissioning process. There is no standard convention for determining which costs are included in the total cost of commissioning, but typically included are the commissioning agent's fee, costs for other team members who participate in the commissioning process, and the anticipated cost of correcting problems identified during the commissioning process. Regardless of the commissioning scope, however, the cost of commissioning accounts for only a very small part of the overall construction budget.

The Commissioning Process

Commissioning a new building is a five step process that includes key activities in each phase of the project. A description of the activities associated with each commissioning phase is shown in the table below. A more thorough and detailed explanation of the activities associated with each commissioning phase can be found in several of the key documents referenced in this guide including ASHRAE Guideline 0 – 2005 and the ACG Commissioning Guideline.

Commissioning Phases and Key Activities

Commissioning Phase	Project Milestone(s)	Commissioning Activities
1. Pre-Design Phase (Project Planning Phase)	• Design team chosen	• Owner generates Request For Qualifications (RFQ) and Request For Proposal (RFP) • Cx agent selected • Cx agent helps develop the Owners Project Requirements (OPR) • Design Intent Document (DID) created • Define Cx roles and responsibilities • Begin developing the Commissioning Plan
2. Design Phase	• Building designed (schematic design) • Bid documents prepared • Job awarded to general contractor	• Plan developed • Cx agent verifies design documents accurately reflect owner's OPR • Cx agent reviews and comments on Basis of Design and Design Narrative • Format of Issues Log determined • Update Commissioning Plan • Commissioning specification are created • Cx agent performs design review
3. Construction Phase	• Construction of facility • Start-up of equipment	• Commissioning Plan is implemented • Cx agent reviews submittals • Test and Balance (TAB) procedures reviewed by design & Cx team • Cx agent observes and evaluates equipment installation • Commissioning agent maintains the Issues Log • Regular Commissioning meetings are held • Controls point to point checks (pre functional checklists) • HVAC start ups (correct problems and retest) • Test and Balance (TAB) agency performs their work • Operations & Maintenance (O&M) documentation and training
4. Acceptance Phase	• Training completed • Documentation completed • Building accepted by owner	• Cx agent conducts functional performance testing (FPT) • HVAC controls documented • TAB report submitted to design team and Cx agent verifies • Problems found are corrected and retested • O&M Documentation & Training
5. Post-Acceptance Phase (Project Occupancy Phase)	• Owner occupies building and assumes responsibility for ongoing operations and maintenance	• "Off season" FPTs • Problems are corrected and retested • Final Commissioning Report is issued

Indoor air quality is a big problem in U.S. commercial buildings, some 20 to 30 percent of which suffer from indoor air quality problems. Poor indoor air quality is especially troubling in schools, where students spend close to 13,000 hours between kindergarten and twelfth grade. The U.S. Environmental Protection Agency reports that almost 20 percent of U.S. schools—where more than 55 million students, teachers, and school staff spend the majority of their time—have indoor air quality problems[13].

So what will it cost to commission your next project? The median cost to commission a new building was found to be $1.16/sqft[14]. The California Commissioning Guide for New Buildings suggests a cost range between $0.49 - $1.66/sqft[15]. A better rule of thumb for estimating the cost of new building commissioning may be based on overall construction cost, which is estimated to be about 0.4 percent[16].

"Over the past 20 years we have tracked the issues identified and resolved through the commissioning process. We find that in a typical project, the owner has recovered the full cost of the commissioning process about 80 percent of the way through design as a result of eliminated change orders and requests for information, improved system operation, and reduced maintenance."

-Chad Dorgan, Commissioning Provider[17]

Commissioning Deliverables

The key deliverables that are associated with the commissioning process include:

- Commissioning Plan
- Pre-Functional Construction Checklists
- Functional Performance Test Procedures
- Issues Logs
- The Final Commissioning Report

These are not the only deliverables to be expected from the commissioning agent. Other important deliverables include: thorough review of the owner's project requirements, design documents, submittal documents, and O&M manuals with comments provided back to the team for consideration, commissioning progress reports, commissioning meeting minutes, Systems Manuals, O&M training verification, and a warranty review report.

Final Commissioning Report

The commissioning agent is responsible for preparing and submitting the final commissioning report to the owner and the design team. The final commissioning report is a critical document that summarizes the commissioning effort and evaluates whether all of the commissioned systems meet the specifications in the OPR. It should include:

A written narrative of the commissioning agent's assessment of each of the commissioned system's compliance with contract documents and the OPR, as well as any unresolved commissioning issues

- Commissioning Plan
- Functional Tests
- All commissioning reports and reviews
- Issues Logs
- All major communications such as emails, memos, and letters

The owner and design team should review the final commissioning report to determine completion of the commissioning plan. A sample final report is provided in Appendix A.

Systems Manual

The Systems Manual includes the final Owner's Project Requirements, Basis of Design, the final Commissioning Plan, Commissioning Process Report, manufacturer installation manuals, manufacturer operations and maintenance manuals, system schematics, verified Record Drawings, and test results. It can either be printed or an electronic version. A detailed outline of what is contained in the Systems Manual can be found in appendix O of ASHRAE Guideline 0.

O&M Training and Training Manuals

A critical component of the commissioning process is training of the operations staff. Assembly of a complete set of operations and maintenance manuals is also an instrumental part of the training process. The general contractor is responsible for providing the training to the operations staff, and the commissioning agent needs to review the training program to ensure it meets the requirements of the

specifications. Training classes should be recorded and kept on file in the building for future training needs. It is recommended that the training requirements are clearly described in the specification documents. Key information that should be conveyed during the training sessions includes:

- System design documents (Plans & Specifications)
- Start-up and shut-down procedures
- Operational sequences
- Complete listing of contractors and manufacturer contact information
- Detailed instructions on the control system
- Recommended procedures for effective operational monitoring including trending and graphics features for direct digital control systems
- Routine preventative maintenance procedures as specified by the designer or recommended by the manufacturer
- Provisions for safety shutdowns, emergency conditions, and interfaces with building automation systems and life safety systems.

An example of a training manual outline or syllabus that is focused on electrical and mechanical systems is provided in ASHRAE Guideline 0 appendix P. The U.S. Department of Energy Federal Energy Management Program has also published an Operations & Maintenance Best Practices Guide to achieving operational efficiency. It can be viewed at: *www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf*

Building Your Commissioning Team

Commissioning is a team effort that requires effective communication, coordination, and cooperation between all of the parties involved with the project. The Commissioning Agent leads the team.

Not all of the commissioning team members will be involved in each phase of the project. However, each should be fully engaged in the activities that they are contractually required to perform. For quick reference, the following table outlines the roles and responsibilities of the Owner and Owner's O&M Staff. The other team member's roles and responsibilities are explained elsewhere in greater detail, including the California Commissioning Guide for New Buildings (See Endnote 1 for web link) and Appendix B – Commissioning Team Roles and Responsibilities.

Team Member	Roles and Responsibilities
Owner	• Identifies commissioning as a requirement for the project and ensures its inclusion in the project specifications • Develops the Owner's Project Requirements • Selects the commissioning agent • Ensures involvement of all team members as required • Allocates staff resources to the commissioning process and includes them as early as possible
Owner's O&M Staff	• Contribute to the development of the OPR • Review designs for maintainability • Participate in periodic site walk-throughs, commissioning meetings and functional testing • Participate in training sessions

DEFINITION OF TERMS

Commissioning Agent, Commissioning Authority, and Commissioning Provider are used interchangeably to represent the person(s) who will be providing the commissioning services.

Owner – The owner's contribution to the commissioning process is vital to the success of every project. One of the owner's primary responsibilities is to clearly communicate expectations about how the building should operate, as defined in the OPR. It is also imperative that commissioning specifications are included in the design documents and reviewed by the owner. Failure to do so will result in a change order for additional commissioning services. The owner needs to be a strong advocate of the commissioning process and motivate the entire team to actively participate by supporting both the commissioning agent's responsibility to identify issues and the rest of the team's responsibility to resolve them.

Facility Manager and Building Staff – The Facility Manager and O&M building staff are also important members of the commissioning team. Both can benefit from the commissioning process if engaged early in the process as possible. In pre-design, the facility manager should contribute to the development of the OPR. In the design phase, the facility manager can contribute to the design, based on their experience that can improve the staff's ability to operate and maintain the building and equipment. These may include modifications to control point naming conventions, graphic layouts of the energy management system, system choices, equipment layout, and other factors that affect maintainability.

By participating in the commissioning process, building staff will gain an understanding of the building's systems and their interactions well in advance of tenant turnover and occupancy. Observing functional tests and participating in training provided by the contractors and the commissioning agent will improve the staff's understanding of equipment and control strategies.

Selecting Your Commissioning Agent

Selecting the commissioning agent is a key decision when initiating a commissioning project. A thorough selection process involves identifying potential providers, reviewing qualifications and sometimes proposals of those providers, and then establishing appropriate contract terms. This section describes the two main selection processes: selection by qualifications and the more formal selection by proposal. Which process you choose will depend upon the requirements of your organization and the complexity of your project.

Identifying Potential Commissioning Agents

Whether you are going to select a commissioning agent by the Request for Qualifications (RFQ) or by the Request for Proposal (RFP), you must begin by identifying the field of potential candidates. Commissioning can be completed by a member of your own organization, by a third party commissioning agent, by the general, mechanical-electrical sub-contractor, or by a member of the design team. However, to deal with the complexities involved in a large commissioning project and to avoid any potential conflict of interest, the best approach is often to hire an independent third party commissioning firm. There are many third party commissioning service providers, each with unique technical expertise, specializing in different building types, and with varying project experience. Following these procedures will help you identify a provider who meets the needs of your project.

To find a qualified commissioning agent to undertake your project, a good place to start is by looking for those certified by nationally recognized commissioning organizations. Such a certification can tell you that the agent has obtained specific training for building commissioning. Selection of a trained commissioning professional is good practice and it may be a requirement if your code jurisdiction has adopted a commissioning requirement[18].

A list of certified commissioning agents can be located through the certification organizations' websites or from the California Commissioning Collaborative website (www.cacx.org/resources/provider_list.html). Certifications requirements vary and compiling a list from these sources is just the first step in the selection process. In the next steps, careful attention is given to selecting a provider with the relevant experience needed to achieve success for your project.

Request for Qualifications

Unless your organization requires a formal request for proposals, you may want to consider selection by qualifications as a relatively streamlined method for finding the right provider. A well-executed Request for Qualifications (RFQ) can help you to select the provider who is best suited for your project. The RFQ document introduces your project and your expectations for the commissioning process, and requests information from prospective providers about their relevant experience and fees. Selecting the right agent for your project is then a matter of comparing qualifications, fees, and references, combined with a phone or in-person interview.

Your RFQ document will be most effective if it provides enough information about your project to allow a commissioning agent to give you examples of similar work that they have successfully completed. A sample RFQ is provided as Appendix C. At a minimum, the project description included in the RFQ should include:

- The size and location of your project
- The type of building and its dominant uses
- The current project phase
- Key milestones in the project schedule
- A summary of the project management structure
- Any specific expertise needed for your project.

The evaluation of agents' qualifications begins after you have sent the RFQ to your list of potential candidates and received responses. Once responses for the RFQ are received you can compare the candidates' overall submissions, qualifications, and fees. You may choose to contact their references as well. This is largely a comparative evaluation, but you will want to enforce some minimum requirements. For any agent to be selected for an interview the answer to the following questions should be YES.

DOES THE PROVIDER...	
Have the necessary technical knowledge?	Lack conflicts of interest?
Have relevant experience?	Exhibit strong project management skills?
Have professional commissioning certification?	Provide documentation and references from successfully completed projects?

Source: California Building Standards Commission[19]

As a final step in the RFQ selection process, you may wish to interview the top ranked candidate(s). This will give you an additional opportunity to evaluate their communication style and to assess the fit with your project team.

ORGANIZATIONS PROVIDING CERTIFICATION FOR COMMISSIONING AGENTS

- **Organization:** AABC Commissioning Group
- **Commissioning Agent Certification Title:** Certified Commissioning Authority (CxA)
- **Website**: www.commissioning.org

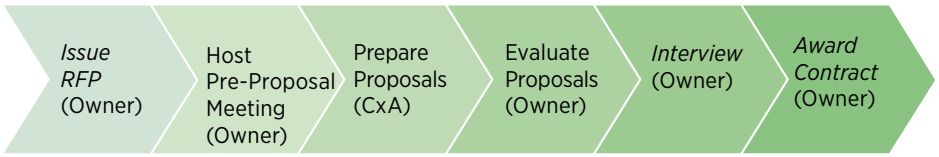
- **Organization:** Building Commissioning Association
- **Commissioning Agent Certification Title:** Certified Commissioning Provider (CCP)
- **Website**: www.bcxa.org

- **Organization:** Association of Energy Engineers
- **Commissioning Agent Certification Title:** Certified Building Commissioning Program (CBCP)
- **Website**: www.aeecenter.org

- **Organization:** ASHRAE
- **Commissioning Agent Certification Title:** Commissioning Process Management Professional (CPMP)
- **Website**: www.ashrae.org

Request for Proposals

Although most building owners will employ the RFQ process, a formal request for proposals (RFP) offers an alternative selection process that demands a higher level of effort by both providers and project managers. In return for this higher level of effort, it provides both the information on qualifications that would be obtained through an RFQ, plus a detailed scope of work and budget specific to your commissioning needs. For large or complex projects, the additional level of effort may be worthwhile, and certain organizations require any contractor to be selected by this type of competitive solicitation. A typical procedure for selecting a commissioning agent through a RFP is shown in the figure below.



RFP for a commissioning agent, identifying the lead for each activity

The first two steps of the process, issuing the RFP and hosting a pre-proposal meeting, give agents the information they need to construct a well-considered proposal for your project. To this end, the RFP includes the same descriptive project information provided in the RFQ, plus a list of your expectations for the commissioning process. List meetings that must be held, systems that will require functional testing, extent of sampling allowed, as well as documentation and training requirements. The RFP also gives bidders specific guidance on the proper format for proposals and the procedure that will be used to determine the winning proposal. Appendix D provides an example of an RFP for commissioning services.

The standard process for selecting from the proposals that are submitted is to form a selection committee. The selection committee will typically include many members of your project team and may include additional stakeholders. A range of perspectives will be valuable when evaluating the proposals. The selection committee can evaluate the agents' submissions using a comparative approach, wherein each proposal is ranked according to its performance in several categories such as proposed approach, relevant experience and qualifications, quality of references, and budget estimate. These criteria can be weighted as needed to fit the priorities of your project.

As in the RFQ process, the top-ranked agent(s) will often be invited to interview with the project team. This additional step allows you to confirm that the commissioning agent is a good match to your project team before establishing a contract.

Contracting a Commissioning Agent

Once a commissioning agent has been selected through an RFP or RFQ process, you will then establish a contract with that provider to deliver a specified scope of commissioning services. Before addressing the fundamentals of this contract, it is important to note that while this is arguably the most important contract for your commissioning services, it should not be the only contract. To ensure that the key players in your project will actively engage in the commissioning process, it is important to include requirements to participate in the commissioning process in the contracts of your design and construction teams. Setting this requirement early and with agreed upon rate schedules for commissioning work, will facilitate the work of the commissioning agent and avoid later disputes.

The contract with a commissioning agent details the scope of work that they are expected to perform, the budget for that work, and the rate schedule for any out of scope tasks that you may later assign to them. The scope described in the RFQ or RFP will provide a starting point, but the contracting process provides an opportunity to negotiate a specific set of tasks and deliverables with your selected agent for pre-design, design, acceptance and post-acceptance project phases. A responsibility matrix can help to identify the roles of the owner, commissioning agent and other commissioning team members throughout all these phases.

In addition to the scope of work, terms of compensation and schedule, the commissioning contract also includes standard language governing contract modifications, liability and the legal rights of both parties. A sample contract for the first phase of existing building commissioning services is provided as Appendix E. This sample can be modified to meet the specific contract requirements of your organization.

MOVE FORWARD WITH AN UNCERTAIN SCOPE

When contracting an agent in the pre-design phase of a complex project, many details may remain undecided that will ultimately affect the commissioning scope. In this situation, a possible solution is to contract for commissioning services in two-phases; one contract for services in the design phase and a second to be agreed upon when the full scope of later phases can be more precisely determined.

Additional Resources

Including commissioning in your building development plan can reap rewards well beyond the completion of the project. Not only does commissioning ensure a complete and thorough analysis of the building design and function, which results in energy savings, it will improve building performance, equipment operation, and occupant comfort. The benefits to the building owner and facility manager include fewer system deficiencies at building turnover, lower maintenance costs, increased equipment life, lower energy costs, more knowledgeable maintenance staff, decreased potential for liability related to indoor air quality, increased profit, and a more valuable building.

Commissioning resources are widely available to building owners considering commissioning, and we encourage you to review additional literature before embarking upon your commissioning project. Below are some websites that provide useful and up to date information that can be used to assist you through the commissioning process:

1. ASHRAE Guideline 0 2005 and ASHRAE Guideline 1.1 2007, available for purchase at http://webstore.ansi.org
2. Associated Air Balance Council (AABC) Commissioning Group (ACG):
3. www.commissioning.org
4. Building Commissioning Association:
5. www.bcxa.org
6. California Commissioning Collaborative:
7. www.cacx.org
8. GSA Commissioning Guide: www.wbdg.org/ccb/GSAMAN/buildingcommissioningguide.pdf
9. NEBB Building Systems Commissioning (BSC) Procedural Standards: www.nebb.org/neb/BSC%20PST%20FINAL%2002-17-09.pdf
10. NEBB Procedural Standards for the Retro-Commissioning of Existing Buildings: www.nebb.org/neb/RCX%20PST%20Final%2003-31-09.pdf
11. Whole Building Design Guide (National Institute of Building Sciences): www.wbdg.org

Acknowledgements

The information in this document is drawn from several existing commissioning guides and reports:

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- California Commissioning Collaborative. California Commissioning Guide: New Buildings; 2006. http://www.cacx.org/resources/documents/CA_Commissioning_Guide_New.pdf
- Lawrence Berkeley National Laboratory, Portland Energy Conservation Inc., Texas A&M University Energy Systems Laboratory. The Cost Effectiveness of Commercial Buildings Commissioning: A Meta Analysis of Energy and Non Energy Impact in Existing Buildings and New Construction in the United States. Report Number 56637; December 2004. http://eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf
- Mills, Evan. Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions. Prepared for California Energy Commission Public Interest Energy Research (PIER); 2009. http://cx.lbl.gov/2009-assessment.html
- Mills, Evan. Commissioning, Capturing the Potential. ASHRAE Journal; February 2011. http://evanmills.lbl.gov/pubs/pdf/ashrae-commissioning-mills.pdf
- Oregon Office of Energy, prepared by PECI. Commissioning for Better Buildings in Oregon; March 1997. http://www.oregon.gov/ENERGY/CONS/BUS/comm/docs/commintr.pdf?ga=t

Appendices

A) Final Commissioning Report – Fire Station #XXX, 2005. PECI.

B) Commissioning Team Roles and Responsibilities

C) Sample Request for Qualifications (RFQ), Source: Building Commissioning Association, https://netforum.avectra.com/eweb/StartPage.aspx?Site=BCA&WebCode=HomePage, Accessed June 23, 2011

D) Sample Request for Proposal (RFP), Source: Building Commissioning Association, https://netforum.avectra.com/eweb/StartPage.aspx?Site=BCA&WebCode=HomePage, Accessed June 23, 2011

E) Sample Commissioning Contract, Source: State of Georgia Building Commissioning Interim Recommended Guidelines (2002), www.atlantaga.gov/client_resources/forms/energy%20conservation/guidelines_for_commissioning.pdf

(Endnotes)

[1] California Commissioning Collaborative. California Commissioning Guide for New Buildings; 2006. http://www.cacx.org/resources/documents/CA_Commissioning_Guide_New.pdf

[2] Washington State University Extension Energy Program with support from Northwest Energy Efficiency Alliance. Building Commissioning for New Buildings; 2005. Energy Efficiency Fact sheet. EnergyIdeas Clearinghouse. WSUEEP98-018. http://cru.cahe.wsu.edu/CEPublications/wsueep98-018/wsueep98-018.pdf

[3] U.S. Department of Energy. Building Commissioning, The Key to Quality Assurance; http://www.peci.org/documents/PECI_BIdgCxQA1_0500.pdf

[4] California Commissioning Collaborative 2006

[5] Nodal, G., P.E., Konopacki, S. Energy Conservation Auditing. Data Center Dynamics Focus Magazine, July 15, 2008. http://www.zdtweb.com/ME2/Audiences/dirmod.asp?sid=4015BD1DA6DE4E5A9CFBFE0FD8A9D12C&nm=Magazine+Archives&type=Publishing&mod=Publications%3A%3AArticle&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=985DEB9A11E14FA588002BCD339D2062&AudID=E5BD2FF22AF74DF3A0D5F4E519A61511 (Accessed June 23, 2011)

[6] U.S. Department of Energy

[7] Mills, Evan, P.h.D. Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions. Prepared for California Energy Commission Public Interest Energy Research (PIER); July 21, 2009. http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf

[8] Mills 2009

[9] Mills, Evan. Commissioning, Capturing the Potential. ASHRAE Journal; February 2011. http://evanmills.lbl.gov/pubs/pdf/ashrae-commissioning-mills.pdf

[10] California Commissioning Collaborative 2006

[11] Oregon Office of Energy, Prepared by PECI. Commissioning For Better Buildings in Oregon; March 1997. http://www.oregon.gov/ENERGY/CONS/BUS/comm/docs/commintr.pdf?ga=t

[12] Mills 2009

[13] U.S. General Accounting Office, Health, Education, and Human Services Division. Conditions of America's Schools. Document# GAO/HEHS-95-61, Report B-259307; February 1995. http://www.gao.gov/archive/1995/he95061.pdf

[14] Mills 2011

[15] California Commissioning Collaborative 2006

[16] Mills 2009

[17] California Commissioning Collaborative 2006

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Appendix A

A Guide to Building Commissioning:

Final Report (example)

Final Commissioning Report

to

XXX

for

Fire Station #XXX

submitted by

Portland Energy Conservation, Inc.
1400 SW 5th Avenue
Suite 700
Portland, OR 97201
503-248-4636

July 2003

IMPORTANT NOTICE: This sample document is provided for instructional purposes only. CCC is not rendering advice concerning any commission project or practices. This document is neither approved nor intended to serve as a standard form. The user of these documents should confer with qualified advisors with respect to its commissioning and other documentation.

Table of Contents

Introduction

Portland Energy Conservation Inc. (PECI) had contracted with the Client to perform design-phase and construction-phase commissioning on the new Fire Station #XXX project to meet the requirements of the Utility's *XXX* program. The following report will outline the project, document the commissioning issues and their resolution, and summarize current operating parameters of the systems commissioned.

Project Description

Fire Station #XXX is a new facility constructed in the XXX area of City, State. The building is single story, approximately 5,600 square feet, and is occupied 24 hours per day, 365 days per year. The original design estimated a 20% reduction in energy consumption over a building constructed to meet State Energy Code, based on incorporating the following design features:

- daylighting control;
- occupancy sensors;
- efficient HVAC systems; and
- efficient construction.

The facility received a "Green" certification rating through Utility's *XXX* program.

Design Intent

The primary design intent for the facility was to achieve a "Green" certification rating through Utility's *XXX* program. In order to achieve that goal, several individual measures under each of the general categories outlined below had to be met.

- Energy Efficiency
- Quality Indoor Environment
- Environmental Responsibility
- Resource Efficiency

Two primary criteria necessary to achieve a "Green" certification were an estimated 20% reduction in energy usage over a building designed to meet the State Energy Code and participating in a full building commissioning process. A detailed description of the overall building design intent and a copy of the energy conservation measures implemented to achieve the 20% energy reduction can be found in the appendix.

The building commissioning process entailed:

- a comprehensive design review to ensure the design intent was met, including the addition of commissioning language in the contract documents;
- submittal review of all equipment to be commissioned, as well as other items that could impact any *XXX* measures;
- site visits during construction to identify and resolve issues that could impact system performance; and
- functional performance testing of each system to ensure proper operation and compliance with the design intent.

Copies of submittal review comments, field/commissioning reports, and system performance testing documentation can be found in the appendix.

As-Operating System Descriptions

HVAC Units

Building heating and cooling loads are met by three roof-top HVAC systems and radiant heating units. Each system is individually controlled and discussed in greater detail below.

AC-1

The sleeping quarters, fitness room, and various utility rooms are served by roof-top HVAC unit AC-1 with rated cooling and heating capacities of 3.5 tons and 60,000 Btuh, respectively. The unit is controlled by a programmable thermostat that is located in the main hallway. Since this space is basically occupied 24 hours per day, the scheduling features of the programmable thermostat are not enabled. Current heating and cooling setpoints are approximately 70°F and 73°F, respectively, but are adjusted as needed by building occupants to meet desired space temperatures.

The supply fan is presently set in the "auto" position, which means the supply fan only cycles on and off with a call for either heating or cooling. This minimizes energy usage by the supply fan motor, but also means that ventilation air is not continually circulated through the space. However, the lack of continuous ventilation air is not as critical here since the building is equipped with many operable window and exterior doors.

The HVAC unit is also equipped with an economizer which will allow space cooling loads to be satisfied by outside air, rather than using the compressor, when atmospheric conditions are acceptable. Economizer control is achieved using a snap disc which will enable the economizer when outside air temperature is typically less than 60°F to 65°F, and disabled the economizer when

the outside air temperature is typically greater than 70°F to 75°F. A snap disc operates based on the thermal expansion and contraction of a bi-metallic element at corresponding temperatures, which either closes or opens the economizer circuit. Since the operating temperature range for a snap disc cannot be adjusted manually, economizer operation cannot be optimized.

AC-2

The day room, kitchen area, and dispatch room are served by roof-top HVAC unit AC-2 with rated cooling and heating capacities of 3.5 tons and 60,000 Btuh, respectively. The unit is controlled by a programmable thermostat that is located in the main day room area. Since this space is basically occupied 24 hours per day, the scheduling features of the programmable thermostat are not enabled. Current heating and cooling setpoints are approximately 70°F and 73°F, respectively, but are adjusted as needed by building occupants to meet desired space temperatures.

The supply fan is presently set in the "auto" position, which means the supply fan only cycles on and off with a call for either heating or cooling. This minimizes energy usage by the supply fan motor, but also means that ventilation air is not continually circulated through the space. However, the lack of continuous ventilation air is not as critical here since the building is equipped with many operable window and exterior doors.

The HVAC unit is also equipped with an economizer which will allow space cooling loads to be satisfied by outside air, rather than using the compressor, when atmospheric conditions are acceptable. Economizer control is achieved using a snap disc which will enable the economizer when outside air temperature is typically less than 60°F to 65°F, and disable the economizer when the outside air temperature is typically greater than 70°F to 65°F. A snap disc operates based on the thermal expansion and contraction of a bi-metallic element at corresponding temperatures, which either closes or opens the economizer circuit. Since the operating temperature range for a snap disc cannot be adjusted manually, economizer operation cannot be optimized.

AC-3

The meeting room is served by roof-top HVAC unit AC-3 with rated cooling and heating capacities of 4 tons and 90,000 Btuh, respectively. The unit is controlled by a programmable thermostat that is located on the back wall of the room. The meeting room is basically unoccupied most of the time and its use is very sporadic, therefore the programmable thermostat interfaces with the occupancy sensor used to control the lights. When the space is unoccupied, the thermostat maintains heating and cooling setpoints of 60°F and 85°F, respectively. However a signal from the occupancy sensor triggers the thermostat into the "occupied" mode and maintains heating and cooling setpoints of 70°F and 73°F, respectively. When the signal from the

occupancy sensor is gone, the thermostat reverts back to the unoccupied mode temperature settings.

The supply fan is presently set in the "auto" position, which means the supply fan only cycles on and off with a call for either heating or cooling. This minimizes energy usage by the supply fan motor, but also means that ventilation air is not continually circulated through the space. However, the lack of continuous ventilation air is not as critical here since the building is equipped with many operable window and exterior doors.

The HVAC unit is also equipped with an economizer which will allow space cooling loads to be satisfied by outside air, rather than using the compressor, when atmospheric conditions are acceptable. Economizer control is achieved using a snap disc which will enable the economizer when outside air temperature is typically less than 60°F65°F, and disable the economizer when the outside air temperature is typically greater than 70°F65°F. A snap disc operates based on the thermal expansion and contraction of a bi-metallic element at corresponding temperatures, which either closes or opens the economizer circuit. Since the operating temperature range for a snap disc cannot be adjusted manually, economizer operation cannot be optimized.

Apparatus Bays

The apparatus bays are served by two natural gas-fired radiant heaters rated at 60,000 Btuh each and the units are controlled by manual thermostats. Since radiant heaters heat objects rather than the surrounding air, the heaters can be turned on and off as necessary and still provide adequate heating to the occupant within the work space. It is most likely that the building occupants will adopt this type of control strategy and turn the heaters on and off only when necessary.

There are no supply fans associated with the radiant heaters to circulate air or introduce ventilation air into the space. However, the lack of continuous ventilation air is not as critical here since adequate ventilation can be introduced through the exterior doors and main overhead garage doors if necessary. The space is also equipped with a vehicle exhaust fan system that will remove all engine exhaust should any vehicle need to operating while in the apparatus bay.

Interior Lighting

The lighting throughout the building primarily utilizes 4-foot T8 lamps and compact fluorescents. The average lighting density for the facility is approximately 1.0 watt/SF. Much of the lighting is controlled by manual wall switches; however, there are several automatic lighting control features in various area throughout the building, which are described below.

Day Room. The lighting in the day room includes both 4-foot T8 lamps and recessed compact fluorescent fixtures, and all are controlled by manual switches,

occupancy sensors, and daylighting controls. The occupants can manually turn the lights on and off as desired, the occupancy sensor will turn the lights off if the space in unoccupied, and the daylighting sensor will dim the lights based on ambient light levels within the space. Note that the light sensor used to dim the lights is wired directly to the ballasts and sends out a continuous control signal. The electronic ballasts can dim down to approximately 5% total power, but they will not turn off regardless of the amount of ambient light entering the space.

Fitness Room. The lighting in the fitness room are 4-foot fixtures with T8 lamps, and are controlled by manual switches, occupancy sensors, and daylighting controls. The occupants can manually turn the lights on and off as desired, the occupancy sensor will turn the lights off if the space in unoccupied, and the daylighting sensor will dim the lights based on ambient light levels. Note that the light sensor used to dim the lights is wired directly to the ballasts and sends out a continuous control signal. The electronic ballasts can dim down to approximately 5% total power, but they will not turn off regardless of the amount of ambient light entering the space. It was noted during initial site visits that the occupancy sensor occasionally shut the lights off even when the space was occupied, however it appears that the problem has been solved since the occupants did not mention the issue during subsequent visits. Should the issue arise in the future, sensor sensitivity may need to be increased and a shield installed to prevent movement in the hallway from triggering the lights.

Meeting Room. The lighting in the meeting room includes both 4-foot T8 lamps and recessed compact fluorescent fixtures, and all are controlled by manual switches, occupancy sensors, and daylighting controls. The occupants can manually turn the lights on and off as desired, the occupancy sensor will turn the lights off if the space in unoccupied, and the daylighting sensor will dim the lights based on ambient light levels within the space. Note that the light sensor used to dim the lights is wired directly to the ballasts and sends out a continuous control signal. The electronic ballasts can dim down to approximately 5% total power, but they will not turn off regardless of the amount of ambient light entering the space.

The original design included a dimmer switch to manually override the control signal from the light sensor and adjust the light output from the 4-foot T8 fixtures and two of the recessed compact fluorescent fixtures as desired. A subsequent design revision included a twist timer wired in series with the dimming rheostat so that the signal from the light sensor could not be overridden continually. Due to a misinterpretation of the revised design by the electrical contractor, the lighting for this area is controlled as follows:

- The two compact fluorescent fixtures that were to be connected to the dimming circuit are now connected directly to a twist timer and will only operate at full light output whenever the twist timer is enabled.
- A manual rheostat was never installed so there is no manual control over light output of the 4-foot T8 fixtures in the space. On/off control for these fixtures is controlled by the wall switches and occupancy sensors, while light output is controlled only by the light sensor.

- The remaining recessed compact fluorescent fixtures in the space are controlled by the wall switches and occupancy sensor (per the original design).

Even though the as-constructed lighting control strategy does not meet the original design intent, the lights operate very efficiently and the less-that-optimal manual control over light output from the dimmable lights is a minor inconvenience.

Apparatus Bays. The lighting in the apparatus bays are 4-foot fixtures with T8 lamps, and are controlled by manual switches, occupancy sensors, and daylighting controls. The occupants can manually turn the lights on and off as desired, the occupancy sensor will turn the lights off if the space in unoccupied, and the daylighting sensor will dim the lights based on ambient light levels within the space. Note that the light sensor used to dim the lights is wired directly to the ballasts and sends out a continuous control signal. The electronic ballasts can dim down to approximately 5% total power, but they will not turn off regardless of the amount of ambient light entering the space.

Exterior Lighting

All of the exterior light fixtures mounted around the perimeter of the building contain compact fluorescent lamps and are controlled by a single photocell that will turn the lights on and off based on ambient light levels. The parking lot is served by two self-contained solar powered fixtures, each with a single high intensity discharge lamp. The solar panel should charge the respective battery during the day and the integral control module will power the light with the energy stored in the battery based on ambient conditions. Neither of the fixtures have any electrical back-up should the solar panel/control module experience a failure or be taken off-line for service.

During the first few months of occupancy, it was noted that one of the fixtures did not operate correctly. Both the manufacturer and electrical contractor have worked to resolve the problem and as of this writing, it appears that both fixtures are operating as intended.

Special Features

The meeting room is equipped with mechanical shades that can be lowered to reduce the amount light and solar energy entering the space. The original design intent was to have these shades operate automatically based on reducing the solar heat gain to the space; however the as-constructed control strategy is manual operation. Even though this deviates from the original design intent, the impact on energy usage will be minimal since the HVAC unit serving this area only operates when the space is occupied. In addition, manual control of the blinds not only provides the occupants with increased flexibility in controlling ambient light levels, but will also reduce solar heat gains when they are lowered.

Conclusions

Building occupancy began in November 2002 and all systems were tested for proper operation and safety under all operating conditions. All of the goals for the project were met and the project was a success. The final commissioning report documents the overall process as well as "as-operated" parameters for the primary HVAC and lighting equipment.

The appendix contains documentation pertaining to the building design intent, building efficiency measures, commissioning recommendations/findings/issues, and system functional performance verification. This report should be kept with the O&M manuals, which were provided by the general contractor, for future reference. The information in these documents will help the building owner maintain proper system operation and can provide guidance during future remodels, renovations, or additions to ensure the original design intent continues to be met (or refined as necessary).

Appendix

Appendix B

A Guide to Building Commissioning:

Commissioning Team Roles and Responsibilities

Commissioning Team Roles and Responsibilities

Team Member	Roles and Responsibilities
Owner	Identifies commissioning as a requirement for the project and includes a statement regarding design professional commissioning responsibilities and scope in the request for design services. Develop and commit to the Owner's Project Requirements. Selects the commissioning authority – 3rd party provider recommended. Ensures availability of operating staff for all scheduled instruction and demonstration sessions. Ensures appropriate involvement of the team members, including Electrical Engineer, Architect, and any other consultants as required, during the commissioning process.
Mechanical Engineer	Participate and assist in the development of the Owner's Project Requirements (OPR). Attend the Pre-Design and Design Phase coordination and review meetings. Review the Commissioning Plan and participate as appropriate in on-site commissioning meetings. Review and incorporate as appropriate the commissioning authority's comments from submittal reviews. During the acceptance phase of the commissioning process, be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.
Mechanical Contractor	Cooperate with the commissioning authority and other team members to facilitate completion of the commissioning process. Attend commissioning meetings, foster communication between mechanical subs, and follow through on all action items. Provide estimate of cost to participate in the commissioning process. Ensure the controls contractor performs their commissioning activities. Provide instruction on equipment operation. Facilitate cooperation and participation of sub-contractors. Facilitate participation of major equipment manufacturers in start-up, testing, and training. Ensure correct and complete installation of all equipment and systems to ensure safe start-up. Prepare equipment for FPT's. Carry out the FPT's with the commissioning authority oversight. Correct deficiencies as necessary. Submit O&M manuals and conduct training. Generate As-Built drawings.
Controls Contractor	Include cost for commissioning in quoted price. Thoroughly review specifications to ensure compatibility with FPTs. Ensure proper sizing and functionality of equipment safety features, actuators, sensors, control sequences, valves and dampers. Attend commissioning meetings. Provide submittals and manuals to the commissioning authority. Demonstrate system performance to the commissioning authority. Provide thorough training to operating personnel. Participate in system verification and functional performance testing. Support TAB Agency as necessary.

TAB Agency	Provide cost of commissioning in bid documents. Attend commissioning meetings Submit proposed TAB procedures to commissioning authority and mechanical engineer for review and acceptance. Submit the final TAB report to the construction team. Participate in verification of the TAB report by the commissioning authority by re-testing 10% to 20% of the TAB measurements. Participate in O&M personnel training sessions.
General Contractor	Ensure the overall completion of the work. Participate as required in the HVAC commissioning process. Ensure the Mechanical Contractor performs all assigned HVAC commissioning responsibilities. Ensure the Electrical Contractor performs all assigned HVAC commissioning responsibilities. Ensure the cooperation and participation in the HVAC commissioning process of all other sub-contractors. Assign a representative to the commissioning team to attend meetings, ensure all action items are followed through on, and facilitate communication between team members.
End User	
Commissioning Authority	Plan, organize, and implement the commissioning process as specified. Prepare the commissioning plan, and ensure its distribution for review and comment. Revise the commission plan as required during construction. Chair commissioning meetings and prepare and distribute minutes to all commissioning team members. Coordinate commissioning activities among all contractors, subs, and suppliers. Develop and maintain an Issues Log. Monitor system verification checks and ensure the results are documented. Monitor controls point to point checks done by the controls contractor, and ensure the results documented. Observe all start-ups and initial system operations tests and checks. Direct the contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verifications purposes. Witness all functional performance tests and document results. Prepare and submit a Commissioning Report which documents all checks and tests done throughout the commissioning process, and the results obtained from each. Ensure all required O&M manuals, instructions and demonstrations are provided to the owner's designated operating staff.
Owner's O&M Staff	Review designs for maintainability Participate in periodic site walk-throughs Participate in commissioning process meetings Observe functional testing Participate in training sessions.

Appendix C

A Guide to Building Commissioning:

Request for Qualifications (example)

Request for Commissioning Services Qualifications
Inquiry Only – This is not an order

[**Insert Owner's Name**] invites prospective consultants to submit a written proposal to provide consulting services as Commissioning Authority (CxA) for the implementation of commissioning services for [**Insert Project Name**].

Please provide your qualification in an electronic format as well as three (3) bound copies in paper format, including one (1) original, signed in ink, in a sealed envelope bearing the assigned RFQ name located on the first page of the RFQ document. All qualifications must be submitted to the address listed below by no later than 5:00 p.m. **[EST] [CST] [MST] [PST],** [**Insert Date**].

Proposal Mailing Address:

Electronic Address:

Direct Questions to:

Proposers may elect to mail or personally deliver their qualifications. Bidders are encouraged to submit their qualifications prior to the above stated deadline. [**Insert Owner's Name**] shall bear no responsibility for late mail delivery or technical problems related to electronic transmittal.

[**Insert Owner's Name**] assumes no liability for any costs associated with preparation or submittal of vendor qualifications. Additionally, [**Insert Owner's Name**] reserves the right to accept or reject any or all qualification or to accept a portion of any qualification, or to cancel this RFQ in its entirety.

Appendix D

A Guide to Building Commissioning:

Request for Commissioning Services Proposal

Request for Commissioning Services Proposal
[Review and edit to suit project]

Issuance Date:

Closing Date:

[**Insert Owner's Name**] (Owner) requests written proposals to secure commissioning authority (CxA) services for the **[Project or Location]**. The owner is committed to commissioning this facility to systematically optimize the building and ancillary systems so that they operate efficiently and effectively in accordance with the Owners Project Requirements, and that the facility staff has adequate system documentation, and training. It is the intent of the owner to ensure that the fundamental systems are calibrated and operating as required to deliver functional and efficient performance.

The project is a _____ gross sqft., ___ story, Class ___ [type] _____ building in _____, _____, [city & state] with a project budget of $_____ million. The facility is expected to be comprised of ____% [space type], ____% [space type], and _____% [space type]. **[Add and edit as required to match specific project. Provide as much information as possible.]** The project is currently in the **pre-design, schematic design, design development, construction documents.** The expected schedule is to start design by _____, start construction by _____, and occupy by _____.

Provide the proposers with a copy of the programming report and any design documents completed to date.

The CxA will plan, manage, perform and report on the commissioning activities, utilizing the reporting formats and standardized forms provided by the CxA **whenever** required. The CxA will submit deliverable report to [**Owner**] according to a project schedule set by CxA and agreed upon by [**Owner**]. It is extremely important that all commissioning tasks be conducted in a transparent manner and involve the building engineer and operations staff to the greatest degree possible.
The management structure is **[traditional design/bid/build]** **[design/build]** with full design documents and specifications developed by an architectural/engineering firm. The construction documents will be let out to bid and a general contractor will be hired to complete the construction. The owner's primary construction representative on-site will be provided by the separately contracted services of a construction manager. The commissioning authority will be hired by and report directly to the owner.

The systems to be commissioned are: **[Add and edit as required]**

1. Refrigeration systems
2. Heating systems
3. Steam systems
4. Air handling systems
5. Runaround loop energy recovery system
6. HVAC controls systems. The system shall tie into the BAS.
7. Plumbing water systems

Appendix E

A Guide to Building Commissioning:

Sample Contract for the First Phase of Existing Building Commissioning Services

BUILDING COMMISSIONING SERVICES CONTRACT

BETWEEN OWNER AND COMMISSIONING AUTHORITY

(GSFIC)

STATE OF [STATE] PROJECT NUMBER: _____

COUNTY OF [COUNTY] PROJECT NAME: _____

PROJECT SITE: _____

THIS CONTRACT made the _____ day of_____, 200____, by and between the Construction Division, [STATE] State Financing and Investment Commission whose address is[ADDRESS], a commission in the Executive Branch of state government in the State of [STATE], hereinafter called the Owner, and _____ _____, whose address is _____, hereinafter called the Commissioning Authority ("CxA"), for building Commissioning services for the above referenced project, hereinafter referred to as the Project.

WHEREAS, Owner requires building Commissioning services for the Project; and

WHEREAS, CxA possesses the skills and experience to provide the building Commissioning services for the Project; and

WHEREAS, Owner selected CxA pursuant to a qualifications-based selection process as required by O.C.G.A. §50-22-5 or 6;

NOW, THEREFORE, Owner and CxA, in consideration of the mutual benefits and promises flowing to each of the parties agree as follows:

ARTICLE 1

1.1 The CxA's Basic Services - The CxA's Basic Services are the professional services as set forth in Attachment A, Scope of Basic Commissioning Services, incorporated by reference herein. These services are generally described in "Building Commissioning – Interim Recommended Guidelines" published by the Georgia State Financing and Investment Commission, as amended, hereinafter referred to as the "Guidelines," incorporated by reference herein.

1.2 Standards - The CxA shall conform to and be bound by Attachment A, Scope of Basic Commissioning Services, and the Guidelines, and shall perform the Basic Services consistent with all applicable laws and codes in effect at the time the Basic Services are delivered to the Owner. The CxA is fully responsible for any work performed by its consultants the same as if said work were performed, approved, certified, or accepted by it. The CxA, by the execution of this agreement, contracts that it is possessed of that degree of care, learning, skill, and ability that is ordinarily possessed by other members of the its profession and further contracts that, in the performance of the duties herein set forth, it will exercise such degree of care, learning, skill, and ability as is ordinarily employed by professionals under similar conditions and like circumstances, and shall perform such duties without neglect, and shall not be liable except for failure to exercise such degree of care, learning, skill, and ability. The CxA acknowledges and agrees that, in performing the services for the Project called for in this contract, it shall regard sound principles of design, construction, and operations. By signature on this Contract, the CxA certifies that he or the firm's principal in charge of the performance of the Basic

Services is professionally qualified, registered, and licensed to practice in the State of[STATE].

1.3 Content – The content for the Basic Services shall generally conform to the content outlined in the Guidelines, for those services within the Scope of Commissioning services set forth in Attachment A.

1.4 The CxA's Additional Services - The CxA agrees to perform the Additional Services set forth in Attachment B, Additional Services, incorporated by reference herein.

1.5 Use of and Reliance Upon the Basic and Additional Services – The CxA acknowledges that the Commissioning services provided to, or for the benefit of, the Owner include reasonable justification or explanation of the Commissioning Authority's professional decisions, and that those decisions may be reasonably relied upon by the Owner, a contractor, a professional, or any other party delivering services to, or installing work for, the Owner in accordance with the Project for which the Owner retained the Commissioning Authority.

1.6 Ownership and Copyright – All Commissioning deliverables, information, data, photos, videos, or documents produced hereunder by the CxA, or its consultants shall be delivered to the Owner, and title thereto shall vest in the Owner regardless of the stage to which the development of the study may have progressed. In addition, the CxA hereby expressly assigns, transfers, and otherwise quitclaims to the Owner, its heirs and assigns forever, all right, title, and interest, including all copyrights and all termination/renewal rights in such copyrights, and all causes of action accruing under such copyrights, in all studies, study calculations, drawings, specifications, other data, embodiments of such studies, documents, or other works of authorship produced hereunder by the CxA, its consultants, or its employees. The CxA further warrants that this transfer of copyrights and other rights is valid against the world. Finally, all original study deliverables and other technical data shall be furnished to the Owner without cost whether the project for which they are made be executed or not. The CxA may make and retain for its use such additional copies as it may desire.

1.7 Owner's Approvals - The CxA acknowledges and agrees that the Owner does not undertake to approve, or pass upon, or undertake to inquire into the adequacy, fitness, suitability, or correctness of any Commissioning conclusions. The CxA acknowledges and agrees that the approval or acceptance of the Commissioning services by the Owner is limited to the function of determining whether there has been compliance with instructions issued to the CxA regarding the Basic and Additional Services to be performed. The CxA agrees that no approval of any Commissioning services, program, document, video, photograph, or deliverables by any person, body, or agency shall relieve the CxA of responsibility for the adequacy, accuracy, fitness, suitability, and correctness of the services performed in accordance with sound and accepted principles applicable to the services.

1.8 Administrative and Coordination Services Included within Basic Services:

1.8.1 The CxA shall arrange and conduct all Commissioning meetings that shall include equipment manufacturers, the designer team, and the construction contractor and/or subcontractors. The CxA shall take minutes of the meeting and distribute typewritten copies to all parties attending the meeting within five (5) calendar days.

1.8.2 The CxA, as the representative of the Owner, shall advise and consult with the Owner during all phases of the services provided.

1.8.3 The CxA shall be responsible for the professional quality, technical accuracy, and the coordination of all studies, tests, designs, drawings, specifications, and other services furnished under this Contract. The CxA shall, without additional compensation, correct or revise any errors, deficiencies, or omissions in the analysis, studies, designs, drawings, specifications, estimates, and other services.

1.8.4 The Owner's review of, approval of, acceptance of, or payment for the services required under this Contract shall not be construed to operate as a waiver of any rights under this Contract or of any cause of action arising out of the performance of this Contract. The CxA shall remain liable to the Owner for all damages caused by the CxA's negligent performance of any of the services furnished under this Contract.

1.8.5 The CxA shall submit to the Owner and Design Team a Commissioning specification for inclusion in the construction contract(s).

1.8.6 The CxA shall submit a Commissioning Schedule, for the Owner's review and approval, of the Basic and Additional Services set forth in Attachments A and B. The Commissioning Schedule shall outline all times, projections and milestones for all reviews, meetings, investigations, and other portions of the Project. The CxA shall develop the Schedule and shall submit the preliminary schedule within ten (10) working days of execution of

this contract. The Project Construction Schedule shall incorporate the Commissioning Schedule as developed by the Design Team and the Constructors. All Commissioning services shall be coordinated with the actual construction progress.

1.8.7 The warranty period shall be as defined in the Specifications (normally one (1) calendar year from the date of Final Acceptance of the Project by the Owner). The CxA shall provide the Basic and Additional Services as needed for the full term of the warranty period. The CxA shall attend all warranty inspections to determine if any defects in the Work exist. The CxA shall notify the Owner (verbally within 24 hours of the inspection and followed up in writing within five (5) days of the inspection) of any defects, and whether or not the defective work is covered by the warranty. The CxA shall notify the Owner in the same fashion of any defective work the CxA may identify at any time on the Project.

ARTICLE 2

2.1 Fees – The Owner shall pay the CxA a Fee of $_____ for the Basic Services. The Owner shall pay the CxA for Additional Services an Additional Fee to be negotiated and recorded upon Attachment B. The Fee may be increased by mutual agreement if further additional services are needed. Payment shall be as set forth in Article 5 below.

2.2 Reimbursements - The Owner will not make reimbursement for any expense unless the Owner requests the expenditure and approves it in advance. Transportation costs, living expenses, reproduction costs, courier service costs , and long distance telephone charges shall not be reimbursable unless the Owner grants written approval for these expenditures in advance.

2.3 Time for Completion – Unless modified in Attachment A, the time for completion of the Basic and Additional Services shall be consistent with the design and construction schedules, and warranty period. Non-warranty services and offseason testing shall be completed prior to the completion of the Project. The Owner, may permit in writing, in its sole discretion, certain designated Commissioning services to be completed after occupancy, but shall set a date certain for completion if such permission is granted. Should Owner-initiated changes in the requirements result in substantial re-work of the Basic Services, the Owner and CxA shall mutually negotiate both an additional fee and any required extensions of time.

ARTICLE 3

3.1 Special Additional Services - Payment for special consultants or special studies when requested by the Owner and agreed to by the Owner and CxA in advance shall be in addition to the payments for Basic Services defined in Attachment A and Additional Services defined on Attachment B.

3.2 Hourly Rates - The hourly rates to be included in the invoices of the CxA for Special Additional Services agreed to under Article 3.1 and not contained on Attachment B shall be as follows:

(A) For principals of the CxA and for principals of firms engaged as consultants shall be a rate of $150.00 per hour.

(B) For registered professionals of the CxA and for registered professionals of the firms engaged as consultants shall be a rate of $125.00 per hour.

(C) For drafters of the CxA or firms engaged as consultants shall be a rate of $75.00 per hour.

(E) For administrative personnel of the CxA or firms engaged as consultants shall be a rate of $40.00 per hour.

ARTICLE 4

4.1 Owner's Option for Additional Professional Services – Owner reserves the right—which right may be exercised in Owner's sole and absolute discretion, without the necessity of further competitive selection processes, including any further process under O.C.G.A. §50-22-1 et seq.—to select CxA as the professional consultant for other additional or special additional services to the Project and to negotiate an amendment to this contract or to negotiate a separate professional services contract for such professional services.. Owner is under no obligation to select CxA for any additional professional services for this Project, and may conduct a new qualifications-based selection process as my required by O.C.G.A. §50-22-5 or 6. CxA is entitled to no additional compensation, other than for the Basic, Additional and Special Additional Services provided herein, from Owner should Owner elect not to exercise its option under this paragraph.

4.2 Separate Contracts - Unless agreed to in writing by the Owner, the various components of the Project may be awarded under separate contracts, including this contract, professional services contracts, an Architectural Design Contract, and one or more construction contracts.

ARTICLE 5

5.1 Payments - The CxA agrees that:

(A) Invoices for Fees for Basic, Additional, and Special Additional Services shall be submitted monthly for payment by the Owner and shall be based on the CxA's good faith estimate of percentage of services actually complete at the time of the billing, plus any completed Additional Services and reimbursable expense previously approved by the Owner.

(B) Requests for reimbursable expenses shall be submitted with the monthly invoices for fees and allocated by person to whom the expenses apply, accompanied with copies of receipts and invoices as set forth in the latest rules and regulations promulgated by the State Auditor for travel expenses.

(C) Final payment for Basic Services, Additional and Special Additional Services, and for final reimbursable expenses shall not be due and payable until the Owner has accepted and approved the Basic, Additional and Special Additional Services as complete.

5.2 The CxA shall make payments to its consultants not more than ten (10) working days following receipt of payment from the Owner. Statements of the CxA for fees subsequent to the first statement must contain a notice that "all consultants have been paid in full to the extent that the CxA has been paid." If this certification cannot be made, the CxA must affirmatively state for each such consultant the amount not paid and the reasons therefore.

ARTICLE 6

6.1 Assignment -The CxA hereby agrees that the Owner may, if it wishes to do so, assign this contract to another governmental entity. The CxA hereby agrees that it shall not assign, or transfer any interest or right in this Contract in whole or in part to any party without the written consent of the Owner in advance.

ARTICLE 7

7.1 Professional Liability Insurance - Within ten days after execution of this Contract and during the entire period of the contract, the CxA shall maintain professional liability insurance applicable to the work being performed. The CxA shall file with the Owner a certificate of insurance from an insurance company licensed to do business in the State of Georgia showing evidence of such professional liability insurance (errors and omissions insurance) in limits of not less than $1,000,000 per claim. Any deductibles and self-insurance retention may not be greater than $25,000.

7.2 Workers Compensation and General Liability insurance - Within ten days after execution of this Contract and during the entire period of the contract, the CxA shall maintain Workers Compensation and General liability insurance as provided herein. The CxA shall file with the Owner a certificate of insurance from an insurance company licensed to do business in the State of Georgia showing evidence of workers compensation insurance meeting statutory requirements and commercial general liability insurance limits of not less than $1,000,000 per claim and $2,000,000 in the aggregate.

ARTICLE 8

8.1 Termination for Convenience of the Owner (Without Cause) - The Owner may at any time, and for any reason or without any reason or cause, terminate this contract by written notice to the CxA specifying the termination date, provided that in the event of termination under this provision the Owner shall pay to the CxA all fees properly due (i) for services already properly performed prior to the effective date of the termination and (ii) for all reimbursable expenses properly incurred. In the event of such termination the CxA shall have no claim in excess of what is allowed in this Article 8.1 for any sum of money, however denominated, as a result of or relating to such termination.

8.2 Termination For Cause - In the event the CxA through any cause fails to perform any of the terms, covenants, or provisions of this contract on its part to be performed, or if it for any cause fails to make progress in the work hereunder in a reasonable manner or if the conduct of the CxA impairs or prejudices the interests of the Owner or the Firm violates any of the terms, covenants, or provisions of this contract, the Owner shall have the right to terminate this contract by giving notice in writing of the fact and date of such termination to the CxA, and all study deliverables and other documents relating to the Basic Services shall be surrendered forthwith by the CxA to the Owner, PROVIDED, HOWEVER: That the CxA shall have five (5) business days from the date of the notice to cure the defects, and PROVIDED FURTHER: That in such case the CxA shall receive equitable compensation for such services as agreed between the parties, or, in the event of an inability to agree, shall in the opinion of an independent auditor selected by the Owner and paid for by the Owner to which the CxA shall have no reasonable objection, to have been satisfactorily performed by the CxA up to the date of termination of this Contract. The parties agree that the decision of the said auditor concerning the matters set forth in this Article 8.2 shall be final.

ARTICLE 9

9.1 Personal Work - In contemplation that the Commissioning services to be performed are personal services, the CxA hereby agrees that no material change in the business organization under which the firm shall perform the present contract may be made without written consent of the Owner in advance, and such consent of Owner may be credited upon retention of the key staff persons of the CxA for performance of the work. The CxA must provide revised tax identification numbers prior to payment of the invoice following any such change.

ARTICLE 10

10.1 Modifications to the Contract - The CxA covenants that no modifications, either written or oral, may be made in the terms and provisions of this Contract without the written consent in advance of the Owner. It is agreed between the CxA and the Owner that, in the absence of such written consent, neither any modifications nor any undertaking to modify the contract shall be binding but shall be absolutely null and void.

10.2 Superseding Of Earlier Agreement And Fees - The parties hereto agree that these presents take the place of and supersede entirely any existing contracts, agreements, arrangements, understandings, undertakings, courses of dealing, or customs and practices, either implied or express and whether written or oral, in regard to the Project. This contract represents the entire and integrated agreement between the Owner and the CxA and may be amended only by written instrument signed by both the Owner and the CxA.

ARTICLE 11

11.1 Prohibited Acts - The CxA by execution of this contract warrants that it has not employed or retained any company or person, other than a bona fide employee working solely for it, to solicit or secure this contract and that it has not paid or agreed to pay any person, company, corporation, individual, or firm, other than a bona fide employee working solely for it, any fees, commission, percentage, gift, or other consideration contingent upon or resulting from the award or making of this contract.

11.2 Minority Participation Policy - It is the policy of the State of Georgia that minority business enterprises shall have the maximum opportunity to participate in the State purchasing and contracting process. Therefore, the State of Georgia

encourages all minority business enterprises to compete for, win, and receive contracts for goods, services, and construction. In addition, the State encourages

all companies to subcontract portions of any State contract to minority business enterprises. CxAs who use qualified minority subcontractors may qualify for a Georgia state income tax deduction for qualified payments made to minority subcontractors. See O. C. G. A. §48-7-38.

11.3 Drug-Free Work Place - The CxA acknowledges that it is fully aware of the contents and requirements of O.G.C.A. §50-21-1 et seq. of the Official Code of Georgia. The CxA, by execution of the present contract, does hereby certify that it and its consultants are in compliance with the aforesaid code section.

11.4 Full Performance - The Owner and the CxA hereby agree to the full performance of the terms, duties, obligations, responsibilities, conditions and stipulations contained herein.

11.5 This Agreement shall be construed and enforced according to the laws of the State of Georgia.

IN WITNESS WHEREOF, the parties have each caused these presents to be duly signed, sealed, and delivered by their duly authorized representatives on the day, month, and year first above written.

COMMISSIONING AUTHORITY: _____

By:_____

[SEAL] Name:_____

Title: _____

OWNER: _____

By:_____

[SEAL] Name:_____

Title:_____

ATTACHMENT A

SCOPE OF BASIC COMMISSIONING SERVICES

[To be detailed by the Owner]

ATTACHMENT B

SCOPE OF ADDITIONAL SERVICES

{Note that, in the version of this attachment that the Agency should prepare, words inside the square brackets [ ] and the brackets themselves will be replaced by Agency specific requirements. The fill-in here is given for example only.}

The CxA shall provide training services as follows:

- The CxA shall develop a training program for existing O&M personnel of Owner, consisting of [for example, an eight-hour course, including both platform instruction and hands-on training of the commissioned systems on the Project].

- The CxA shall develop and provide to the Owner a Training Manual to supplement the training program and provide for Owner-led training of new employees.

- The CxA shall present the training course two times to facilitate attendance by all of Owner's O&M personnel and appropriate administrative personnel. While administrative personnel may attend, the training is to be structured most effectively for O&M personnel. The Owner shall provide a training room adequate for the platform training, and shall provide services for copying training materials as needed.

- The CxA shall coordinate all training provided by the General Contractor.

- The CxA shall provide a videotape and catalogue of each training session.

- The CxA shall provide the Additional Services on this Attachment B for a Lump Sum Fee of $_____. If additional training sessions are requested by Owner, each shall be conducted for a supplementary Fee

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