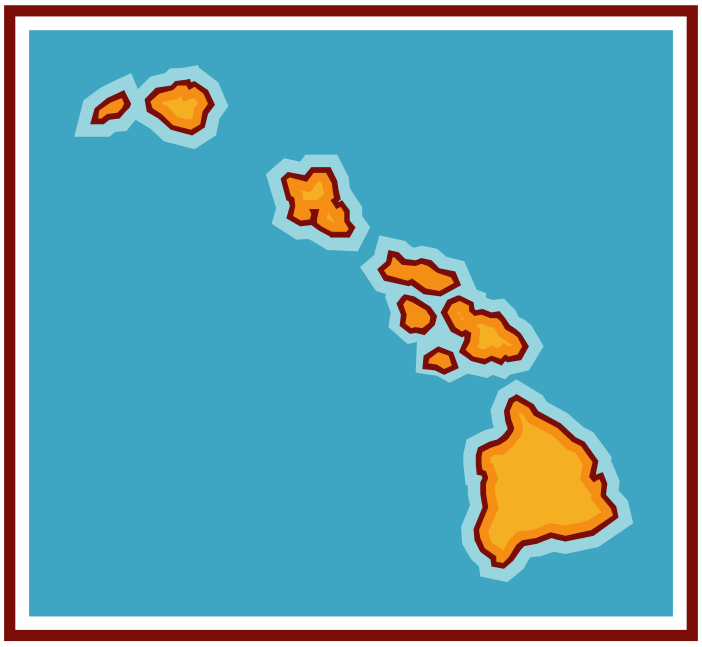

State of Hawaii

Building Commissioning

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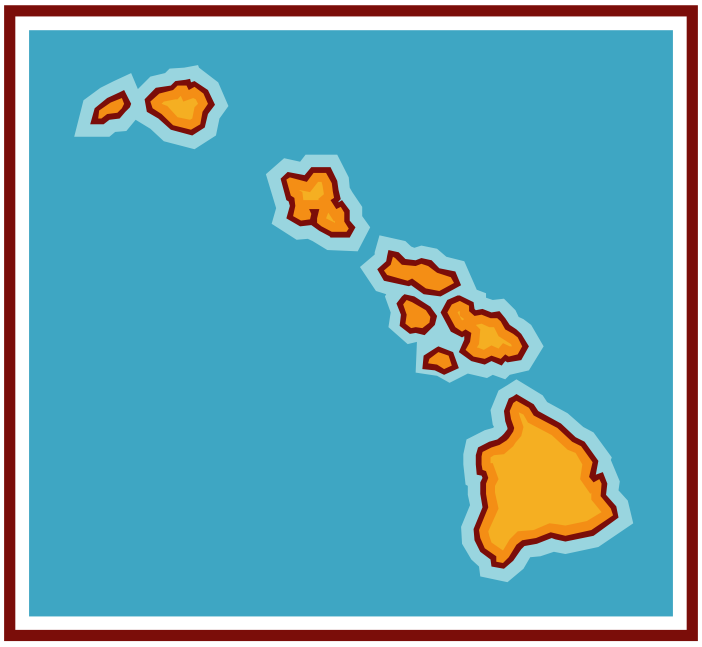
Retro Commissioning

Guidebook

Department of Business, Economic Development, and Tourism (DBEDT)

Second Edition - October, 2008



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Preface

In the early summer of 2007, Keithly Barber Associates Inc. was contracted by the State of Hawaii Department of Business, Economic Development and Tourism (DBEDT) to work on a project aimed at integrating formal commissioning procedures into the existing building construction and on-going maintenance programs for all state agencies. One of the desired components of the work scope included the development of a document that would help these agencies better understand the building commissioning process and more importantly, provide an easy to use implementation "guidebook" for the typical project manager.

There are currently many excellent commissioning guidelines and process publications available from a variety of sources. For those persons who require or desire a more in-depth and technical understanding of the commissioning process, the author recommends the following:

- *Building Commissioning Guidelines* available from the Energy Design Resources website @ http://www.energydesignresources.com/resource/37/
- *The Building Commissioning Guide* available from GSA @ http://www.wbdg.org/ccb/GSAMAN/buildingcommissioningguide.pdf
- *Adopting the Commissioning Process for the Successful Procurement of Schools* available from the California Division of the State Architect @ http://www.chps.net/links/pdfs/CommissioningProcessGuide.pdf
- *A Retro-Commissioning Guide for Building Owners* available from Portland Energy Conservation Inc. @ http://www.peci.org/library.htm

You can also contact DBEDT for information on the building commissioning and energy efficiency programs at their website: http://www.hawaii.gov/dbedt/info/energy/.

Table of Contents

SECTION 1: Introduction

1.1. Purpose and Intended Audience for this Guide

The purpose of this guide is to provide State of Hawaii project managers, construction managers, facility engineers and the many professionals that serve them with a better understanding of how formal building commissioning procedures can be applied to improve both new construction projects and existing building systems. In addition, this document was designed to provide an easy to follow "step-by-step" road map for the application of the commissioning process. This guidebook is not intended to provide a detailed description of the technical aspects of commissioning or retro-commissioning buildings. Neither is this guide intended to provide required format or process requirements for professional commissioning authority firms performing work on State of Hawaii projects.

An increasing number of local and state building codes now require some level of building project commissioning. In addition, the United States Green Building Council (USGBC) includes very specific and mandatory requirements for commissioning on projects seeking to achieve various Leadership in Energy and Environmental Design (LEED) certifications. Many states and numerous private companies have incorporated commissioning requirements into their capital building programs and the U.S. General Services Administration (GSA) has produced a very comprehensive commissioning guide for use on their many federal building projects.

The State of Hawaii endorses the integration of commissioning procedures into the capital construction and facility maintenance programs of the various state agencies as a means to improve the level of quality assurance on new construction projects and to improve the operational and energy usage performance of existing buildings. The message is clear: "Better performing buildings benefit everyone in Hawaii".

1.2. Building Commissioning and Retro-Commissioning Defined

Over the years, building owners and occupants, project managers, building operating engineers and others have often been frustrated by the failure of new and existing building systems to perform as expected. While various aspects of quality control and quality assurance have been evident to some degree for many years in the building construction industry, there has generally not been a dedicated attempt to coordinate all these efforts into a common organized and documented process. In addition, many building systems fall into disrepair and dysfunctional condition as a result of neglect caused by a lack of emphasis placed on the real need for on-going preventive maintenance procedures performed by adequately trained staff. In an effort to address these types of issues for their clients, a number of institutional and professional organizations began to promote comprehensive "quality assurance" based programs

aimed more directly at creating an organized and documented approach to verifying that building systems are designed, built and tested for compliance with established operational and functional performance criteria. In addition, similar services were offered to address poorly functioning systems in existing buildings. As this trend took hold, a new and distinct discipline was firmly established and "Building Commissioning" has now become a familiar term within the construction and facilities engineering arenas.

While several appropriate definitions for the term "Building Commissioning" can be found among the multitude of reference documents available on the subject, the overall theme remains very simply the same:

Building Commissioning is a planned, coordinated and documented process of reviews and testing whereby the desired design, installation, performance, maintenance and operational criteria of various building systems are established and verified.

In other words; building owners, project managers and facility engineers can use the building commissioning process to provide a systematic and documented approach to improving the design, installation, functional performance and on-going maintenance and operation of any building system, both in new or existing buildings.

1.3. Why is Building Commissioning Necessary?

We all know by experience that building projects can fail to meet expectations, even when they are adequately funded and staffed with experienced professionals. The design and construction process is extremely complex and involves critical contributions from a multitude of individual sources, each one with the potential to derail the project with a bad decision or a bit of work that didn't get done correctly. Many times these failures can be caught and corrected with limited impact. Other times these errors are not discovered until it is too late and the "damage" is more costly to deal with, or simply ignored.

When a logical and appropriate quality assurance (building commissioning) plan is developed and integrated into a project approach, the goal is to substantially reduce the risk of ending up with costly or even catastrophic mistakes, and provide the project owner with a higher level of assurance in regards to the proper design, installation and functional operation of various critical building systems. In addition, when the responsibility for designing and directing the commissioning plan is dedicated to a separate individual or firm (the Project *Commissioning Authority*), the individual quality assurance efforts of the entire team can be coordinated and completed in unison, as one joint endeavor.

Often we hear the following question asked in regards to building commissioning:

Why do we need to hire a separate firm to commission our project; isn't that supposed to be the responsibility of the designers and contractors?

Typically, neither the project designer nor the contractor takes the lead on developing and implementing a comprehensive plan for integrating and coordinating the quality assurance (building commissioning) effort. While the design and construction firms involved on a project team may have some form of an established quality control process built into their own business models, there are few firms with the expertise and available staffing necessary to develop and implement a comprehensive quality assurance (building commissioning) plan for an entire major building project. And it could be argued that due to potential conflict of interest issues, a comprehensive building commissioning effort is best performed by a third-party firm that is not financially or contractually associated with either the designer or the contractor.

1.4. Commissioning and Energy

Does commissioning save energy? Numerous published case studies show that it does. Through the commissioning of building systems we can often identify and correct the potential waste of energy. And in many cases, this waste can be significant, with the resulting energy savings easily paying for the extra cost of the commissioning effort.

On State of Hawaii commissioning projects it may be desirable or even a requirement to calculate the energy savings due to the commissioning effort. Section 4 of this guidebook speaks in more detail to this topic. It is important that the Project Manager and Commissioning Authority understand when these requirements will apply and any related work scope must be reflected in the commissioning contract.

It should be clearly understood that the primary goal of commissioning is to verify that systems operate as intended. In some cases, bringing a building system back into compliance with the "design intent" through retro-commissioning can actually increase the amount of energy being used. Certainly we can all understand that the chilled water air conditioning system uses less energy when the circulation pumps are broken and not running, but the occupants might suffer as a result! Our goal must always be to design, construct and operate building systems that consume the minimum amount of energy while providing a reasonable and appropriate level of occupant comfort and safety. Commissioning can help us to determine when we have met or failed to meet that goal.

1.5. When is Commissioning New Construction Appropriate?

As a rule, some level of formal commissioning procedures should be considered for any new construction or major renovation project where major mechanical or electrical systems are involved. It may be most appropriate and cost-effective to provide only installation reviews and functional performance testing routines on projects where only

one major system component is involved (a chiller replacement for example). This will help to keep the cost of the commissioning effort within a reasonable percentage of the total project cost. In addition, formal commissioning should always be seriously considered for "mission critical" applications where failure of the building system to function properly could have more serious or even catastrophic results.

1.6. When is Commissioning of Existing Buildings Appropriate?

When standard commissioning procedures are applied to investigating and making repairs/improvements to existing building systems, we call this process "retro-commissioning". The following should be considered when deciding if a building might benefit from completion of formal retro-commissioning procedures:

- Does the building use a higher than average (compared to similar buildings in the same geographic area) amount of energy?
- Do the building occupants generally complain about poor temperature control, bad ventilation, mold, odors, leaks, drafts, inadequate or excessive lighting levels, excessive mechanical system noise or other similar issues?
- Has the building experienced premature failure of any building system components?
- Has the building undergone any major system replacements or upgrades without formal commissioning of the new or upgraded systems?

All the above are classic symptoms of an inefficient and poorly operating building. A comprehensive retro-commissioning process can effectively diagnose the problems, prescribe appropriate remedies and then verify the building has been returned to "healthy" condition.

1.7. Potential Costs for Commissioning and Retro-Commissioning

Data provided by the Lawrence Berkeley National Laboratory (*"The Cost Effectiveness of Commercial-Buildings Commissioning," December 2004*) indicates that the median cost for comprehensive (design through construction and project acceptance) commissioning on new building projects in the United States has been approximately $1 per square foot. The cost for retro-commissioning of typical existing buildings has been averaging approximately ½ that amount ($.50 per square foot), although that does not include the cost for necessary system repairs and improvements that may be indicated and completed as a result of the retro-commissioning process. One must clearly understand that these are averages and the range of actual fees for commissioning can

vary significantly depending on the size, type, location and complexity of the building systems being commissioned. Very simple and typical systems such as unitary rooftop HVAC equipment on a 50K square foot elementary school could likely be commissioned for 70 to 80 cents a square foot while a 30K square foot college laboratory HVAC

system with multiple fume hoods and critical pressure differential requirements might be closer to $3 a square foot.

Some other common “yardsticks” for commissioning fees have been established based on the budgeted costs of the systems being installed. For example commissioning fees might be estimated within a range of .5 to 3% of the total new construction cost, 1.5 to 2.5 % of the mechanical contract (for mechanical systems only commissioning) or 1 to 1.5% of the electrical contract (for electrical systems only commissioning).

It is important to understand that many of the costs associated with a quality building systems commissioning process are somewhat fixed and therefore the cost per square foot will likely be less on larger projects, and higher on smaller projects. The geographical location of Hawaii must also be considered due to business costs that are somewhat higher than the national average and the relatively few commissioning professionals based locally. The complexity of the systems being commissioned will also be a cost factor due to the additional number of functional tests that will be required to verify all potential system attributes. In addition, when the scope of the commissioning work is expanded to include items such as multiple design reviews, extensive systems training and post-occupancy reviews, the cost for services will obviously increase as a result.

For those agencies with little or no experience in estimating potential commissioning fees for a specific project, it might be appropriate to seek the advice of another source with experience commissioning projects similar to yours.

1.8. Getting Started

For those whom remain uncertain as to whether or not commissioning or retro-commissioning might be appropriate for a specific building project, DBEDT currently has an advisor under contract to assist with weighing the pros and cons and answering questions in this regard. In addition, this advisor can help to estimate fees, initiate the project commissioning process and can assist the project team by providing a level of commissioning process oversight on behalf of the agency. This service is currently offered free of charge to any State of Hawaii agency seeking to integrate commissioning and/or retro-commissioning into their programs. Please contact the DBEDT office for more information regarding the DBEDT Building Commissioning Assistance Program.

SECTION 2: Commissioning New Projects

Integrating Commissioning Into Your Project

2.1. A Typical Approach to New Construction Commissioning

An outline for a typical comprehensive approach to commissioning new construction projects can be found on the flow chart provided in Appendix 5.1. More detailed process descriptions can be found in Appendix 5.2. While the particular building systems chosen for commissioning and the available budget may warrant abbreviating this scope to some extent, all of the items listed have value and should at least be considered. Note: Appendix 5.2 also addresses the various LEED commissioning requirements.

2.2. Impact on the Project Schedule

When properly designed and executed, the commissioning process should have minimal negative impact on the overall project schedule. In fact, a properly executed commissioning process should actually expedite the closeout phase of a project. It could certainly be argued that a reasonable level of quality control and quality assurance is typically intended to occur on every project and the formal commissioning process is simply a more organized and better documented version of what has always been expected. Completion and occupancy schedules may be forced to "slide" when significant design or construction issues are discovered, but this has always been the case and hopefully when the commissioning process is integrated into the project at an early stage, most of these issues will be discovered sooner or perhaps avoided entirely. The commissioning process milestones should be defined for every project and included within the master project construction schedule.

2.3. Potential Commissioning Team Members

It is critically important to understand that a successful approach to commissioning building systems hinges on the early involvement and active cooperation of many typical project team members. These individuals may include:

- State Agency/Owner's Representatives
- Project Manager
- Architect
- Design Engineers and Design Consultants
- LEED Consultants
- The Commissioning Authority
- Construction Manager
- Installation Contractors

- Other Testing Consultants and Contractors
- Maintenance Contractors
- Equipment Suppliers
- Utility Providers

2.4. Impact on Other Consultant Contracts

The commissioning process simply cannot be as effective when only the commissioning authority is actively involved and other project team members consider the commissioning process to be beyond their contracted work scope and responsibilities. The project manager who is managing the commissioning contract must verify that all the project team members are fully aware of their commissioning related roles and responsibilities, and their contracts for services must include both the appropriate language and adequate compensation to insure their willing cooperation. Appendix 5.3 describes some potential commissioning related roles for various project consultants.

Hiring a Project Commissioning Authority (CxA)

2.5. When to Hire

Ideally, the commissioning authority should be selected and contracted very near the start of the project. To be most effective, the commissioning process begins prior to the start of project design so as to include active participation of the CxA in the development of the owner's project requirements and designer's basis of design documents. These documents really "set the stage" for all the commissioning-related work to follow as they are intended to establish the specific desired installation and performance criteria that shall be verified through the commissioning process. (Reference Appendix 5.4 for a description of these documents). Consider hiring the CxA at the same time as the other design professionals. This will also allow the CxA to more easily integrate into the project team and clearly demonstrate the project owner's commitment and recognition of the importance given to including a formal commissioning effort.

2.6. The Request for Qualifications (RFQ) Document

Professional project consultants such as the commissioning authority are typically hired through a process of selection based on qualifications, followed by the negotiation of actual desired work scope and fees. The qualification documents for prospective firms are reviewed and scored, with the top scoring applicants usually gaining a formal interview with the selection committee. If the client cannot successfully negotiate a scope and fee structure with the most qualified firm, the next qualified firm is then contacted, or the entire process may need to be repeated.

It is obviously very important that the RFQ be well designed so as to accurately convey the appropriate project information and the client's desired qualifications. A sample RFQ document for soliciting a new construction commissioning authority is provided in Appendix 5.5.

2.7. Where to Advertise for a Commissioning Authority

The following is a list of possible venues that might be considered for advertising. In some cases, State of Hawaii contracting laws may require advertising in a specific manner. Contact your contracting department to review any particular requirements that may apply.

- Most State of Hawaii professional services advertisements are posted on the State Procurement Office website at http://www4.hawaii.gov/bidapps/
- Request for qualifications and commissioning project descriptions might also be posted with the Building Commissioning Association @ www.bcxa.org

2.8. Commissioning Authority Selection Criteria

Every agency will need to develop a "score sheet" for the purpose of rating the responses to the RFQ. Generally speaking, choosing the most qualified commissioning authority for a specific project is no different than choosing any other project consultant. The firm should provide references that can be contacted to verify performance and client satisfaction. It is also important to take a close look at the experience, expertise and current workload of the individual proposed for the role of commissioning project manager as they will likely be the most important single factor in regards to the potential for success of the particular commissioning project. Additionally, look for experience with similar projects and similar building systems. Finally, be sure the firm clearly identifies what it considers to be the major indicators of a successful commissioning project. These indicators should closely match your own intended goals.

In all cases, selection criteria for commissioning and retro-commissioning professionals should be based on compliance with Hawaii Revised Statutes HRS103D-304 Procurement of Professional Services.

2.9. Establishing the Project Commissioning Goals

Once the most qualified candidate firm has been selected, it is critically important that a clearly defined and comprehensive list of desired goals for the commissioning process be developed for the project. These goals must be provided to the CxA firm so they can then develop a proposed final detailed work scope description and associated fee schedule they feel will best address these goals. The CxA firm may even be asked to assist with developing these goals as their experience on previous projects could help

to develop goals that are better defined and/or more appropriate for this project. Among the goals for commissioning that might be considered could be the following:

- Costs for the commissioning related fees within a desired budget amount.
- Useful and appropriate owner project requirements and basis of design documents.
- Building system design documents and specifications that provide adequate clarity and detail.
- Design compliance with the owner's previously defined project requirements.
- Commissioning related specification sections that clearly and comprehensively define the contractor's related requirements.
- A logical, appropriate, clear and comprehensive commissioning plan.
- Consensus gained from the project team regarding the importance and value of the commissioning process.
- Contractor submittal documents that are compliant with the desired performance and operational features.
- Construction and equipment installation procedures that are monitored often enough by site reviews to insure compliance with the design intent and specified requirements before mistakes are repeated or covered.
- Specified equipment start-up and testing procedures recommended by the equipment suppliers that are verified and documented as completed by the contractors.
- Completed building systems that have been carefully reviewed for installation and desired features in compliance with the design intent and specified requirements.
- Completed building systems that have been thoroughly functionally tested in all potential modes of operation and proven (with documented results) to perform in compliance with the design intent and specified project requirements.
- Training and associated documentation provided that allows for the building maintenance staff to fully understand and correctly maintain and operate the commissioned building systems.
- Issues identified and resolved early. A minimum of unresolved issues at the completion of the construction process, and no remaining critical issues.

- Documented verification of post occupancy energy usage in compliance with the design intent and owner expectations. This may include LEED requirements.

- Documented verification of occupant and building operations staff satisfaction through post-occupancy interviews, inspections and additional testing of performance.

2.10. Developing the Commissioning Services Contract

After completing a list of goals, the CxA firm should then be asked to provide the project manager with a proposed final scope of work and associated proposed fee schedule. (Appendix 5.6 contains a sample CxA scope-of-work and fee estimating worksheet). It is then the project manager's responsibility to review and approve this document for inclusion in the formal consultant contract. The PM must verify that the scope of work adequately addresses every desired goal and that the proposed fees represent a fair level of compensation for the required effort. If necessary, the PM must be prepared to negotiate changes in the scope of work and fee proposal. These negotiations may also require the PM to make changes in the project goals if it is determined that all the goals cannot be accomplished given the budget amount that is available for the commissioning effort.

While the final contract may reflect either an agreed upon labor and materials rate or a lump sum value, it is important to request the consultant to provide an estimated breakdown of the proposed hours per task and any associated expenses, including travel. Because travel expenses to Hawaii can potentially be a significant component of the expense for a firm not located near the project site, the project manager needs to understand how much of the proposal might reflect travel costs and how much reflects the time actually proposed to be spent working on the project work scope. And finally, it is important to clearly define all the desired deliverable products expected and at what point in the project they should be delivered for approval. The following is a list of typical new construction commissioning deliverables that might be required.

- Written comments from the commissioning authority's review of the owner's project requirements and designer's basis of design documents. (Reference Appendix 5.7 for a sample document review format).

- Written comments from the CxA review of the various design stage documents, including the schematic design, 50% and 100% design documents stages. (Reference Appendix 5.7 for a sample document review format).

- Commissioning specification sections to be included within the contractor's project specifications. (Reference Appendix 5.8 for a sample commissioning related specification section).

- A formal commissioning plan that outlines and defines the entire proposed commissioning process. This plan is updated and revised by the commissioning authority during the entire commissioning process. (Reference Appendix 5.9 for a sample list of new construction commissioning plan components).

- Written comments from the CxA review of relevant contractor equipment and system submittals. (Reference Appendix 5.7 for a sample document review format).

- Site installation reviews and witnessing reports completed during CxA construction site reviews and contractor start-ups. (Reference Appendix 5.10 for a sample inspection and witnessing log).

- Training witnessing and O&M document review reports. (Reference Appendix 5.11 for a sample training witnessing log) (Reference Appendix 5.7 for a sample document review format).

- A commissioned systems manual as required if the project is attempting to achieve the LEED Earth and Atmosphere additional (non prerequisite) commissioning credit #3. Requirements for this manual can be found on pages 208 and 209 of the LEED-NC 2.2 Reference Guide, and are listed in Appendix 5.12 of this commissioning guidebook.

- Meeting minutes from all commissioning related project meetings.

- A continuously updated version of the commissioning issues log. (Reference Appendix 5.13 for a sample issues tracking document format). Note: A final version of this list should be contained within the final commissioning report.

- A final commissioning report with all post-construction inspections and tests completed. This report should contain the following components:
    - An executive commissioning project overview that summarizes the entire commissioning process with a clear description of any remaining unresolved issues and recommendations for further action.
    - An updated and final version of the project commissioning plan including all completed inspection and test documents, and a final version of the issues and resolutions list.

- A post-occupancy review report. This report should be submitted for review by the entire project commissioning team. Any new or remaining unresolved issues should be noted and a plan developed for resolution. The master issues log
- should also be updated with appropriate revisions and additions, and resubmitted for inclusion in the final commissioning report.

These deliverables should be noted as milestones or re-occurring events on the project master schedule, and/or on a separate commissioning project schedule. This separate

commissioning schedule could also be included in the CxA contract for commissioning services.

Understanding the Project Manager's Commissioning Role

2.11. Acting as an Advocate for the Commissioning Process

Absolutely nothing is more important to the success of any commissioning project than the demonstration of support provided by the project manager (PM), representing the project owner. Therefore, the PM must be convinced of the value of a well designed and implemented commissioning process. To put it simply and honestly; if the PM does not believe the process will work, it won't. Take the time to understand the entire process (hopefully reading this guide will help!) and get all your questions answered. The project manager should not begin to integrate commissioning into a project until they are convinced that it will add value and improve the chances for success!

Furthermore, the project manager must clearly and continuously communicate support and expectations for the commissioning effort. Please remember, the commissioning authority has no actual legal authority to enforce participation or cooperation in the process. The project manager represents the owner and has the responsibility to ensure that all specified and contracted services are provided. This is the only "stick" the CxA has available, and from time-to-time the project manager may need to enforce the project contract specifications in support of the commissioning process.

2.12. Defining Expectations for the Commissioning Team

As part of getting familiar with the commissioning process, the project manager must fully understand the commissioning related roles and responsibilities of all the project team members as defined in the project commissioning plan. It is then critically important that the project manager review expectations with the entire project team and secure an agreement as to their cooperation.

In addition, it can really help if the PM makes a clear statement as to what the project commissioning goals are and why they are important to achieve. Project team members are always more inclined to help reach goals when they are clearly defined and they understand their importance to a project owner.

And finally, the PM should list some reasons why achieving the established project commissioning goals might be important to other people on the project team. For example, point out how commissioning can greatly reduce the number of warranty period issues. Achieving this goal clearly benefits everyone, but perhaps most especially the contractors who typically get the first phone calls when things aren't working quite right.

2.13. The OPR and BOD Documents

In order to get the commissioning project started on the "right foot", make sure to allow some time to develop a clear list of those things you expect to see provided in terms of both the project products and methods of delivery. This list should include specific product features and performance expectations that the owner has indicated, and is often referred to as the Owner's Project Requirements (OPR) document. Time spent developing this document will be well invested and the requirements will provide the design team with a much clearer understanding of what they need to include within the design documents. In fact, the design team will then be expected to develop their own Basis of Design (BOD) document that addresses every item on the OPR and clearly indicates how they propose the design will satisfy these requirements.

In the interest of better tracking the designer's responses to all the owner's project requirements, it may be prudent to combine the OPR and BOD into one document. You can find an example of this combined document approach provided in Appendix 5.4.

2.14. Disseminating Correspondence and Reports

Another important role the project manager assumes is related to insuring that effective communication lines are established and providing critical and timely information between all project team members. While this is an important role in a general project sense, it becomes especially critical when issues are discovered during the commissioning process. The PM must be certain that those persons expected to be involved in the resolution of issues are kept informed regarding both the discovery and current status of each issue. While the commissioning authority is typically responsible for editing and distributing an updated issues tracking report, the project manager must be sure this information is flowing to the right individuals on a timely basis. One of the major goals of commissioning is the early identification and expedient resolution of issues. If the lines of communication between project team members become confused or delayed, this can only detract from the commissioning effort.

2.15. Assisting with Issue Resolution

Resolving issues discovered during the commissioning process must be considered a responsibility of the entire project team. The project manager will many times be called upon to help in the assignment of responsibility for issue resolution, and may even be called upon to actively assist or take the lead in gaining resolution to specific issues. In cases where the owner's preference has not been adequately defined in the project design documents, the project manager may be called upon to gain approval or disapproval directly from the owner.

2.16. Review and Approval of the Commissioning Deliverables

Over the course of any serious commissioning effort, the CxA will be expected to provide various deliverable products, depending on the scope of desired work as defined in the consulting contract. While it is certainly appropriate to expect prompt delivery of these deliverable items per the project schedule, it is equally important that the project manager be responsive in regards to providing a timely review and approval.

2.17. Assisting with the Transition between Project Phases

In many new construction situations, the owner will have different representatives who assume the key roles during the project design, construction and occupied maintenance and operation (M&O) phases. These key individuals may take the form of project managers, construction managers, maintenance and operations personnel, or others. When a project is managed through various phases by several potential individuals, and then turned over to another department for the on-going maintenance and operation, it is critically important to determine where to "pass the baton" in regards to managing the commissioning process. It is also critically important that all potential project managers and M&O staff understand the entire commissioning process and especially the components of the process that are typically scheduled to occur under their "watch". For example, the CxA interaction and involvement with the design team will likely be managed by the initial project manager, while the project construction manager will likely be most involved with commissioning after the bid is awarded and the actual construction work begins. The on site managers and M&O department will then become more involved during the acceptance and training phases, and will most certainly be most involved in any post occupancy commissioning procedures.

Therefore, prior to the start of any new construction commissioning project, it is critically important that all these potential project and M&O managers be invited to a commissioning orientation session where the actual individual responsibilities for managing the commissioning process are discussed and agreed upon.

2.18. Transition to the Maintenance and Operations Department

The Maintenance and Operations Department should be well represented during the entire commissioning process and it is vitally important that the final transition from project completion to on-going maintenance and operations be well orchestrated. The project manager must be sure that M&O staff clearly understand how the commissioned building systems function and are fully trained to maintain and operate them. New building systems will quickly slip into a state of disrepair and dysfunction if there is inadequate training and/or manpower available to adequately sustain their proper maintenance and operations. The CxA can help in this regard by both passing along knowledge regarding the systems and by researching additional training opportunities that may be available. In the case where responsibility for system maintenance and

operation will be turned over to a private contractor, the commissioning authority should be asked to meet with the contractor to verify they are adequately trained and the service contract provides for sufficient scope.

2.19. A New Construction Commissioning Project Checklist

Appendix 5.14 contains a sample commissioning project checklist that might be used by a project manager during the course of a typical new construction commissioning project. Prior to use, the project manager should carefully review and edit the checklist as necessary to match the CxA's actual contracted scope of work.

SECTION 3: Retro-Commissioning for Existing Buildings

Applying the Retro-Commissioning Process

3.1. A Typical Approach to Retro-Commissioning

A typical comprehensive approach to the retro-commissioning of existing buildings can be found on the flow chart provided in Appendix 5.15 and the process descriptions in Appendix 5.16. While the particular building systems chosen for retro-commissioning and the available budget may cause some of this scope to be abbreviated, all of the items listed have value and should at least be considered.

3.2. Potential Retro-Commissioning Team Members

It is critically important to understand early on that a successful approach to retro-commissioning building systems hinges on the active involvement and/or full cooperation of many typical project team members. These individuals may include:

- Owner's Representatives and O&M Staff
- Building Occupants
- Project Managers
- The Commissioning Authority (CxA)
- TAB Contractor (typically hired by the CxA)
- The Original Design Engineers (if available)
- The Original Installing Contractors (if available)
- System Maintenance Contractors (typically make simple repairs and adjustments through an existing contract with the owner)
- New Design Engineers (when major repairs or improvements are indicated)
- New Equipment Suppliers (when major repairs or improvements are indicated)
- New Installing and/or Repair Contractors (when major repairs or improvements are indicated)
- Utility Providers

Hiring a Commissioning Authority for Retro-Commissioning

3.3. When to Hire

The commissioning authority firm must be selected and contracted at the start of the retro-commissioning project. To be most effective, the retro-commissioning process should include active participation of the CxA in the development of a list of desired project goals. These goals then help to establish an appropriate final scope of work and become the measure of project success. A list of some typical retro-commissioning goals can be found below in paragraph 3.7 of this guide.

3.4. The Request for Qualifications (RFQ) Document

Professional project consultants such as the commissioning authority are typically hired through a process of selection based on qualifications, followed by the negotiation of actual desired work scope and fees. The qualification documents for prospective firms are reviewed and scored, with the top scoring applicants usually gaining a formal interview with the selection committee. If the client cannot successfully negotiate a scope and fee structure with the most qualified firm, the next qualified firm is then contacted, or the entire process may need to be repeated.

It is obviously very important that the RFQ be well designed and accurately conveys the appropriate project information and the client's desired qualifications. A sample retro-commissioning RFQ document is provided within Appendix 5.17 of this guide.

3.5. Where to Advertise for a Commissioning Authority

The following is a list of possible venues for RFQ advertising. In some cases, State of Hawaii contracting laws may require advertising in a specific manner. Contact your contracting department to review any particular requirements that may apply.

- Most State of Hawaii professional services advertisements are posted on the State Procurement Office website at http://www4.hawaii.gov/bidapps/
- Request for Qualifications and commissioning project descriptions might also be posted with the Building Commissioning Association @ www.bcxa.org

3.6. Commissioning Authority Selection Criteria

Every agency will need to develop a "score sheet" for the purpose of rating the responses to your RFQ. Generally speaking, choosing the most qualified CxA for a specific project is no different than choosing any other project consultant. The submitting firms should be asked to provide project references to verify performance and client satisfaction. It is also important to take a close look at the experience, expertise and current workload of the individual proposed for the role of commissioning project manager as they will likely be the most important single factor in regards to the potential for success of the retro-commissioning project. Additionally, look for experience with similar projects and similar building systems. And finally, be sure the firm clearly identifies what it considers to be the major indicators of a successful retro-commissioning project. These indicators should closely match your own intended project goals.

In all cases, selection criteria for commissioning and retro-commissioning professionals should be based on compliance with Hawaii Revised Statutes HRS103D-304 Procurement of Professional Services.

3.7. Establishing the Project Retro-Commissioning Goals

Once the most qualified candidate firm has been selected, it is critically important that a clearly defined and comprehensive list of desired goals be created for the retro-commissioning process on any project. These goals must be provided to the CxA firm so they can then develop a proposed final detailed work scope description and associated fee schedule they feel will best address these goals. The CxA firm may even be asked to assist with developing these goals as their experience on previous projects could help to develop goals that are better defined and/or more appropriate for the project. Among the goals for retro-commissioning that might be considered could be the following:

- Costs for the retro-commissioning project within a desired budget amount.
- A reasonable and appropriate retro-commissioning project goals document.
- An appropriate and effective retro-commissioning plan that provides a clear process “road-map” for the proposed retro-commissioning process.
- A thorough and comprehensive investigation of the current physical and operational condition of the systems proposed for retro-commissioning.
- A comprehensive list of recommended repairs and improvements, including a range-of-magnitude cost estimate and energy savings potential for each item, when appropriate.
- Designer and contractor submittal documents that are reviewed for compliance with the desired performance and operational features (when major repairs or improvements are to be contracted out).
- Repair and improvement procedures that are monitored often enough by site inspections to insure compliance with the desired project goals and typical standards of good workmanship.
- Specified equipment start-up and testing procedures recommended by the equipment suppliers that are verified and documented as completed by the contractors.
- Repaired and/or improved building systems that have been carefully inspected for proper installation and desired features in compliance with the specified requirements.
- Completed repairs and improvements to building systems that have been thoroughly functionally tested in all potential modes of operation and proven (with

documented results) to perform in compliance with the current design intent and specified project requirements.

- Training and associated documentation provided that allows for the building maintenance staff to fully understand and correctly maintain and operate the retro-commissioned building systems.

- A minimum of unresolved issues at the completion of the retro-commissioning process, and no remaining critical issues.

- Documented verification of occupant and building operations staff satisfaction through post-project interviews, inspections and additional testing of performance.

- Documented verification of post project energy usage in compliance with the design intent and owner expectations.

3.8. Developing the CxA Scope of Work and Fee Schedule Document

After completing your list of goals, the CxA firm should then be asked to provide a proposed final scope of work and associated proposed fee schedule. (A sample retro-commissioning work scope and fee development worksheet is provided in Appendix 5.18 of this guide). It is then the project manager's responsibility to review and approve this document for inclusion in the formal consultant contract. Verify that the scope of work adequately addresses every desired goal and that the proposed fees represent a fair level of compensation for the required effort. If necessary, be prepared to negotiate changes in the proposal until the proposal is acceptable. These negotiations may also require changes in project goals if it is determined that all the desired goals cannot be accomplished given the budget amount that is available.

One approach that might be considered when hiring a consultant for retro-commissioning work is to split the project into two separate stages, with two separate scope and fee details developed.

The first stage might include the following:

- Stage 1 scope and fee structure development

- Building systems investigation including inspections and testing of existing system

- Recommendations for repairs and improvements

The second stage might then include:

- Stage 2 scope and fee structure development

- Management, oversight or simply verification of repairs and improvements

- Verification of satisfactory system condition and performance through comprehensive inspections and functional testing

- Turnover to maintenance and operations, including training and post-project review

By using a two-stage approach, the owner and CxA can more accurately estimate the cost of services prior to the start of the second stage and therefore lower the risk of estimating too high or too low. In addition, the discovery of significant and costly issues during the investigative phase may cause the need to delay resolution of these issues until adequate funds can be allocated. In some cases these delays may be significant and it is in everyone's best interest if the first phase contract can be completed prior to development of a second phase scope and fee schedule.

While the final contract may reflect either an agreed upon labor and materials rate or a lump sum value, it is important to request the consultant to provide an estimated breakdown of the proposed hours per task and any associated expenses, including travel. Because travel expenses to Hawaii can potentially be a significant component of the expense for a firm not located near the project site, the project manager needs to understand how much of the proposal might reflect travel costs and how much reflects the time actually proposed to be spent working on the project work scope. Finally, it is important to clearly define all the desired deliverable products expected and at what point in the project they are expected to be delivered for review and approval. The following is a list of some typical retro-commissioning deliverables that might be considered:

- A comprehensive and detailed retro-commissioning plan that clearly describes all aspects of the proposed retro-commissioning process and provides a process "road map" and schedule for the project. Reference Appendix 5.19 for a sample list of typical retro-commissioning plan components.

- Written comments from the commissioning authority's review of the existing plans, specifications, shop drawings and other documents that pertain to the systems scheduled for retro-commissioning. Reference Appendix 5.21 for an example format for a list of document review comments.

- Documented results of the investigative phase inspections and testing.

- A comprehensive list of recommended repairs and improvements as a result of the investigative phase results. Reference Appendix 5.20 for an example format for a list of recommended repairs and improvements.

- Written comments from the CxA review of relevant design documents and contractor equipment and system submittals (when major repairs and improvements are designed).

- Site review and witnessing reports completed during CxA site inspections and contractor start-ups (when major repairs and improvements are contracted).

- A report on the final site review of all completed repairs and improvements that verifies an installation in compliance with the desired intent and readiness for comprehensive functional testing.

- Functional testing scripts as included in the retro-commissioning plan and to be completed as part of the final commissioning of repaired and improved systems.

- Minutes from all retro-commissioning related project meetings and pertinent written correspondence related to the retro-commissioning effort.

- A continuously updated version of the retro-commissioning issues log initiated during the comprehensive review and functional testing of all retro-commissioned systems. Reference Appendix 5.13 of this guide for a sample issues log format.

- A preliminary final retro-commissioning report and record with the documented record of all inspections and tests completed. This report should contain an executive project overview and clearly identify the status of those issues that remain unresolved.

- A post-construction review report indicating the sustained operation and performance of previously retro-commissioned systems and an updated issues log list of any new or remaining issues.

Some of these deliverables might be noted as milestones or re-occurring events on a retro-commissioning project schedule that the project manager and/or CxA maintain.

The Project Manager's Role in the RCx Process

3.9. Acting as an Advocate for the Retro-Commissioning Process

Absolutely nothing is more important to the success of any retro-commissioning project than the demonstration of support provided by the project manager (PM), representing the project owner. Therefore, the PM must be convinced of the value of a well designed and implemented retro-commissioning process. To put it simply and honestly; if the PM does not believe the process will work, it won't. Take the time to understand the entire process (hopefully reading this guide will help!) and get all questions answered.

Furthermore, the project manager's support must be clearly and continuously communicated throughout the retro-commissioning effort. Please remember, the CxA has no actual legal authority to enforce participation or cooperation in the process. The project manager may be the only "stick" the CxA has available, and from time-to-time the PM may need to work with various individuals to help garner and maintain support for the retro-commissioning process.

3.10. Providing Existing Construction and O&M Documents

A major part of the retro-commissioning effort involves the comprehensive review of existing construction documents (plans, specifications etc.) and all other available information related to the systems scheduled for retro-commissioning. This process provides the CxA with a fundamental understanding regarding the original design intent and also provides information related to any major repairs, improvements or upgrades that may have occurred during the life of the building. The project manager must assist in the location of all existing documents that could help the CxA in this effort.

In addition, the CxA will need to perform an initial site visit to gain a better familiarity with the building and to interview those persons who might be able to provide additional information related to the systems scheduled for retro-commissioning or the current building maintenance and operations procedures in general. The project manager will need to help arrange this visit and secure the attendance of those individuals who might have knowledge and experience related to the systems scheduled for retro-commissioning.

3.11. Providing Site Access and Informing Building Occupants

Once the schedule for on-site work is determined, the project manager must assist the CxA in securing access to those areas of the building where inspections and tests will need to be completed. In addition, the occupants of the building must be clearly informed in regards to the general nature of the work and the proposed schedule. It may also be prudent to personally introduce the occupants to the retro-commissioning team members who will be working in their environments.

3.12. Defining Expectations for the Retro-Commissioning Team

As part of getting familiar with the retro-commissioning process, the project manager must fully understand the retro-commissioning related roles and responsibilities of all the project team members. It is then critically important that the PM review expectations with the entire project team and secure an agreement as to their cooperation. The PM may want to enlist the help of the CxA during this discussion so that everyone will be aware of the specific issues (resolved or unresolved) related to any of the team members.
In addition, it can really help if the PM makes a clear statement as to what the project retro-commissioning goals are and why they are important to achieve. People are always more inclined to help reach goals when they are clearly defined.

And finally, try to list some reasons why achieving the established project retro-commissioning goals might be important to other people on the project team. For example, point out how retro-commissioning can greatly reduce the number of chronic complaints from building occupants. Achieving this goal clearly benefits everyone, but perhaps most especially the maintenance and operations staff that typically get the first phone calls when things aren't working quite right.

3.13. Disseminating Correspondence and Reports

Another important role the project manager assumes is related to insuring that effective communication lines are established and providing critical and timely information between all project team members. While this is an important role in a general project sense, it becomes especially critical when issues are discovered during the retro-commissioning process. Those persons expected to be involved in the resolution of issues must be kept informed regarding both the discovery and current status of each issue. While the CxA is typically responsible for editing and distributing an updated issues tracking log, the project manager must be sure this information is flowing to the right individuals on a timely basis. One of the major goals of retro-commissioning is the early identification and expedient resolution of issues. If the lines of communication between project team members become confused or delayed, this can only detract from the retro-commissioning effort.

3.14. Decisions Regarding Potential Repairs and Improvements

Once the CxA has developed an initial list of recommended system repairs and improvements, the project manager and others representing the owner must carefully review this list; ask all necessary questions and make decisions regarding going forward. Often these decisions are based on the potential for saving energy and therefore the return on investment must be carefully considered. Section 4 of this guidebook provides information in this regard.

It is important that the project manager and all necessary representatives of the owner understand the significant amount of time and energy often required to make these decisions and provide for the future direction of the commissioning process. Often retro-commissioning projects can become stalled at this juncture due to the failure to estimate the amount of work involved in making and implementing these often very complex and expensive decisions. This may be another good reason to consider a two stage approach to retro-commissioning where the first stage contract is actually completed when the CxA provides the list of recommended repairs and improvements to the owner.

3.15. Managing the Completion of Repairs and Improvements

Depending on the desired scope of work for the CxA, the project manager may also be involved in managing the completion of various critical repairs and/or improvements to the systems scheduled for retro-commissioning. This responsibility might range from oversight of existing maintenance personnel or contractors to the development of design documents and the securing of formal bids.

Earlier it was mentioned that a two-stage retro-commissioning approach might be worth considering as it is difficult (if not impossible) to accurately predict the scope and potential cost of repairs and/or improvements that may be identified as critically necessary once the investigative phase is completed. In addition, once the full extent of the desired repairs and improvements are known, the level of effort and responsibility for management can be better estimated and most appropriately assigned.

3.16. Assisting with Issue Resolution

Resolving issues discovered during the functional testing phase of the retro-commissioning process must be considered a responsibility of the entire project team. The project manager will many times be called upon to help in the assignment of responsibility for issue resolution, and may even be called upon to actively assist or take the lead in gaining resolution to specific issues. In cases where the owner's preference has not been adequately defined by the retro-commissioning project goals, the project manager may be called upon to gain approval or disapproval directly from the owner.

3.17. Review and Approval of the Retro-Commissioning Deliverables

Over the course of any serious retro-commissioning effort, the CxA will be expected to provide various deliverable products, depending on the scope of desired work as defined in the consulting contract. While it is certainly appropriate to expect prompt delivery of these deliverable items per the project schedule, it is equally important that the project manager be responsive in regards to providing a timely review and approval.

3.18. Assisting with the Transition to Maintenance and Operations

While hopefully the M&O Department has been well represented during the entire retro-commissioning process, it is vitally important that the final transition from project completion to on-going maintenance and operations be well orchestrated. The project manager must be sure that M&O staff clearly understand how the retro-commissioned building systems function and are fully trained to maintain and operate them. Building systems will quickly slip back into a state of disrepair and dysfunction if there is inadequate training and/or manpower available to adequately sustain their proper maintenance and operations. The commissioning authority can help in this regard by both passing along their personal knowledge regarding the systems and by researching additional training opportunities that may be available. In the case where the responsibility for system maintenance and operation will be turned to a private

contractor, the CxA should work with the contractor to be sure they are adequately trained and that the service contract provides for sufficient scope.

3.19. A Retro-Commissioning Project Checklist

Appendix 5.22 contains a sample retro-commissioning project checklist that might be used by a project manager during the course of a typical retro-commissioning project. Prior to use, the project manager should carefully review and edit the checklist as necessary to match the CxA's actual contracted scope of work.

SECTION 4: Energy Usage Reduction through Commissioning and Retro-Commissioning

4.1. Energy Usage in Hawaii

Hawaii is somewhat unique among the other states in the U.S.A. when it comes to energy consumption and the application of energy conservation projects. Nearly 90% of Hawaii's electricity is produced from fossil fuel resources and 99% of that fuel is supplied by foreign countries. Further, the electric rates in Hawaii (as of September, 2008) are currently the highest in the nation, averaging from 33 cents per kWh on Oahu to 49 cents per kWh on the neighboring islands. The State of Hawaii must be vigilant and creative in looking for ways to reduce energy usage in order to minimize our dependence on foreign energy sources, reduce CO2 emissions and lower the energy related expense burden to our citizens.

4.2. State of Hawaii Energy Related Goals for Cx and RCx Projects

The State of Hawaii has a major interest in promoting and achieving increased energy efficiency and building performance with the goal of reducing energy usage and demand. Through the use of effective commissioning and retro-commissioning procedures, building systems can be verified to be installed and operating in compliance with the owner's design intent. For the State of Hawaii, that design intent includes providing a safe, clean and comfortable building environment while using the least possible energy.

4.3. Understanding Electric Utility Rates

Electric utility rates in Hawaii are higher than those of most U.S. mainland utilities and also vary somewhat by island and type of commercial customer. The demand (kW) charges are fairly small at 10-15 percent while the kWh charges are 45-50 percent. The fuel cost adjustment (FCA) charge makes up major remaining charges at 35-40 percent. This adjustment charge may even go higher as the cost of fuel oil continues to increase.

The suggested method to determine electric dollar savings is to use the "effective" rate per kWh for the past 12 month period to the nearest cents/kWh. The effective rate is calculated by dividing the total electric bill over the past 12 months by the total kWh usage over the same period.

Note:
Please see the HECO website at www.heco.com, Business Services tab, Electrical Rates tab for the current electrical rates at your project location in Hawaii.

4.4. Considering Energy Conservation Measure (ECM) Costs

When considering the inclusion of energy conservation measures within a retro-commissioning project it is critical to understand that the cost to purchase and install energy conservation technologies in Hawaii is much higher than it is for many locations on the mainland and may even vary significantly by island. Almost all equipment must be shipped to Hawaii and shipping costs are related to the cost of fuel. Potential costs can be estimated using sources such as the RSM Means Cost Data handbooks and the California Energy Commission (CEC)'s, Database for Energy Efficient Resources (DEER). It is recommended that these costs should be increased by about 30% (multiply by 1.3 or more) to represent the typical product and labor costs of Hawaii.

4.5. Using a Standardized Approach to Energy Savings Calculations

When the scope of the commissioning project includes estimating the energy savings from energy conservation measures (ECMs) and Cx/RCx procedures, the commissioning authority should follow standard procedures recognized by the Association of Energy Engineers (AEE), American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and Illumination Engineering Society of North America (IESNA). Below is a sample ECM spreadsheet format that might be submitted by the CxA.

Sample Standardized ECM Table

Description of Proposed Energy Conservation Measure (ECM)	Estimated Energy Savings @ 40 cents per kWh		Estimated ECM Cost	Estimated Payback	Related Comments
	(kWh/year)	($/year)	($)	(years)	
ECM 1- Chiller Replacement /Upgrade	57,428	$22,971	$68,363	3.0	Consider working with a performance contractor.
ECM 2 – Replace Dirty Air Filters	7,969	$3,187	$1,000	0.3	Use DAGS personnel
ECM 3- Repair Leaking Supply Air Ductwork	12,610	$5,044	$3,200	0.6	Use Maintenance Contractor
ECM 4-Replace Cooling Tower Media	6,400	$2,560	$8,000	3.1	Use Maintenance Contractor
Total of Proposed ECMs	**118,407**	**$23,682**	**$70,563**		

Note:
The above sample calculations assume an effective electric utility rate of 40 cents per kWh.

In the above sample table, the proposed ECMs should be clearly described along with the potential energy savings, project costs and payback time. Energy savings is the estimated usage reduction of the specific energy source such as kWh/year (electricity), gallons/year (fuel oil) or therms/year (natural gas). The associated energy savings expressed in dollars per year is calculated by simply multiplying the estimated energy

savings by the effective utility rate for the particular energy source at the time of the study. The estimated total ECM project cost is defined in dollars and the estimated payback time (in years) is calculated by dividing the estimated total project dollars by the estimated annual dollars of energy savings for each ECM.

4.6. Low and No-Cost ECMs

It is always prudent to consider what low and no-cost energy conservation measures might be employed as part of an overall effort to increase building energy efficiency. Appendix 5.23 contains a list of energy saving ideas that should be reviewed and considered for potential implementation on typical State of Hawaii buildings.

4.7. Energy and Retro-Commissioning

As stated earlier in this guidebook, it should be clearly understood that in some cases the energy usage of particular building systems could actually increase as a result of the retro-commissioning (RCx) process. This could happen if the equipment is not currently operating in compliance with the buildings design intent. Some common examples of this might include:

- The repair of non-functioning equipment such as chillers, air handlers, pumps and other significant energy using building system components.
- The increased delivery of fresh (outside) air to insure healthy ventilation levels in compliance with ASHRAE 62 standards. Repairs to the fresh air delivery system may actually increase energy usage because of the added energy required to condition that additional air.
- The repair or improvement of lighting systems where additional lighting is provided in inadequately illuminated areas of the building.

However, an experienced and creative commissioning authority should be able to find additional opportunities in the building systems which can help to result in a net energy savings. Energy conservation measures such as Super T8 lighting, de-lamping, premium efficiency motors, improved operating schedules and the use of Energy Star equipment are some examples.

4.8. Retro-Commissioning and Energy Performance Contracts

One of the obstacles often encountered during a retro-commissioning project involves securing funding for the necessary critical repairs and desired system improvements identified. When adequate funding is not readily available from previously appropriated funds, bonds or existing budgets, it may be appropriate to consider other less conventional funding sources. For those repairs and improvements that have a potential for reducing energy usage, energy performance contracts (EPC) may be an effective means to consider.

The EPC is typically provided through an energy services company (ESCO) with specific expertise in both identifying potential energy conservation measures (ECMs) and securing the third-party funding necessary to implement these measures. Appendix 5.24 contains Section 4 of a detailed "Guide to Energy Performance Contracting" that contains information pertinent to the potential application of the EPC process on Hawaii projects.

For comprehensive retro-commissioning projects, it may be desirable to secure the services of a potential ECM provider firm as part of your retro-commissioning team. The expertise of the ESCO can provide your team with additional potential for identifying and justifying energy cost saving measures, and your commissioning authority firm can provide an independent level of expert oversight for the energy performance contract.

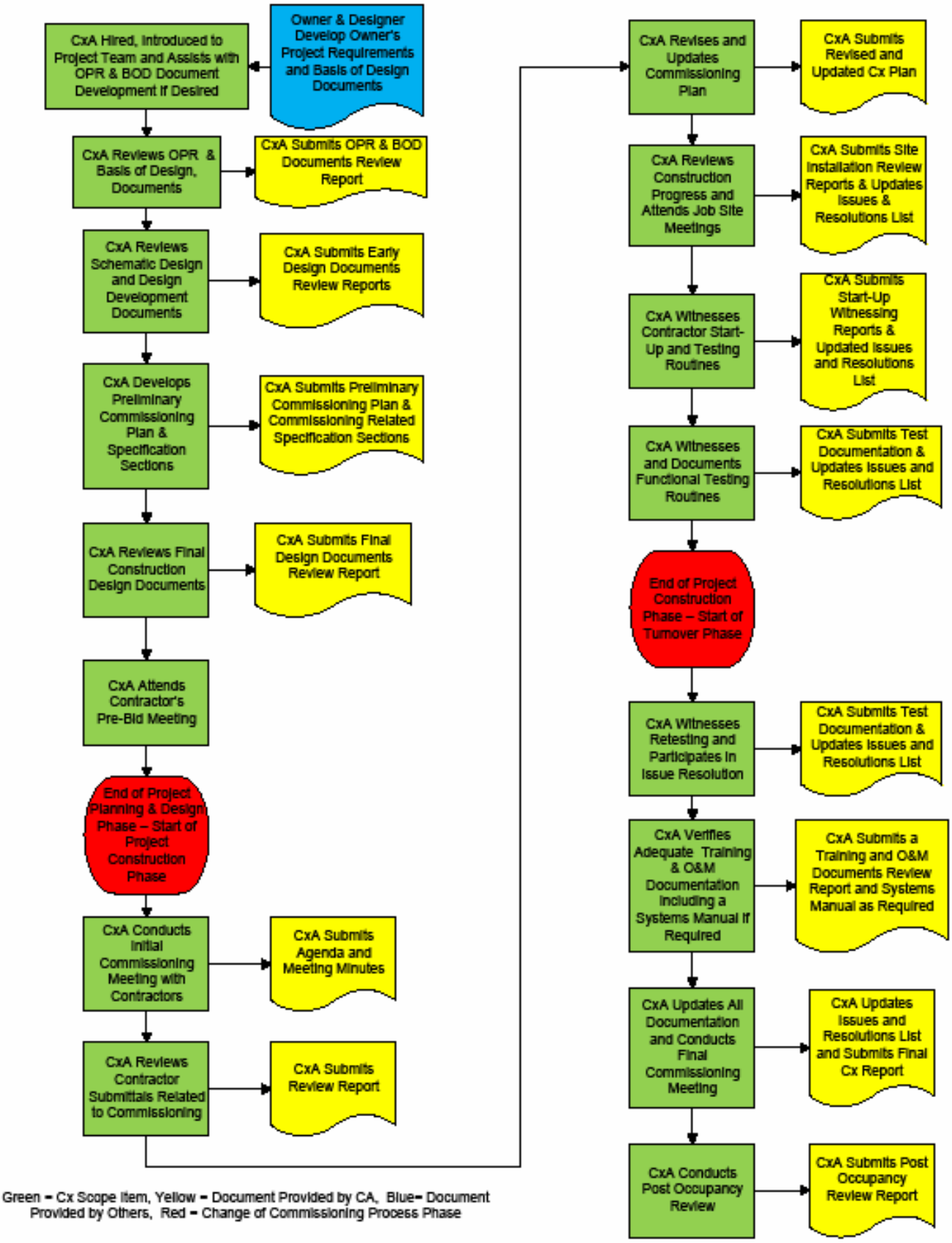
4.9. LEED Commissioning and Retro-Commissioning Requirements

Generally speaking, the scope of work recommended in this guidebook provides a commissioning process believed to be in compliance with the 2008 commissioning requirements for the U.S. Green Buildings Council (USGBC) Leadership in Energy and Environmental Design (LEED) programs for the commissioning of new construction (NC) and the retro-commissioning of existing buildings (EB). In addition, the full scope of work for commissioning new construction projects described in Appendix 5.2 should satisfy both the requirements for the Fundamental Commissioning Prerequisite (EA Prerequisite 1) and the Enhanced Commissioning Credit (EA Credit #3). However, it would be prudent to provide the USGBC a copy of the preliminary project commissioning plan and/or a copy of the actual CxA contracted scope of work, within the required early LEED submittal documents for each LEED project.

For a more detailed description of the LEED commissioning requirements related to both new construction commissioning (NC) and the commissioning of existing buildings (EB), please refer to the detailed process descriptions located in Appendix 5.2, Appendix 5.12 and Appendix 5.16 of this guidebook.

SECTION 5: Appendix Sections

Appendix 5.1 - NEW CONSTRUCTION COMMISSIONING PROCESS FLOW CHART



Green = Cx Scope Item, Yellow = Document Provided by CA, Blue= Document Provided by Others, Red = Change of Commissioning Process Phase

Appendix 5.2: New Construction Commissioning Process Description

Develop Preliminary Commissioning Plan: The preliminary commissioning plan will describe the entire proposed commissioning process and also create the framework for the final commissioning report and record. The submitted plan is typically presented at an initial commissioning introduction meeting with the project team. The plan is then reviewed and approved by the project manager and other commissioning team members. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Review Owner's Project Requirements (OPR) and Basis of Design (BOD) Documents: The success of the entire project depends in large part on the ability to clearly define the client's operational and performance requirements for the equipment and systems scheduled for commissioning. These requirements must be established early in the process and continually referenced. In addition, the commissioning authority (CxA) must review the designer's Basis of Design document to verify it addresses the items identified on the OPR. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Review Design Development Documents (Prior to Mid-Construction Documents): The purpose of this review is to verify compliance with the OPR and BOD, and to identify any issues that may preclude successful commissioning of the systems. The documents are also reviewed for constructability and maintainability issues. A document review letter is created and presented to the design team and project manager. (Required for LEED NC 2.2 EA Credit 3)

Develop Commissioning Specifications: The commissioning-related specification sections are created based on the approved preliminary commissioning plan and the various project design documents. It is important to include these specifications in the "bid set" of project construction documents so that the contractors are aware of their responsibilities related to commissioning when developing their bid. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Review Final Construction Documents: Once the project design "bid set" of documents are completed they are reviewed one final time to ensure that all previously identified commissioning related issues have been resolved.

Pre-Bid Meeting: The specified contractor requirements pertaining to commissioning should be clearly identified to all prospective bidding contractors. In some cases it may be appropriate to ask the CxA to attend the pre-bid meeting to explain the commissioning process and answer relevant questions.

Conduct Initial On-Site Commissioning Coordination Meeting: The commissioning coordination meeting is attended by the project manager, commissioning authority, general contractor, appropriate sub-contractors and appropriate design team members. The purpose of the meeting is to review the specified commissioning process and to identify specific roles and responsibilities. The meeting allows the commissioning team

members to be identified and is used to clarify issues and set a tone of cooperation. Communication modes and the reporting structure are also discussed. The commissioning plan must be updated prior to this meeting.

Review Submittals: Submittals on all commissioned systems are reviewed by the commissioning authority in parallel with the design engineer. Issues specific to each system are identified and documented for resolution. The CxA provides the Design Team with commissioning review comments, which the Design Team integrates with their comments. The Design Team issues a single set of integrated CxA / Design Team review comments to the Contractor. (Required for LEED NC 2.2 EA Credit 3)

Update of Project Commissioning Plan: Based on the final design, addendum and submittal information, the working contractor system readiness checklists and functional testing procedures are added to the commissioning plan.

Develop Installation Verification Documents: Based on the master equipment list, an installation verification checklist is created for every piece of equipment and system scheduled to be commissioned. These checklists are used to help insure that equipment and systems are installed correctly and ready for functional testing. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Conduct Installation Reviews: During construction the CxA will perform periodic site observations in conjunction with scheduled commissioning meetings. The focus of these observations will be to identify issues related to long-term performance and maintenance, and the ability to commission components. Issues are noted on a "Commissioning Issues" log. This list becomes a working and regularly revised document that records the eventual resolution of all issues. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Witness Contractor Start-Up Routines: Typical project specifications often require contractors to complete various documented system start-up routines as part of their specified installation process. The commissioning authority may witness these routines and will receive and approve any specified documentation as submitted by the contractors.

Receive Completed and Signed Contractor System Readiness Forms: Contractor submittal of the signed system readiness forms indicates that the contractor has completed all start-ups and pre-testing to confirm that the systems comply with the functional performance test acceptance criteria. Functional performance demonstrations cannot commence prior to the approval of this submittal and therefore it is important it be tracked as a critical milestone on the project schedule.

Demonstrate Functional Performance: Once the system readiness forms have been received and approved, the functional performance demonstrations may commence. These functional performance demonstrations are completed as specified per the commissioning plan by the responsible contractor and commissioning authority working

as a team. Issues are noted on the issues tracking log. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Re-Testing and Issue Resolution: All issues reported as corrected by the responsible contractor are verified by the CxA prior to being acknowledged as fully resolved. In some cases this may involve a repeat of the initial functional performance demonstration procedures. Issue resolution may also involve working with the members of the design team to develop and implement appropriate changes to design. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Review M&O Manuals: The CxA reviews these documents in parallel with the design team to verify they are in compliance with the specifications and adequate for use by the staff charged with maintaining the facility.

Review Training of Operation Staff: As part of the original document review, specific training requirements will be identified. The CxA will request and review training plans submitted by the contractors and verify that the training is fully provided and appropriate. (Required for LEED NC 2.2 EA Credit 3)

Systems Manual: The CxA develops and submits a systems manual that provides future operating staff the information needed to fully understand and optimally operate the commissioned systems. This manual generally focuses on operating rather than maintaining the equipment. (Required for LEED NC 2.2 EA Credit 3)

Final Report: At the close of the project, a final report based on the commissioning plan is created. This report will contain all previously generated commissioning documentation and a project summary that identifies any unresolved issues and makes further recommendations for action as deemed necessary. This report should be presented to the project commissioning team at a final meeting. (Required for LEED NC 2.2 PR1 and EA Credit 3)

Post Occupancy Activities: During the warranty period, the CxA will schedule and complete a post-occupancy review to verify the sustained operational performance of all commissioned systems. The CxA will submit a report detailing this review and identifying any new or remaining issues. (Required for LEED NC 2.2 EA Credit 3).

Additional LEED NC Requirements:
The project manager should be aware of these LEED NC requirements if the project is attempting to gain any LEED rating:

- The following systems must be commissioned: HVAC and controls, lighting controls, domestic water heating and any renewable energy systems such as wind powered generators, photo-voltaic panels or rain water collection systems.
- The project team must designate a specific individual as the “Commissioning Authority” (CxA).
- The CxA must have documented commissioning experience.

- The CxA must be “independent” of the project design and construction team if the project is larger than 50K SF.
- The project owner must develop the Owner’s Project Requirements (OPR) document.
- The design team must develop the Basis of Design (BOD) documents for all commissioned systems.
- The project contract (bid) documents must include commissioning requirements (commissioning specification sections) for the contractors.

Appendix 5.3: Commissioning Roles for Project Consultants

Project Architect

The following activities are some of the critical commissioning responsibilities of the Project Architect:

- Manage the participation of the AE commissioning representatives in the commissioning process.
- Assist in the development of the Owner's Project Requirements or Design Intent document as required for LEED compliance.
- Review and incorporate commissioning related bid specifications into the project bid documents.

Project System Engineers / Designers and Other Consultants

The following activities are some of the critical commissioning responsibilities of the system designers such as mechanical and electrical design engineers, acoustic consultants and various testing consultants.

- Providing input regarding the design intent and basis of design for all systems scheduled for commissioning.
- Developing and submitting a Basis of Design document that reflects all items as identified on the Owner's Project Requirements or Design Intent document.
- Reviewing proposed commissioning specification sections and coordinating other bid specifications sections with the requirements for commissioning.
- Responding promptly to design review comments as provided by the CxA.
- Responding promptly to potential design related issues as identified during the CxA inspections and the functional testing process.
- Participating in commissioning related meetings as requested and assisting the project commissioning team with the resolution of issues related to system design or specified equipment performance.

Project LEED Consultant

For projects where a consultant has been hired to provide LEED related services, the following are some of the critical commissioning related responsibilities:

- Review the CxA's contract for appropriate scope and qualifications in compliance with specified LEED commissioning related requirements.
- Review the submitted commissioning plan for compliance with specified LEED requirements.

- Review the final commissioning report and record for compliance with specified LEED requirements.
- Verify the appropriate information has been submitted to the USGBC in regards to all required LEED submittals related to commissioning.

Appendix 5.4: Understanding the Owner's Project Requirements (OPR) and Basis of Design (BOD) Documents

It is important to understand the highly significant roles of the Owner's Project Requirements (AKA Design Intent) and Basis of Design documents, especially in regard to the fundamental LEED commissioning requirements. The following paragraphs provide clarification regarding these documents.

- The Owner's Project Requirements (OPR) document describes the Owner's functional, operational and other requirements for the project, including priorities and how successful implementation of these requirements will be determined (the success criteria). This document embodies the criteria by which the success of the project will be judged relative to meeting the Owner's needs.
- The design team develops the Basis of Design Documentation (BOD) from the OPR. The Basis of Design Documentation is an opportunity for the design team to verify their understanding of the OPR and describe how they intend to satisfy the OPR requirements with the design. The BOD Document may record the concepts, design assumptions, important calculations, decisions, product selections, and rationale used to satisfy the Owner's Project Requirements (OPR), regulatory requirements, and industry standards and guidelines. It also may describe basic operating concepts and principles, and the interaction between systems.

The following descriptions can be found within in the LEED Reference Package and ASHRAE Guideline 1.

Owner's Project Requirements

ASHRAE: "Detailed explanation of ideas, concepts and criteria defined by the owner to be important."

LEED: "These requirements typically address HVAC, lighting, indoor environment, energy efficiency... Any criteria listed in the OPR needs to be measurable, documentable and verifiable.

Basis of Design

ASHRAE: "all information necessary to accomplish the design intent, including weather data, interior environmental criteria, other pertinent design assumptions, cost goals, and references to applicable codes, standards, regulations and guidelines."

LEED: adds, "occupancy, space, and process assumptions," and states that "an updated version of the basis of design narrative should accompany each design phase submission."

As a part of the LEED commissioning review requirements, the Commissioning Authority is obligated to verify that the documents address each of the items specifically mentioned in these guidelines, and that the design submittals are consistent with the OPR and BOD document content.

NOTE: The following is provided as a sample format that might be used to create a combination Design Intent (Owner's Project Requirements) and Basis of Design Document:

OPR Description:	Owner desires M&O access to be provided to rooftop HVAC units to avoid the use of ladders from the ground.
OPR Success Criteria:	Safe and reasonable roof access provided from within interior of building.
BOD Response:	Folding stairs and a roof access hatch will be specified to be provided in Room 214.

OPR Description:	Owner desires HVAC system to control interior temperatures during occupied time and provide for night setbacks during unoccupied times.
OPR Success Criteria:	+ or – 1 degree control in space during occupied mode. Ability to automatically change heating and cooling setpoints during unoccupied mode.
BOD Response:	HVAC control system designed to control space + or – 1 degree from setpoint during occupied modes. System also provided with programmable night setback thermostats for different control points during unoccupied mode.

OPR Description:	Owner desires adequate ventilation without waste of energy.
OPR Success Criteria:	Maintain interior space CO2 levels below a maximum of 1000 PPM during occupancy.
BOD Response:	CO2 sensors will be provided in HVAC return air ducts to allow for automatic modulation of outside minimum air damper position in response to CO2 levels in the occupied space.

OPR Description:	Owner desires a central control point to shut off all unnecessary (non-emergency) lighting during the unoccupied mode.
OPR Success Criteria:	Occupants will have one point (near a common exit) to shut off all non- emergency lighting when leaving building.
BOD Response:	Lighting control system will provide for a central control to allow all non-emergency lighting to be shut off at one control point.

Appendix 5.5: Sample RFQ for a Commissioning Authority on New Construction Projects

Note: Items capitalized and in parenthesis must be edited for the specific project.

(OWNER) is requesting qualification submittals from firms with experience in providing building systems commissioning services. The proposed project is a (SIZE) square foot (DESCRIBE TYPE OF BUILDING) located at (DESCRIBE LOCATION). Construction bid documents are expected to be completed by (DATE) and construction started by (DATE), with a final occupancy scheduled for (DATE). The following building systems are currently being considered for commissioning:

(LIST THE ACTUAL BUILDING SYSTEMS BEING CONSIDERED FOR COMMISSIONING). (Note: LEED requires commissioning of all HVAC related systems, lighting control systems and domestic hot water systems at a minimum).

The scope of work for the Commissioning Authority shall be compliant with LEED N.C. 2.2 related fundamental commissioning requirements at a minimum, and may include the following:

1. Attend an initial meeting with the owner to review the potential commissioning scope and assist the owner with developing a final desired work scope and associated fee schedule.
2. Review and provide written comments regarding commissioning related issues within the owner's project requirements, basis of design, proposed project plans and specifications, throughout the construction document design phase of this project.
3. Develop and provide an appropriate commissioning plan and specification sections for submittal to the project team and inclusion into the construction bid documents.
4. Meet with the project owner, design team, general contractor and appropriate sub-contractors to verify individual roles and responsibilities for completing the commissioning process as specified in the commissioning plan/specifications.
5. Monitor construction progress and meet with the project team on a regular basis to help coordinate commissioning related procedures and assist with the integration of the commissioning process into the contractor's schedule.
6. Review equipment submittals for commissioning-related issues.
7. Verify all specified contractor start-up and testing procedures have been completed and documented. Secure all specified start-up and testing documentation for inclusion in the final commissioning report.
8. Develop system readiness checklists to be completed by the contractors and verify all related construction for completeness, workmanship and compliance to
9. the design specifications. Document all issues and note the party responsible for resolution.

10. Develop functional testing procedures for all systems and equipment scheduled for commissioning. Witness and document functional performance demonstration procedures. Verify and approve functional performance of specified systems in all operational modes and through every potential sequence of operation. Document all issues and note the party responsible for resolution.
11. Identify, document and track the status of all commissioning-related issues through final resolution. Attend job site meetings as required to communicate the status of issues. Verify the appropriate resolution of outstanding issues.
12. Verify specified training has been provided to the owner.
13. Verify specified operations and maintenance materials are complete and delivered to the owner.
14. Develop and provide a "Systems Manual" for each system scheduled for commissioning. This manual shall be compliant with the requirements as defined in the LEED N.C. version 2.2 Reference Guide.
15. Document all commissioning procedures and submit a final comprehensive report and record to the owner upon completion.
16. Review and report regarding the sustained performance of all commissioned systems at a point approximately six to eight months into full occupancy.

The successful firm will demonstrate expertise in the ability to coordinate and work effectively with subcontractors, design consultants and the owner's representatives. An extensive background in reviewing control strategy, developing system functional performance tests, TAB expertise, and troubleshooting operational problems is a mandatory requirement.

The Commissioning Authority shall be an independent company, not financially or otherwise contractually associated with any member of the design team or contractors on this project. The selected firm must agree to adhere to commissioning standards as set forth by an organization such as the Building Commissioning Association (BCA).

The qualifications submittal should contain only the following requested information presented in seven (7) separated and tabbed sections:

1. Include a brief history and general overview of the company. Provide a descriptive list of specific commissioning related expertise and services currently available from your company. Identify the percentage of your firm's work associated with commissioning.
2. Demonstrate a familiarity and experience with conducting formal commissioning procedures as endorsed by the Building Commissioning Association (BCA), ASHRAE, and other similar professional organizations. Specifically list and describe the goals and objectives you believe are most important to achieve through the commissioning process on new construction projects.
3. Provide the professional resumes and associated fee schedules for personnel that may be assigned to this project.
4. Define your proposed commissioning project management approach and provide a proposed commissioning procedural outline or flowchart for a typical commissioning

project. Include the specific proposed work-scope for each project participant from your firm or from supporting (sub-consultant) firms.

5. Describe your firm's commissioning experience during the past five years on projects of similar size, similar use and with similar building systems. Specifically identify LEED related project experience. Provide professional and commissioning related project references and letters of recommendation if available.
6. Provide a sample scope of work and associated fee schedule for a recent commissioning project where your company was contracted to provide services as the commissioning authority within the past two years. Define the size, type of building, and systems commissioned. Remove all references to the actual client and project names.
7. Provide samples of commissioning specifications, functional testing procedures, issue logs, and other commissioning-related documentation used by your firm on previous projects. Note: Firms selected for further consideration may be requested to provide additional commissioning-related documentation as produced by the firm during previous commissioning projects.

Submittals must be addressed to (OWNER'S NAME AND ADDRESS). (NUMBER OF COPIES DESIRED) copies of this submittal must be hand delivered or otherwise received by (OWNER'S NAME) prior to the closing date of: (DATE / TIME) to the address noted above. An interview and / or selection will occur within (NUMBER OF WEEKS) weeks following the closing date. The final scope of work, deliverable details and associated fees shall be negotiated with the firm determined to be most appropriate for this project. Questions regarding this request for qualifications should be emailed to: (EMAIL ADDRESS) no later than five (5) working days before the date and time for submittal delivery noted above. Responses to questions will be distributed to all email addresses.

Appendix 5.6: Sample New Construction Commissioning Scope of Work and Fee Estimating Worksheet

Proposed Scope of Work:

The building systems to be commissioned under this proposal include the systems and services listed below.

- HVAC Systems Equipment
- HVAC Systems Controls
- HVAC Related Air and Water Systems Balancing (Verification of TAB procedures).
- Interior Lighting Controls
- Domestic Hot Water System

Services, Procedures, and Deliverable Products:

The work as provided by the commissioning authority (CxA) under this contract shall include the following services, procedures, and deliverable products:

1. Upon receipt of a signed contract for providing commissioning services, the CxA shall attend an initial meeting with the project team to review the CxA contracted scope of work, discuss the commissioning related roles and responsibilities of the current project team and answer questions related to the proposed commissioning process.

2. The CxA shall review the owner's project requirements (OPR) and AE's basis of design (BOD) documents as provided. CxA review comments will be submitted in a written report to the project team through the project manager.

3. The CxA shall review the construction schematic design and design development documents (plans and specifications) at approximately the 50% design completion point. CxA review comments will be submitted in a written report to the project team through the project manager.

4. The CxA shall develop and provide all commissioning related specification sections to the project architect for inclusion in the final project contract documents. These specifications shall clearly define the contractor's role and responsibilities related to the entire commissioning process.

5. The CxA shall develop and submit a commissioning process management plan. At a minimum, this plan shall include the following sections and topics:

    - Project Description

- Actual Contracted Scope of Commissioning Services and Deliverable Products
- List of Systems and Equipment to be Commissioned
- Tentative Commissioning Schedule Including Major Milestones
- List of Commissioning Goals
- The Commissioning Team Member List and Description of Roles
- Owner's Project Requirements and Basis of Design Documents
- Commissioning Related Specification Sections
- Description of Proposed Planning and Design Phase Commissioning Activities
- Description of Proposed Construction Phase Commissioning Activities
- Description of Proposed Post Construction, System Acceptance and Turnover Phase Commissioning Activities
- Description of Proposed Post Occupancy Phase Commissioning Activities
- Description of the Proposed Final Commissioning Report and Record
- A Signature Section (for all commissioning team members to provide final approval for the initial commissioning plan).

The CxA shall schedule and conduct an initial commissioning plan review meeting with the intent of presenting and describing the proposed plan to all project team members and to gain consensus and written approval on the proposed commissioning approach. Minutes of this meeting will be documented by the CxA.

6. The CxA shall review the final (bid set) of construction design documents. CxA review comments will be submitted in a written report to the project team through the project manager.

7. The CxA shall prepare for and attend the contractor's pre-bid meeting to provide an overview of the proposed commissioning process, identify the commissioning related specification sections and answer related questions.

8. Once the bid awards have been completed and the contractors are mobilized, the CxA shall schedule, organize and coordinate an initial commissioning coordination meeting with the contractors to present the more fully developed commissioning plan, and discuss issues related to the proposed commissioning process. A meeting agenda and minutes shall be provided by the CxA and submitted to the project manager.

9. The CxA shall review and report on all contractor-provided equipment, system and service submittals related to systems scheduled for commissioning. The CxA shall schedule and conduct a control system coordination meeting with the appropriate contractors and design team members to fully review all proposed operating sequences as reflected in the control system submittal. A meeting agenda and minutes shall be provided by the CxA and submitted to the project manager.

10. Once the submittal review is complete and the control system coordination issues are resolved, the CxA shall revise and update the commissioning plan to
11. include the actual contractor system readiness checklists and proposed functional testing documentation. The revised and updated commissioning plan shall then be submitted to the project commissioning team (through the project manager) for review and approval.

12. Starting with the installation of mechanical and electrical work, the CxA shall conduct four (4) site installation reviews with the purpose of identifying issues related to workmanship and compliance with the design intent. Site visit reports will be provided to the project team through the project manager. At the completion of all contractor installation procedures, the CxA shall be responsible for performing and documenting a final installation review and for verifying that the equipment and systems designated for commissioning are completely installed and ready for functional performance testing. All issues discovered during this process shall be documented and assigned for future resolution. Documentation of this final installation review shall be provided within the final commissioning report.

13. The CxA shall be responsible for verifying the completion of system start-up and testing routines as specified to be performed by the appropriate contractors, and all functional performance testing and demonstrations as detailed in the commissioning plan. The commissioning specifications as provided by the CxA shall clearly define the contractor requirements related to start-ups, functional performance testing and demonstrations. The CxA will develop functional testing procedures and actively participate in the completion of functional performance demonstrations. The CxA shall also participate in any necessary retesting and will be expected to provide constructive input during the issue resolution process. All issues discovered during these functional performance demonstrations will be logged and tracked by the CxA until resolved.

14. The CxA shall review all provided O&M documentation for compliance with the contract specifications. The CxA shall review and witness all training for compliance with the contract specifications. CxA review comments will be submitted in a written report to the project team through the project manager.

15. In compliance with the requirements for the LEED-NC EA Credit #3, the CxA shall develop and submit a systems manual for all commissioned equipment and systems.

16. At the completion of the startup and functional performance demonstration phase, the CxA shall be responsible for assembling and producing the final commissioning report and record. The report shall contain at a minimum the following:

- An executive overview description of the commissioning process as actually executed.
- The current status of any critical unresolved issues.
- Recommendations for further actions related to the commissioning process.

The commissioning record shall contain at a minimum the following:

- All previously completed and updated commissioning plan documentation.
- Copies of all completed data entry forms related to installation verification checklists, start-up checklists, and functional performance tests.
- A final version of the commissioning issues list showing the current resolution status of all issues, including the status of those issues still outstanding.

17. At a point approximately 6-10 months after acceptance and occupancy of the building, the CxA shall schedule and conduct a post-occupancy review of all building systems previously commissioned to verify sustained operational compliance with the design intent and owner's operational needs. CxA review comments will be submitted in a written report to the project team through the project manager.

Sample

New Construction Commissioning Cost Estimating Worksheet

Note: This worksheet automatically calculates and includes the travel-related expenses within each proposed scope item fee.

Item	Description	Qty	Units	Rate	Trips	Nites	Fee
1	Prepare for and attend an initial meeting with the project team to review proposed CxA scope.	12	Hrs	115	1	1	2,340
2	Review OPR, BOD documents.	16	Hrs	115			1,840
3	Review 50% construction design documents.	32	Hrs	115			3,680
4	Develop and submit Cx specification sections.	12	Hrs	115			1,380
5	Develop and submit initial Cx plan. Prepare for and attend meeting to present and discuss plan.	32	Hrs	115	1	1	4,640
6	Review final set of construction design docs.	16	Hrs	115			1,840
7	Prepare for and attend pre-bid meeting.	16	Hrs	115	1	1	2,800
8	Prepare for and attend intial contractors mtg.	16	Hrs	115	1	1	2,800
9	Review submittals. Conduct controls coord mtg.	60	Hrs	115	1	1	7,860
10	Develop and submit revised and updated Cx plan including final SR & FT docs.	60	Hrs	115			6,900
11	Perform 4 construction site visits and a final installation verification of commissioned systems. Document and report all issues.	40	Hrs	115	5	5	9,400
12	Witness start-ups and functional performance tests. Document and report all issues.	120	Hrs	115	3	12	18,030
13	Review O&M documents & witness training.	24	Hrs	115	1	1	3,720
14	Develop and submit LEED Systems Manual.	24	Hrs	115			2,760
15	Compile Commissioning Record. Revise and submit final Commissioning Report.	24	Hrs	115			2,760
16	Conduct post-occupancy review. Submit report.	24	Hrs	115	1	1	3,720
	Estimated Total Trips and Nights:				15	24	
	Estimated Round Trip Travel Time per Site Trip:	4					
	Estimated Related Expenses per RT Site Trip:	350					
	Estimated Related Expenses Per Night Stay:	150					
	Total Proposed Fee:						**$76,470**
	Travel Expense Budget (included in total fee)						8,850

Appendix 5.7: SAMPLE: Document Review Format

Note: A format similar to this might be used by the Commissioning Authority for the review of various construction related documents including the Owners Project Requirements, Basis of Design, Plans, Specifications, Equipment Submittals, O&M documents, TAB Report and others.

Project: Big State Building Project

Report Date: June 9, 2009

Reviewer(s): Jill Johnson, Keithly Barber Associates (KBA)

Documents Reviewed:

- Drawings – DD/GMP set, dated June 15, 2009
- Specifications – DD/GMP set, dated June 15, 2009

Systems within the commissioning scope of work:

- HVAC
- Lighting Controls

The following observations and comments are provided by the Commissioning Authority as a result of reviewing the above listed documents. This review is primarily intended to identify items that relate to the commissioning scope of work. These comments are made as observations and suggestions only and do not represent direction for change unless approved by the designer and/or client and made part of the final project bid documents or addendum.

When responding to these comments please reference the comment number (CN) or edit responses directly into this document after "*Designer's Response*:" below. Please include your initials and a date with each entry.

CN	PLAN / SPEC REF.	REVIEW COMMENTS
1	Plan M-01	Equipment schedule for air handlers does not include design CFM.
Designer's Response: 10/20/09: Will be corrected in next version. BDB		
2	Plan M-05	Drawing does not indicate the proposed room thermostat location for VAV-7.
Designer's Response: 10/20/09: Will be corrected in next version. BDB		
3	Plan M-07	Piping schematic for B-1 does not indicate the location of specified three-way valve.
Designer's Response: 10/20/09: Will be corrected in next version. BDB		
4	Spec. 15990, 1.01	Specification does not describe the desired sequence of operation for B-1.
Designer's Response: 10/20/09: Will be corrected in next version. BDB		
5	Spec. 15995, 2.07	Specification does not require any certification for the balancing agency.
Designer's Response: 10/20/09: Will be corrected in next version. BDB		

Appendix 5.8: Sample Division 1 Commissioning Specification

SECTION 01810

GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Commissioning is a quality-assurance process designed to verify and document that the design, installation and performance of designated building systems meet the Owner's requirements and satisfy specified criteria as defined by the project contract documents. The formal commissioning process is performed in addition to the quality control inspections and testing normally provided as part of the Contractor's specified contract requirements and typical industry standards regarding reasonable and expected levels of workmanship and performance. Commissioning includes the completion of formal reviews, inspections and functional performance testing procedures performed on the equipment and systems listed within the Commissioning Scope of Work, as specified under 1.3 below. The entire commissioning process is completed by a project Commissioning Team (including Contractors) under the direction of a Commissioning Authority (CxA) and the Contractor's Commissioning Coordinator (CCC). The CxA is an independent firm under a separate consultant contract directly with the Owner, and is not contractually or financially associated with the design team or any contractor performing work on this project. The Commissioning Authority for this project is Keithly Barber Associates, Inc. (206.835.8254). As a member of the Commissioning Team, the Contractor shall be required to actively participate in various portions of the commissioning process as detailed below and within other sections of the contract documents.

B. Commissioning Standards: The commissioning process shall be in accordance with:
   1. All sections of the Contract Documents
   2. The Building Commissioning Association's (BCA) "Essential Attributes of Building Commissioning" (1999 Version)
   3. ASHRAE Guideline 0-2005
   4. USGBC LEED V2.2

C. Contractor's Work Scope: The Contractor is responsible for completion of specified commissioning work within the contract documents. The Contractor's responsibilities include:

1. The General Contractor shall provide a Contractor's Commissioning Coordinator (CCC), as defined under Definition of Terms (1.5, Q) of this section. The CCC is responsible for managing the completion of the Contractor's commissioning work as specified within the project contract documents.
2. The Contractor shall be responsible for providing material, equipment, and labor to participate in the specified commissioning process. The Contractor will assure the participation and co-operation of sub-contractors under their jurisdiction, as required to complete the commissioning process.
3. The Contractor shall support the commissioning process by integrating it into the construction process and schedule.
4. The Contractor shall submit the manufacturer's installation and startup manuals as a part of the initial equipment submittals.
5. The Contractor shall submit the manufacturer's operating and maintenance manuals as a part of the initial equipment submittals.
6. The Contractor shall review and approve the final functional test procedures as included in the commissioning plan in advance of actual functional testing.
7. The Contractor shall complete the system readiness checklists as provided by the CxA prior to the start of functional testing. The Contractor shall be required to verify by a signature that all installation and start-up requirements have been completed and the systems and equipment scheduled for commissioning are ready and capable of successfully completing all functional performance testing procedures as defined by the commissioning plan.
8. The Contractor shall provide qualified personnel to perform functional performance testing and demonstrations as specified in the contract documents and detailed within the commissioning plan.
9. As part of the LEED requirements for this project, the Contractor shall be required to participate in a post-occupancy performance review of the commissioned building systems. This review will be conducted by the Commissioning Authority and Building Owner at a point in time approximately 10 months into the one year warranty period.

1.2 RELATED SECTIONS

A. 15995 – MECHANICAL SYSTEMS COMMISSIONING

B. 16995 – ELECTRICAL SYSTEMS COMMISSIONING

C. All project specifications related to the "Systems Within The Commissioning Scope Of Work"

1.3 SYSTEMS WITHIN THE COMMISSIONING SCOPE OF WORK

A. Heating, Ventilating and Air Conditioning (HVAC) Systems

B. Building Energy Management and Control System

C. Test and Balance Verification

D. Interior Lighting/Daylighting Controls:

1.4 SUBMITTALS

A. Contractor shall provide the following submittals in accordance with the general submittal requirements specified elsewhere and in Division 1.
   1. Manufacturer's recommended installation and start-up procedures for systems and equipment within the commissioning scope of work. Contractor shall provide these documents as part of the initial equipment submittal.
   2. Equipment operation and maintenance manuals as required in the specifications for systems and equipment within the commissioning scope of work. Contractor shall provide these documents as part of the initial equipment submittals.
   3. Completed and signed contractor's systems readiness checklists for all building systems scheduled for commissioning. Contractor shall provide these completed forms once all specified installation and start-up requirements are complete and the building systems have been verified by the Contractor to be capable of performing in compliance with the functional requirements as defined by the functional performance testing acceptance criteria.

1.5 DEFINITION OF TERMS

A. Contractor: For the purposes of this specification section, the term Contractor refers to the entity (including sub-contractors) contractually responsible for completion of all requirements in compliance with the project contract documents, including all specifications, plans and addendum.

B. Acceptance Criteria: Acceptance of the systems is based on the Contractor being able to demonstrate that the systems and their components function in accordance with the commissioning acceptance criteria.
   1. Installation and static testing acceptance criteria: The acceptance criteria for installation and static testing are the materials and methods requirements specified in the contract documents.
   2. Functional testing acceptance criteria: The acceptance criteria for functional performance tests are described within the functional testing procedures. The functional performance test procedures include

descriptions of system's and component's responses that are to be verified. These are the functional testing acceptance criteria. The functional testing acceptance criteria are based on the project documents and the basis of design.

C. The Commissioning Plan is a detailed document prepared and maintained by the CxA that describes the entire commissioning process.

D. Contractor's System Readiness Checklist: These checklists are provided by the CxA and include equipment installation and start-up requirements specified to be performed and verified by the Contractor. These checklists shall be completed by the Contractor and returned to the CxA prior to the final installation verification and functional performance demonstration process.

E. CxA Final Installation Verification Process: This process includes the on-site review of related system components for conformance to the project documents. The CxA will conduct this review and verify system readiness for final functional testing procedures upon receipt of the Contractor completed Contractor's System Readiness Checklists. The CxA shall document issues identified during this process and assign them to the appropriate party for resolution.

F. Functional Performance Testing (FPT) Process: Functional performance testing verifies that the systems perform in accordance with the project documents, the owner's design intent, and the A/E's basis of design. The process includes the documented testing of the systems under actual and simulated operating conditions. FPT procedures are detailed instructions that allow experienced system technicians to perform the FPT with repeatable results. The repeatability of the procedures and results validate the tests. Final performance testing of systems will begin only after the Contractor certifies that systems are 100% complete and ready for functional testing, and the CxA has completed the subsequent installation verification process for the systems to be tested.

G. Commissioning Issues Log: All issues raised during commissioning shall be logged and tracked until they have been resolved. A commissioning issues log shall be maintained by the CxA. The issues log includes the description of all issues discovered as a result of the commissioning process. The list also includes the current issues status, assignment to the responsible party and the date of final resolution as confirmed by the CxA. Items listed may include issues where design, products, execution or performance does not appear to satisfy the project contract documents and/or the design intent. The resolution of issues identified on this list may be the responsibility of the Contractor, Design Team, or the Owner.

H. Back-Checking: Back-Checking is the process of verifying that commissioning related issues have been resolved by the responsible party. The back-

checking process takes place once the Contractor has provided written notification that installation is complete, a system is ready for functional performance demonstration, or an issue or issues in the commissioning issues log have been resolved.

I. Performance Period: The performance period is a set length of time designated to demonstrate proper facility operation prior to acceptance. The performance period commences after successful completion of other functional testing. Performance data is typically collected via DDC system trend logging or data logging. Evaluation typically includes zone temperature stability, optimum start/stop, warm-up period and other related functions. As part of this process the contractor will be required to set up and provide trends of control system parameters per the direction of the CxA. The performance period trend logs will be specified in the functional performance test procedures.

J. Seasonal or Deferred Testing: This testing is completed during conditions that do not occur during the initial functional testing period; for example during design or seasonal transition temperatures. Seasonal or deferred functional performance tests are a limited sub-set of the original tests and are designed to evaluate capacity and systems' interaction.

K. Final Commissioning Report: The Final Commissioning Report contains a summary description of the commissioning process as it occurred and an updated version of the Commissioning Issues Log listing the current status of all resolved and un-resolved issues. The Final Commissioning Report shall be prepared by the Commissioning Authority.

L. Final Commissioning Record: The Final Commissioning Record refers to the collection of all relevent commissioning documentation as produced during the commissioning process.

M. Project Contract Documents: All approved project plans, specifications and addendum, and as defined elsewhere in Division 1.

N. Initial Commissioning Coordination Meeting: This meeting is intended to present the commissioning plan to the Contractor and is typically scheduled to occur after bid award and prior to installation of commissioned systems.

O. The Commissioning Team: Commissioning is performed by the Commissioning Team, which consists of the Owner, Commissioning Authority, the Contractor's Commissioning Coordinator, the Design Team, all subcontractors performing work on the equipment and systems within the commissioning scope of work, and all materials and equipment suppliers supplying equipment and systems within the commissioning scope of work. The Commissioning Team is lead by the Commissioning Authority. The Contractor's Commissioning Coordinator is the on-site manager of the commissioning process.

P. Commissioning Authority (CxA): The CxA is the Owner's commissioning consultant and the leader of the Commissioning Team. The CxA oversees the commissioning process and advises the owner on commissioning issues, emphasizing the long-term performance and maintainability of the systems included in the commissioning scope of work. The CxA is required to advise the owner of issues involving the design, construction, testing, adjusting and balancing, or other issues that would compromise the ability of the facility to meet the needs of the owner. The CxA is authorized to recommend to the owner the acceptance, modification, or rejection of all materials, procedures, schedules, tests, reports, or other required commissioning submittals. The CxA is not authorized to change existing contract documents, schedules, costs, or scope of work for any of the parties involved (architect or contractor).

Q. Contractor's Commissioning Coordinator (CCC): The General Contractor shall provide a Commissioning Coordinator. The CxA and the CCC comprise a commissioning management team. While the CxA leads the overall commissioning process, the CCC is responsible for managing contractors in their day to day performance of the specified commissioning work. The CCC shall be a designated agent or employee of the General Contractor who is regularly and frequently on site. Required qualifications for the Contractor's Commissioning Coordinator include relevant process management experience and excellent abilities to schedule, coordinate, and manage mechanical and electrical subcontractors. The following tasks are included in the CCC's scope of work:
    1. Integrate the specified commissioning activities into an overall construction schedule, update the schedule, and provide two-week look-ahead schedules showing the upcoming commissioning related activities.
    2. Review and provide all required Contractor commissioning submittals to the CxA.
    3. Coordinate owner training and ensure that training is provided in accordance with the contract specifications.
    4. Ensure that appropriate subcontractors and equipment suppliers review and provide written approval for all proposed functional test procedures as provided by the CxA. This includes providing written comments regarding issues from all required FPT participants pertaining to safety, equipment protection, warranty and appropriateness of the test procedure for the systems as provided.
    5. Submit completed test reports and progress reports in accordance with the specified requirements of the project contract documents.
    6. Manage the contractor's participation in the functional performance testing and demonstration process as specified in the commissioning specifications.
    7. Manage the contractor's participation in the resolution of issues identified during the commissioning process.
    8. Ensure that subcontractors perform preliminary testing to verify readiness for final FPT demonstrations; submit documented verification that systems

will pass FPTs with acceptable results as documented in the FPTs; and coordinate the FPT demonstrations to Owner and CxA.

9. Coordinate repeats of FPTs that fail due to contractor deficiencies until acceptable results are achieved.

1.6 RIGOR OF FUNCTIONAL PERFORMANCE TESTING

A. The Contractor shall be duly advised that the rigor of the functional performance testing procedures may include demonstration of any and all specified operational performance criteria as defined by the project contract documents and commissioning plan. The Commissioning Authority shall maintain sole discretion regarding the functional performance demonstration process and those performance criteria deemed to be appropriate for functional demonstrations by the Contractor. The approximate rigor of a typical functional performance test may be estimated by review of the sample functional testing procedure document found at the end of this section. The Contractor shall be advised to budget sufficient time to adequately verify and demonstrate that all installed equipment and systems will perform in compliance with the specified project contract document requirements.

1.7 BACK-CHARGING

A. The Contractor is responsible for scheduling, coordinating, preparing for and participating in various commissioning activities. The Contractor shall reimburse the owner for the cost of commissioning activities that must be repeated because of a lack of preparation or coordination by the Contractor. Reimbursable costs include CxA fees for services billed at the CxA's standard hourly rate of $105.00/Hour, mileage billed at the current IRS rate, and the cost of any rented test equipment. A $200.00 per diem rate shall be assessed to meet travel, meals, and lodging needs.

1. Commissioning issues identified by the CxA during on-going construction site inspections will be documented in the Commissioning Issues Log. The Contractor shall submit a brief written statement of when and how each issue has been resolved, using issues response forms provided by the CxA. The CxA shall back-check these issues on a one-time-per-issue basis to verify they have been resolved. If the back-checked issues have not been resolved as reported, the associated cost of the unsuccessful back-check shall be subject to back-charging.
2. Repeated installation verification: After the Contractor has submitted the completed system readiness checklists, the CxA will perform final installation verifications on selected systems. Discrepancies discovered will be reported in the commissioning issues log. The cost of inspections that do not demonstrate specified acceptance criteria shall be subject to back-charging.

3. Repeated witnessing of FPT demonstrations: As specified in this section, the Contractor shall demonstrate the functional performance tests to the CxA after they have verified that performing the FPTs will yield the documented acceptable results. The cost of CxA witnessing demonstrations that do not demonstrate specified acceptance criteria shall be subject to back-charging.
4. Excessive contractor coordination by the CxA made necessary due to lack of Contractor scheduling, shall be subject to back-charging.
5. Cancelled functional tests or appointments due to the Contractor's lack of preparation or lack of communication, shall be subject to back-charging.

1.8 COMMISSIONING MEETINGS

A. Commissioning meetings provide an opportunity for direct coordination and prompt resolution of commissioning issues. The CCC coordinates the meetings; the CxA chairs and provides notes for these meetings. Participants include the CCC, CxA, Owner, Design Team, Test and Balancing Agency, the Contractors, and key Subcontractors and Equipment Suppliers as needed. Commissioning meetings shall be held in accordance with the following requirements
   1. Commissioning meetings shall be held on an as needed basis until startup and / or functional testing of major equipment begins. The CCC, the Owner, CxA, and all Subcontractors listed as members of the Commissioning Team shall attend these meetings. The attendance of other commissioning team members may be required if necessary to efficiently address the meeting's agenda.
   2. While startup and functional testing are occurring, weekly commissioning meetings shall be held at a regularly scheduled time. The CCC, CxA, Owner, and Subcontractors responsible for installing the system(s) shall attend these meetings. The Design Team members responsible for the design of these systems shall be available by phone. The attendance of other commissioning team members may be required if necessary to efficiently address the meeting's agenda.
   3. Commissioning Site Observations: The Commissioning Authority will perform periodic site observations. Reports will be submitted to the Owner's Representative and the CCC. Copies will be simultaneously distributed to the rest of the commissioning team. Issues identified during the site observations will be logged in the master commissioning issues log

1.9 COMMISSIONING ISSUES LOGGING AND TRACKING

A. Issues identified during the commissioning process, including site observations, final installation verification and functional testing demonstrations, will be logged in the commissioning issues log. The CxA will maintain and distribute revisions

of the master log. For each issue, the CxA will make a recommendation regarding responsibility for resolution of the issue, based on the CxA's best judgment at that time. The Contractor is responsible for reporting to the CxA regarding all issues they feel have been inappropriately assigned for resolution.

B. Each issue in the list will be classified with a "status" of either "*Resolved",* "*Unresolved"* or "*Resolved-Unverified"*. *Resolved* issues are closed – having either been addressed by the contractor and verified as corrected by the CxA, or accepted by the owner. *Resolved–Unverified* issues have been reported as resolved by the contractor, but are not yet verified by the CxA as resolved. *Unresolved* issues have not been reported as addressed by the contractor. Updated unresolved issues lists will be distributed to the Cx team in MS Word format.

C. Materials and methods issues discovered during commissioning that pertain to A/E construction review will be transferred to the Design Team for tracking through resolution. When the design team reports the issue resolved, the CxA will classify the issue as resolved, without back-checking.

D. It is the Contractor's Commissioning Coordinator's responsibility to manage the resolution of all issues assigned to the Contractors, including the determination of how the issue will be resolved and who will do the work.

E. When a commissioning issue is resolved the Contractor shall submit a written response describing when and how the issue is resolved. The CxA or the A/E shall then back-check the issue to verify completion.

1.10 TEST INSTRUMENTATION

A. The contractor shall provide test equipment as necessary to demonstrate system performance.

B. The test equipment shall be provided in sufficient quantities to execute functional testing in an expedient fashion.

C. The test equipment shall be suitable for testing and calibration with accuracy and tolerances necessary to demonstrate that system performance is in accordance with the basis of design.

D. Equipment used for functional testing of sensors and gages shall be certified to an accuracy of 10% of the smallest tolerance to be measured. For example, if a temperature gage is required to be accurate within $\pm$2 degrees F, the calibration device must have a minimum accuracy of $\pm$0.2 degrees F.

E. Instrumentation used for functional testing system performance must have a minimum repeatability and accuracy of ± 1.0% of the acceptance criteria being

measured. For example: if a supply temperature of 50F is being verified, the repeatability and accuracy of the test instrument must be at least ± 0.5F.

F. The test equipment shall have calibration certification per equipment manufacturer's interval level or within one year if not specified.

1.11 DOCUMENTATION

A. All checklists, start-up documentation, test forms and other commissioning related documentation required by contract shall be neatly completed and submitted to the CxA in a clear and easily readable condition.

B. All required checklists, start-up documentation, test forms and other commissioning related documentation shall be submitted to the CxA in accordance with the commissioning and construction schedule.

C. When the Contractor is unable to comply with an item as listed on the checklist or form, the Contractor shall immediately notify the CxA in writing as to the reasons for non-compliance.

PART 2 - PRODUCTS

2.1 CONTRACTOR SYSTEMS READINESS CHECKLISTS

A. The Contractor shall maintain and complete copies of the contractor's system readiness checklist forms for all building systems and equipment scheduled for commissioning. These forms will be provided to the appropriate contractors and the Contractor's Commissioning Coordinator at the initial commissioning coordination meeting. A sample form is provided at the end of this section.

B. Completion of these items shall not release the Contractor from their responsibility to complete other specified requirements of the project contract documents.

2.2 STARTUP PROCEDURES AND FORMS

A. Startup procedures and checklists for equipment within the commissioning scope of work shall be submitted for review as a part of the initial equipment submittal. Minimum startup procedures are specified in the specifications for systems and equipment within the commissioning scope of work. Procedures shall also include all installation and start-up procedures and checklists that are provided by the equipment or system manufacturer. The accepted startup documentation shall be completed by the Contractor and submitted to the CxA for review and inclusion within the final commissioning record.

2.3 PROJECT CLOSE-OUT CHECKLIST

A. The Contractor shall complete, sign and submit the commissioning project closeout checklist to indicate completion of Contractor's specified responsibilities regarding: arrangements for post-construction testing, spare parts for owner, final O&M manuals, as-built documents, O&M training, performance testing, indoor air quality testing and any other requirements that occur just prior to owner acceptance of the project. This checklist will be provided as part of the Contractor checklist package distributed during the initial commissioning coordination meeting.

PART 3 - EXECUTION

3.1 CONSTRUCTION PHASE COMMISSIONING PROCESS OVERVIEW

A. After the bid award and acceptance of mechanical and electrical submittals, the Commissioning Authority will conduct a pre-installation commissioning coordination meeting with the Contractors, Owner's Representative and the Design Team. The CxA will present the commissioning plan, discuss commissioning process in detail, and identify specific commissioning related responsibilities. Milestones shall be discussed, including contractor start-up and testing forms, preliminary O&M manuals, training agendas and other approved submittals needed to complete the plan. The final plan will be developed after the CxA receives all submittals from the contractor and design team.

B. The Contractor shall provide the commissioning submittals as detailed under 1.4 A, 1 and 2 above.

C. Functional performance test procedures shall be developed by the CxA with input from the Contractor, Owner, and A/E, as specified in Part 3 of this section.

D. Commissioning status meetings shall be scheduled to occur during the construction and closeout phase to monitor progress and to help facilitate the commissioning process. Contractor representatives for commissioned systems shall be required to attend these meetings. Meetings will generally be scheduled to occur with scheduled construction or management meetings.

E. The CxA shall perform periodic site visits during construction and identify potential issues in a site report. The Contractor shall review these site reports and resolve issues in accordance with the contract documents.

F. The Contractors shall prepare the equipment and systems and complete startup in accordance with the project documents, industry standard guidelines, and the

guidelines of the equipment and systems manufacturers. The Contractor shall test the systems to verify that they perform in accordance with the project documents, including the commissioning functional performance test procedures. The CxA may witness equipment start up and testing. The contractor shall notify the CxA in writing at least 10 working days in advance of the start-up and testing dates so that the CxA can schedule attendance. If the CxA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CxA. When scheduled start-up activities are not executed because of lack of preparation or coordination by the Contractor, the Contractor will be subject to back-charges in accordance with the contract documents.

G. The CxA creates system readiness forms for the Contractor, which document that the equipment has been provided in accordance with the project requirements and is ready for functional testing.

H. The Contractor completes and signs the forms and submits them for CxA review. The CCC shall review and sign off on all system readiness forms prior to submittal to the CxA. The contractor must have approval from the CxA in order to proceed with subsequent functional testing.

I. Once the Contractor has provided the CxA with written verification (contractor's system readiness checklists) indicating completion of installation procedures, the Commissioning Authority will conduct a final on-site system readiness review of the specific systems and equipment to be commissioned. Issues noted during this process will be documented by the CxA in the commissioning issues list.

J. Upon confirmation of system readiness and receipt of the preliminary balancing (TAB) report, functional performance testing shall be scheduled. Functional testing shall not commence until all critical issues identified during the installation verification and TAB report review process are resolved.

K. The procedure for developing and performing the FPTs shall be as follows.
   1. The Contractor shall provide the equipment and commissioning submittals as specified in the project documents.
   2. The CxA shall draft the FPT procedures based on the contractor's submittals and project documents. The draft procedures shall be submitted to the Commissioning Team for review.
   3. The Contractor shall be asked to provide written comments on the associated FPT regarding each of the following issues:
      a. Verify that the procedures can be performed without compromising the safety of the participants.
      b. Verify that the procedures can be performed without compromising the warranties of equipment, components, and systems.

c. Verify that the procedure is appropriate for the equipment, components, and systems as provided.
d. At the contractor's option, make recommendations to incorporate the FPTs into the contractor's in-house startup and QC testing process.

4. The CxA shall complete the working drafts of the FPTs.
5. The Contractor shall provide the personnel, expertise and test equipment to operate and maintain the systems during testing.
6. The Contractor shall test all systems within the commissioning scope of work, using the FPTs until the acceptable results specified in the FPT procedure are verified and documented. If necessary to obtain acceptable results, the Contractor may consult with the CxA to acquire clarification and resolve issues. The CxA shall be available for on-site assistance of this nature.
7. The Contractor shall submit documentation indicating they have completely tested their system and are ready to demonstrate the FPTs to the CxA. Acceptable documentation may consist of completed FPT record forms which document acceptable FPT results, or indication on the systems readiness checklists that the Contractor's functional testing has verified acceptable functional performance.
8. After the CxA has accepted the Contractor's documentation of acceptable results, the FPTs shall be demonstrated to the CA. If acceptable results are not demonstrated for an FPT, the Contractor shall resolve the issue(s) and the demonstration shall be repeated.
9. The CCC is responsible for scheduling and coordinating functional testing activities. The Contractor shall demonstrate the functional performance tests after they have verified that performing the FPTs will yield the documented acceptable results. The contractor is subject to back-charging, as specified herein, if acceptable results are not demonstrated because of work that should have been verified during pre-demonstration testing. Acceptable results must be obtained during a single demonstration with no more than two delays of 15 minutes or less, during each test.

L. Issues noted during the functional performance tests will be documented by the CxA. When easily corrected, issues will be resolved at the time of discovery. The appropriate contractor will resolve all other issues at a later time. Issues will be tracked by issue number, responsible party, status and activity date. The contractor shall be responsible for reporting, in writing, to the CxA when issues have been resolved so that the CxA can verify the resolution.

M. The construction phase commissioning process will be complete when all noted issues have been corrected, proved to be in compliance with the project contract documents or otherwise resolved to the satisfaction of the Owner.

3.2 CLOSEOUT PHASE COMMISSIONING PROCESS OVERVIEW

A. Contractor closeout responsibilities include completion and submission of the project closeout checklist for commissioned systems. Project closeout requirements and a draft checklist are included in this section.

B. Training on related systems and equipment operation and maintenance shall be scheduled after commissioning is satisfactorily completed, O&M manuals have been accepted and delivered to the owner, and systems are verified to be complete and functional. Each Contractor is responsible to provide a topical outline of all subjects to be covered in the training session(s), the expected length of time for the training sessions, and a brief resume listing the qualifications of the proposed training presenters. Training will be coordinated with the Owner.

C. Upon request, the Contractor is responsible for providing the CxA with copies of all balancing reports, as-built drawings and O&M manuals relevant to the systems commissioned. The CxA will review this material for compliance with project contract documents and will note and report all issues for resolution by the responsible party.

D. Upon completion of all commissioning activities the CxA will prepare and submit to the owner the final commissioning report detailing the commissioning plan and all commissioning activities.

3.3 OTHER SPECIFIED FUNCTIONAL PERFORMANCE TESTS

A. In addition to participating in functional tests developed by the CxA, the Contractor shall be required to complete all start-up and testing procedures as specified elsewhere in the project contract documents.

3.4 PERFORMANCE PERIOD

A. Functional performance testing shall include a performance period test plan, which includes measured variables and success criteria based on performance characteristics described in the project contract documents. The CxA will provide the Control System Contractor with a list of required trend log definitions to be implemented as a basis for reviewing performance during this period.

B. The Contractor will review the performance period test plan and set up the trend log definitions from the CxA. The trending shall be provided by the contractor in both a text and graphic format with related system parameters grouped together for easy comparison. If DDC system resident memory is limited or there are other issues with the trending requirements, the Contractor will notify the CxA and request the CxA redefine the test plan.

C. The performance period shall be as specified in the FPTs. If failures are encountered, the performance period shall be aborted. After corrections are made, the performance period shall be re-started at day one. Back-Charging as specified herein shall apply.

3.5 PROJECT CLOSEOUT

A. Post construction contractor responsibilities include completion and submission of the project closeout checklist for each commissioned system to the CxA, to verify completion of contractual obligations for the owner. A sample project closeout checklist is included near the end of this section.

B. Training on related systems and equipment operation and maintenance shall only be scheduled to commence after functional testing is satisfactorily completed, O&M manuals have been delivered and approved, and systems are verified to be 100% complete and functional. The Contractor is responsible to provide a topical outline of all subjects to be covered in the training session(s), the expected length of time for the training sessions, and a brief resume listing the qualifications of the proposed training presenters. The CCC is responsible for developing the training plan with input from the contractor. The CCC is responsible for coordinating training with the Owner and CxA and to verify execution of the training plan.

C. Upon request, the Contractor is responsible for providing the CxA with copies of all balancing reports, as-built drawings and O&M manuals relevant to the systems commissioned. The CxA will review this material for compliance with project contract documents and will note and report all issues for resolution by the responsible party.

3.6 SYSTEMS ACCEPTANCE

A. Equipment and systems shall not be accepted by the Owner until all commissioning activities are complete and the performance period standards have been met.

3.7 POST OCCUPANCY REVIEW

A. As part of the LEED requirements for this project, the CxA will be conducting a post-occupancy review of all previously commissioned systems, sometime prior to the expiration of the one-year warranty period. The Contractor shall be required to respond promptly to additional and otherwise unresolved issues as identified during this review. This may include the Contractor's required attendance at subsequent meetings to discuss new or as yet unresolved issues related to system installation or performance.

PART 4 - SAMPLE CHECKLISTS AND FT PROCEDURES

A. On the following pages are sample contractor system readiness checklists and functional testing procedures provided to indicate the approximate level of rigor imposed by our typical commissioning process. The actual project Contractor checklists for each commissioned system component will be distributed at the initial commissioning coordination meeting. The actual project functional test procedures will be produced and distributed for Contractor review and approval prior to the start of functional testing.

SAMPLE CONTRACTOR'S SYSTEM READINESS CHECKLIST

SYSTEM NAME: Fan Powered VAV Boxes with Hydronic Reheat Coils (VAV1 – 17)

UNIT NAME/NUMBER: _____

INSTRUCTIONS:

Once all the items below have been verified as complete, the Contractor's Commissioning Coordinator shall check all boxes, sign and return the checklist to the Commissioning Authority. All exceptions must be clearly described below, or on a separate attached sheet.

- ☐ Unit is clearly labeled per the specified requirements.
- ☐ Adequate maintenance access to all VAV boxes has been provided and verified to be in compliance with the specifications and manufacture's recommendations.
- ☐ Power and control wiring is complete.
- ☐ Hydronic piping and insulation is complete.
- ☐ Associated ductwork is complete, sealed and insulated per the specified requirements.
- ☐ Filter replacement access has been verified and clean filters have been installed.
- ☐ This unit has been installed, started and tested per the manufacturer's recommended procedures. Additional checklists as previously submitted have been completed and attached to this document or otherwise provided to the Commissioning Authority.
- ☐ Contractor has verified this unit will perform in compliance with the requirements of the contract specifications and the functional test procedures and acceptance criteria as provided by the Commissioning Authority.
- ☐ All remaining known issues have been reported in writing to the Commissioning Authority and the Contractor considers the installation, startup and functional testing of this unit to be complete.

PLEASE NOTE:

Contractor Readiness Checklists are not intended to represent all the requirements of the Project Contract Documents. Completion of the items on this checklist does not release the contractor from their contractual obligation to complete work as specified elsewhere.

Signed: _____ Date: _____
Contractor's Commissioning Coordinator

SAMPLE FUNCTIONAL TEST PROCEDURE

SYSTEM NAME: Fan Powered VAV Boxes with Hydronic Reheat Coils (VAV1 – 17)

SYSTEM TEST: VAV Box Heating Output Performance

ACCEPTANCE CRITERIA: Minimum of 20 degree and maximum of 40 degree rise across coil with hydronic supply temperature at minimum (160 degrees).

Test Procedure Steps:

1. Verify hydronic loop is circulating and heating supply temperature control is being maintained at minimum (approximately 160 degrees).

2. Place unit in a null call for a minimum of five minutes. Verify primary damper is at design minimum position. Record primary air temp and supply air temperature.

3. Place VAV box in a full call for heating. After a minimum of 5 minutes, record discharge air temperature and differential between null supply air temp and full heat supply air temp.

4. Return VAV box to normal control and document all issues.

Data Entry Table for Above Test Procedure

A	B	C	D	E	F	G
UNIT #	(2) Damper at Min? (Y/N)	(2) Primary Air Temp	(2) Null Supply Air Temp	(3) Full Heat Supply Air Temp	(3) Temp Diff (E – D)	Pass / Fail? (P/F)
VAV-1						
VAV-2						
VAV-3						

Approval Signature: _____ Date: _____

Project Commissioning Authority

END OF SECTION O1810

Appendix 5.9: New Construction Commissioning Plan Components

- Brief Project Description
- Actual Contracted Scope of Commissioning Services and Deliverable Products
- List of Systems and Equipment to be Commissioned
- Tentative Commissioning Schedule Including Major Milestones
- List of Commissioning Goals
- The Commissioning Team Member List and Description of Roles
- List of Systems and Equipment to be Commissioned
- Owner's Project Requirements and Basis of Design Documents
- Commissioning Related Specification Sections
- Description of Planning and Design Phase Commissioning Activities
- Description of Construction Phase Commissioning Activities
- Description of Post Construction and System Acceptance andTurnover Phase Activities
- Description of Post Occupancy Phase Commissioning Activities
- Description of Final Commissioning Report and Record

Appendix 5.10: Sample CxA Installation Review and Witnessing Log

Project Name: _____

Date of Review/Witnessing: _____

CxA Representative: _____

Contractor Representative: _____

System(s) Reviewed:_____

Actions Witnessed: _____

Issues Noted: _____

Note: All unresolved issues will be posted on the Issues and Resolutions list for distribution and tracking during the commissioning process.

Appendix 5.11: Sample CxA Training Witnessing Log

Project Name: _____

Date and Duration of Witnessing: _____

CxA Representative: _____

Contractor Representative: _____

System(s) Trained On: _____

_____ _____

Names of Students Attending:

_____ _____

Note: All deficiencies regarding training will be posted on the Issues and Resolutions list for distribution and tracking during the commissioning process.

Appendix 5.12: Requirements for Systems Manual per Additional LEED EA Credit #3 (Enhanced Commissioning)

The following are the current (May, 2008) actual requirements for the "Systems Manual" as defined by LEED and as documented in the LEED-NC Version 2.2 Reference Guide on pages 208 and 209. Note; this systems manual is only required if the project is seeking to obtain the Energy and Atmospheric Credit #3 for "Enhanced Commissioning".

"Develop a systems manual that provides future operating staff the information needed to understand an optimally operate the commissioned systems.

Provide a Systems Manual in addition to the O&M Manuals submitted by the Contractor. The Systems Manual generally focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment.

The Systems Manual shall include the following for each commissioned system:

- *A final version of the Basis of Design document (as provided by the design team).*
- *System single line diagrams (as provided by the design team and contractor submittals).*
- *As-built sequences of operations, control drawings and original setpoints.*
- *Operating instructions for integrated building systems.*
- *Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals.*
- *Recommended schedule for retesting of commissioned systems with blank test forms from the original Commissioning Plan.*
- *Recommended schedule for calibrating sensors and actuators."*

Appendix 5.13: Sample Commissioning Issues Log Format

The Commissioning Issues Log Process: Issues identified during the commissioning process will be recorded in the Commissioning Issues Log. The CxA will maintain the master log. For each issue, the CxA will make a recommendation regarding who they believe is most appropriate to be assigned for the resolution.

When a commissioning issue is resolved the responsible party shall submit a written response describing when and how issue was resolved. The CxA will then back-check the issue to verify resolution.

Issue Resolution: The contractors and designers retain primary responsibility for resolving issues identified during the commissioning process. Members of the commissioning team will participate in problem resolution as needed, with the CxA providing a third party opinion and suggesting additional diagnostic measures where necessary.

NOTE: The following is provided as a sample format for the Issues Log.

The following issues, observations and comments are provided by the CxA as a result of completing commissioning procedures on this project. These comments are made as observations and suggestions only and do not represent direction for change unless formally approved by the appropriate party. When responding to issues, please reference the issue number (IN) in your response.

I.N.	ISSUE DESCRIPTION, RESPONSES AND CURRENT STATUS	Assigned To:
1.	3/3/07: Fan-Coil #303 is missing an air filter.	Issue Closed
	Response / Status: 3/7/07: HVAC contractor has installed an air filter. KBA has confirmed. Issue is resolved.	
2.	3/4/07: Discharge air temperature from AC-2 is 72 degrees when unit placed in full call for cooling.	HVAC Contractor
	Response / Status: 3/6/07: HVAC contractor has been notified and will investigate ASAP.	
3.	3/10/07: Lighting does not come on with occupancy sensor in room B-101.	KBA
	Response / Status: 3/14/07: Lighting contractor has replaced the sensor and reports this is now working properly. KBA to verify.	

Appendix 5.14: A Project Manager's Step-by-Step Checklist for Managing the Commissioning Process on New Construction Projects

Project Planning and Design Phase:

- Verify that all current members of the project team understand the decision to include formal commissioning procedures on the project and review the potential commissioning related roles and responsibilities with each project team member (see sample project team commissioning related roles and responsibilities in Appendix 5.3 of this guide). Verify that each current and potential future project team member understands that these commissioning related responsibilities will be expected as part of their contracted work scope and adjust their contracts as necessary.
- Develop an appropriate advertisement for requesting Commissioning Authority (CxA) services qualifications. (see sample Request for Qualifications advertisement in Appendix 5.5 of this guide).
- Advertise for and select the most qualified firm.
- Negotiate a final scope of work and fee schedule (see sample scope-of-work description and fee estimating worksheet for commissioning new construction projects in Appendix 5.6 of this guide).
- Complete all necessary State of Hawaii consultant contract document requirements and verify delivery of a fully executed contract to the CxA.
- Formally introduce the CxA to your project team and review the CxA scope of work with all current project team members.
- Coordinate CxA access to all existing and future design document submittals and include the CxA on the distribution of all project meeting minutes related to those systems scheduled for commissioning.
- Review and approve the initial project Commissioning Plan as developed and submitted by the Commissioning Authority (CxA). Verify all components of the plan have been provided per the contracted scope of work. (See a sample of typical new construction commissioning plan components in Appendix 5.9 of this guide).
- Review and approve all CxA project design review comments, including those pertaining to the Owner's Project Requirements and Designer's Basis of Design documents. (See a sample design review document in Appendix 5.7 of this guide).
- Verify distribution of CxA design review comments to the appropriate project team members.
- Verify responses to all design document review comments are provided to the CxA by the appropriate project team members.
- Review and approve all commissioning related specification sections as provided by the CxA for inclusion in the project bid documents. Verify project designer's review and approval as well. (See sample commissioning related specification section in Appendix 5.8 of this guide).
- Coordinate the attendance of the CxA at the project pre-bid meeting to explain the specified commissioning related work scope and responsibilities for all contractors.

Project Construction Phase

- Verify the CxA has met with the project contractors to review the commissioning process and the commissioning milestones have been coordinated between the CxA and the contractors and included in the master project construction schedule.
- Review all site visit and construction inspection reports as provided by the CxA. (See sample reports in Appendix 5.10 of this guide).
- Attend all commissioning related job site meetings as scheduled. Review commissioning meeting minutes as provided by the CxA.
- Review all final inspection and functional testing documents as provided by the CxA and included within the updated commissioning plan.
- Review the Commissioning Issues and Resolutions list as it is generated, updated and distributed by the CxA (See sample list in Appendix 5.13 of this guide).
- Verify appropriate and timely response to all issues by the individuals noted as responsible for resolution. Assist CxA with expediting resolution as necessary.

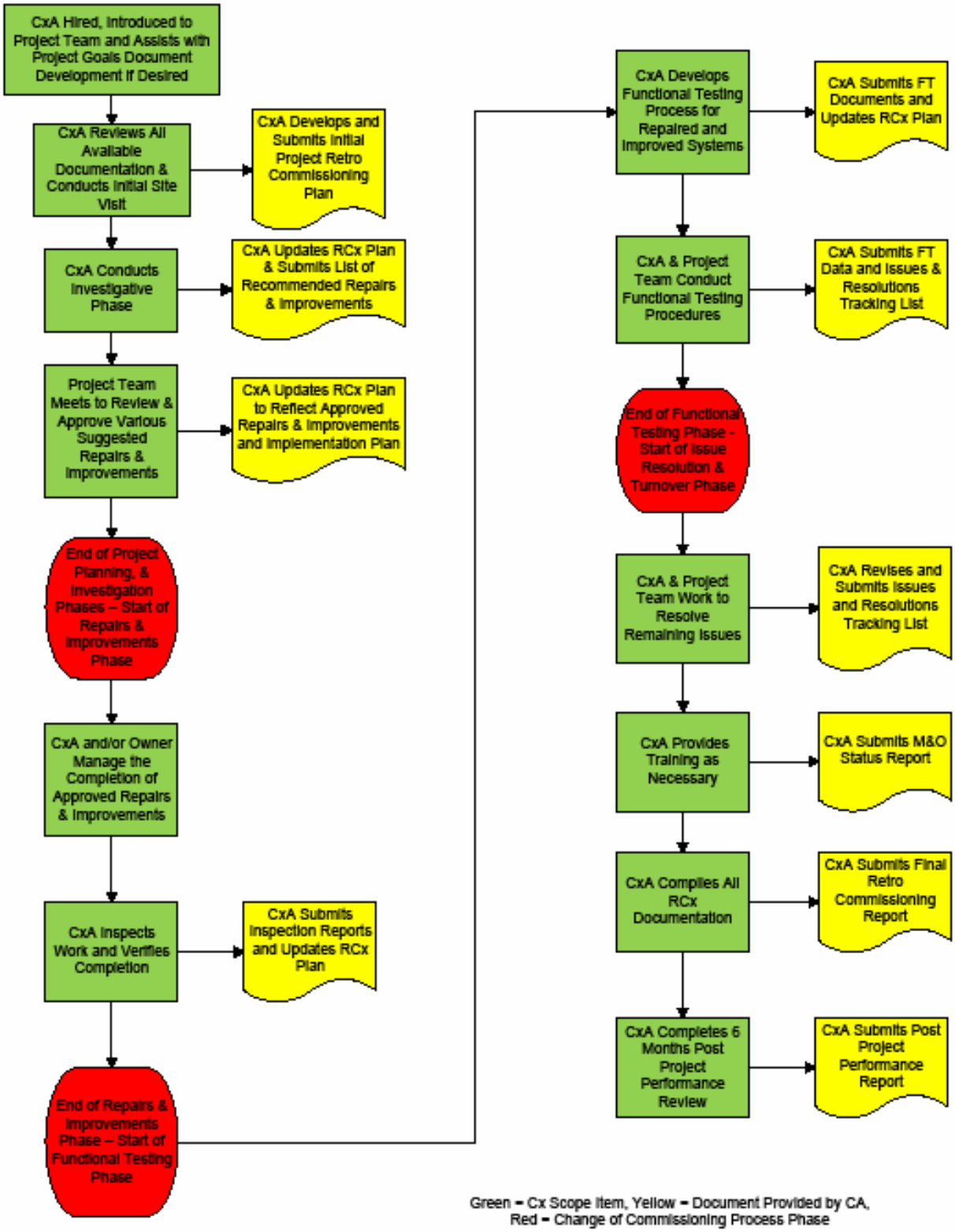
Project Post-Construction and Pre Acceptance Phase

- Verify CxA has documented the successful completion of all specified and desired training on the commissioned systems. (See Appendix 5.11 of this guide).
- Verify the CxA has reviewed and approved the specified Maintenance and Operations documents as provided by the contractors.
- Review and approve the final commissioning report as provided by the CxA and verify owner and occupant acceptance regarding the status of any currently unresolved issues.
- Verify the scheduling of any additional post-occupancy commissioning activities as defined by the CxA scope of work.

Post Project Acceptance and Post Occupancy Phase

- Review and approve the CxA Post Occupancy Review Report.
- Distribute the report to all previous project commissioning team members.
- Verify all new and otherwise unresolved issues have been documented with a proposed course of action for resolution.
- Insert the Post Occupancy Review Report within the project Final Commissioning Report.

Appendix 5.15 - SAMPLE RETRO COMMISSIONING PROCESS FLOW CHART



Appendix 5.16: Retro-Commissioning Process Descriptions

Develop Owner's Project Goals Document: The success of the entire project depends in large part on the ability to clearly define the client's operational and performance requirements for the equipment and systems scheduled for retro-commissioning. We must establish these requirements early in the process and continually reference them as we more fully develop our retro-commissioning project approach and establish our functional testing criteria. A list of typical goals for retro-commissioning can be found in Section 3.7 of this guide.

Review Existing System Related Documents and Perform a Site Visit: The purpose of the document review and site visit is to gain a better understanding regarding the original design intent, the current general condition and the current operational needs of the systems scheduled for retro-commissioning. Interviews with occupants and M&O staff are especially important in regards to gaining historical information regarding chronic system issues. Energy usage data may also be important to review at this time. A sample document review format can be found in Appendix 5.7 of this guide.

Develop Preliminary Retro-Commissioning Plan: The preliminary retro-commissioning plan will describe the entire proposed retro-commissioning process in detail and shall also create the framework for the final retro-commissioning report and record. The submitted plan is typically reviewed and approved by the project manager. A list of typical retro-commissioning plan components can be found in Appendix 5.19 of this guide.

Schedule and Conduct Investigation and Analysis of Building Systems: Once the preliminary retro-commissioning plan is developed and approved, the commissioning authority schedules and completes a more in-depth on site investigation and analysis of the systems scheduled for retro-commissioning. This work concludes with the creation of a list of recommended repairs and improvements that is presented to the project manager for consideration. An example of this list can be found in Appendix 5.20 of this guide. The commissioning authority may be asked to estimate costs and help to assign appropriate responsibility for resolution of those repairs and improvements. In addition, the commissioning authority may be required to estimate any energy saving potential for the various suggested repairs and improvements.

Management of Repairs and Improvements: Once the project manager has provided a list of approved repairs and improvements, a decision must be made regarding who will be responsible for managing the completion of this work. In some cases this work will be completed by in house staff or maintenance contractors under the direction of the project manager or site facility manager. Other repairs or improvements might be managed by the commissioning authority.

Verification of Work Completion: Once the repairs and improvements have been reported as complete, the commissioning authority will schedule a site visit to verify

satisfactory completion of all work. The CxA will submit a report listing any remaining issues or other concerns.

Functional Test Development and Comprehensive Functional Testing: Once it is determined that all repairs and improvements have been satisfactorily completed, the commissioning authority will develop functional test sequences designed to confirm operational performance of the systems scheduled for retro-commissioning in compliance with the desired design intent. These tests must provide a comprehensive verification of all desired system functions and performance.

Remaining Issue Resolution: Issues noted during the completion of functional testing will be documented on the issues log and assigned for resolution. The commissioning authority shall track and assist in the resolution of all critical issues as called for within the scope of contracted services. Additional scope for complicated issue resolution may be required and approved at the project manager's discretion. A sample issues log can be found in Appendix 5.13 of this guide.

Verification of Adequate M&O Training: The improvements to the system and proper operational performance can only be sustained if the systems are operated and maintained properly. The commissioning authority must verify the current staff responsible for M&O is adequately trained and the on-going scheduled scope of maintenance services is appropriate. The CxA provides a report to the project manager in regards to suggestions for additional training.

Final Retro-Commissioning Report: At the close of the project, a final report based on the retro-commissioning plan is created. This report will contain all previously generated retro-commissioning documentation and a project summary that identifies any unresolved issues and makes further recommendations for action as deemed necessary. This report should be presented to the project retro-commissioning team at a final meeting.

Post Project Activities: At a point several months after project completion, the commissioning authority will schedule and complete a post-project review to verify the sustained operational performance of all retro-commissioned systems. The commissioning authority will submit a report detailing this review and identifying any new or remaining issues.

LEED EB Requirements:

If this project is attempting to qualify for the LEED Existing Building (EB) commissioning requirements, it will be necessary to comply with the following:

- Develop and submit a comprehensive building operation plan (systems manual) that defines the desired performance and operation criteria (design intent) for the following building systems:
  - HVAC Systems (all related equipment and controls).

- Water Systems (plumbing systems, irrigation etc.)
- Lighting Systems

- Prepare and conduct a commissioning plan to inspect and functionally test systems (included in above recommended scope).
- The owner must agree to make recommended repairs/upgrades or schedule to complete repairs/upgrades over the next five years.
- All “low and no-cost” measures must be completed in first two years
- Systems must be comprehensively inspected and retested once repairs or upgrades are completed (included in above recommended scope).

Appendix 5.17: SAMPLE Retro-Commissioning Building Systems Commissioning Authority "Request for Qualifications" Advertisement

Note: Items capitalized and in parenthesis must be edited for the specific project.

(OWNER) is requesting qualification submittals from firms with experience in providing building systems retro-commissioning services. The proposed project is a (SIZE) square foot (DESCRIBE TYPE OF BUILDING) located at (DESCRIBE LOCATION). The building was originally constructed in (DATE OF CONSTRUCTION). The following building systems are currently being considered for retro-commissioning procedures:

(LIST THE ACTUAL BUILDING SYSTEMS BEING CONSIDERED FOR RETRO-COMMISSIONING).

The scope of work for the Commissioning Authority may include the following:

1. Review and provide written comments regarding all provided existing plans, specifications, submittals, O&M documents, energy usage data, repair and maintenance records, and other pertinent information related to this building.
2. Inspect the building site and review the general building systems condition and access to equipment. Interview building operations staff and maintenance contractor.
3. Develop and provide an appropriate and detailed retro-commissioning plan for submittal to the project team.
4. Complete a thorough investigation and analysis of building systems condition and performance. Develop a list of recommended system repairs and improvements, including rough cost estimates. Calculate potential energy savings for any repairs or improvements expected to result in lower energy usage.
5. Assist the owner with developing an action plan for resolving necessary system repairs and improvements.
6. Verify by inspection the satisfactory completion of all agreed upon system repairs and improvements.
7. Develop functional testing procedures. Perform and document functional performance testing procedures. Verify and approve functional performance of specified systems in all operational modes and through every potential sequence of operation. Document all issues and note the party responsible for resolution.
8. Identify, document and track the status of all retro-commissioning related issues through final resolution. Attend retro-commissioning team meetings as required to communicate the status of issues. Verify the appropriate resolution of outstanding issues.
9. Verify persons responsible for future maintenance and operations of system have adequate training. Verify maintenance contracts have adequate scope for maintaining systems.

10. Document all retro-commissioning procedures and submit a final comprehensive report and record to the owner upon completion.
11. Review and report regarding the sustained performance of all retro-commissioned systems at a point approximately six to eight months after completion of retro-commissioning procedures.

The successful firm will demonstrate expertise in the ability to coordinate and work effectively with maintenance contractors, other consultants and the owner's representatives. An extensive background in reviewing control strategy, developing system functional performance tests, TAB expertise, and troubleshooting operational problems is a mandatory requirement.

The Commissioning Authority shall be an independent company, not financially or otherwise contractually associated with the current maintenance contractors for this building. The selected firm must agree to adhere to commissioning standards as set forth by an organization such as the Building Commissioning Association (BCA).

The qualifications submittal should contain only the following requested information presented in seven (7) separated and tabbed sections:

1. Include a brief history and general overview of the company. Provide a descriptive list of specific retro-commissioning related expertise and services currently available from your company. Identify the percentage of your firm's work associated with retro-commissioning.
2. Demonstrate a familiarity and experience with conducting formal retro-commissioning procedures as endorsed by the Building Commissioning Association (BCA), ASHRAE and other similar professional organizations. Specifically list and describe the goals and objectives you believe are most important to achieve through the retro-commissioning process.
3. Provide the professional resumes and associated fee schedules for personnel that may be assigned to this project.
4. Define your proposed retro-commissioning project management approach and provide a proposed retro-commissioning procedural outline or flowchart for a typical commissioning project. Include the specific proposed work-scope for each project participant from your firm or from supporting (sub-consultant) firms.
5. Describe your firm's retro-commissioning experience during the past five years on projects of similar size, similar use and with similar building systems. Specifically identify LEED related project experience. Provide professional and retro-commissioning related project references and letters of recommendation if available.
6. Provide a sample scope of work and associated fee schedule for a recent retro-commissioning project where your company was contracted to provide services as the commissioning authority within the past two years. Define the size, type of building and systems retro-commissioned. Remove all references to the actual client and project names.

7. Provide samples of retro-commissioning functional testing procedures, issue logs and other retro-commissioning related documentation used by your firm on previous projects. Note: Firms selected for further consideration may be requested to provide additional retro-commissioning related documentation as produced by the firm during previous retro-commissioning projects.

Submittals must be addressed to (OWNER'S NAME AND ADDRESS). (NUMBER OF COPIES DESIRED) copies of this submittal must be hand delivered or otherwise received by (OWNER'S NAME) prior to the closing date of: (DATE / TIME) to the address noted above. An interview and / or selection will occur within (NUMBER OF WEEKS) weeks following the closing date. The final scope of work, deliverable details and associated fees shall be negotiated with the firm selected. Questions regarding this request for qualifications should be emailed to: (EMAIL ADDRESS) no later than five (5) working days before the date and time for submittal delivery noted above. Responses to questions will be distributed to all potential submitters upon request and provision of an email address.

Appendix 5.18: Sample Retro-Commissioning Scope of Work and Fee Estimating Worksheet

Proposed Scope of Work:

The building systems to be retro-commissioned under this proposal include the systems listed below.

- HVAC Systems Equipment
- HVAC Systems Controls
- HVAC Related Air and Water Systems Balancing
- Interior Lighting Controls
- Domestic Hot Water System

Services, Procedures and Deliverable Products:

The work as provided by the commissioning authority (CxA) under this contract shall include the following services, procedures and deliverable products:

1. Upon receipt of a signed contract for providing retro-commissioning services, the CxA shall attend an initial meeting with the project team to review the CxA contracted scope of work and answer questions related to the proposed retro-commissioning process. The CxA shall submit a proposed list of retro-commissioning project goals for client edit, review, and approval.

2. The CxA shall review all available documentation and shall conduct an initial site visit to review the general systems condition, access, and current operational performance of systems scheduled for retro-commissioning. The CxA shall interview occupants and staff. The CxA shall then develop and submit a proposed retro-commissioning plan. At a minimum, this plan shall include the following sections and topics:

    - Project Description
    - Actual Contracted Scope of Retro-Commissioning Services and Deliverable Products
    - List of Systems and Equipment to be Retro-Commissioned
    - Tentative Retro-Commissioning Schedule Including Major Milestones
    - List of Goals for the Retro-Commissioning Process
    - The Retro-Commissioning Team Member List and Description of Roles
    - Description of Planning and Qualification Phase Activities

- Description of Investigative and Analysis Phase Activities
- Description of System Repairs and Improvements Phase Activities
- Description of Comprehensive Functional Testing Phase Activities
- Description of Training and Project Turnover Activities
- Description of Final Retro-Commissioning Report and Record
- Description of any proposed Post Construction Review Activities

3. The CxA shall schedule and conduct a comprehensive on-site system investigation and analysis. At the conclusion of this work the CxA shall develop and submit a list of recommended repairs and improvements to the systems scheduled for retro-commissioning. The CxA shall also review all recommendations for repairs and improvements to determine and estimate potential energy savings. The CxA shall then schedule to meet and review these findings with the project team with the purpose of determining an action plan to complete recommended repairs and improvements as approved by the client.

4. Once all the approved repairs and improvements have been completed, the CxA will conduct a site review to verify satisfactory completion of all work and readiness for the comprehensive functional testing of all systems scheduled for retro-commissioning. The CxA shall submit a report to the project manager detailing this review and noting any issues that remain to be resolved prior to the start of functional testing.

5. The CxA shall develop and submit for approval an updated retro-commissioning plan with proposed comprehensive functional testing procedures.

6. The CxA shall schedule and conduct a comprehensive functional testing of those building systems scheduled for retro-commissioning, including those systems recently repaired and/or improved. The CxA shall revise the retro-commissioning plan to reflect the results of all functional testing and shall develop an issues log to document and track all issues identified during the functional testing process.

7. The CxA shall assist the project team in developing an action plan to resolve all issues as identified on the issues log. The CxA shall provide input on possible methods for resolution of issues as appropriate. The CxA shall continue to track all issues until either resolved or otherwise accepted by the client.

8. The CxA shall assess the training requirements of the proposed systems operation and maintenance staff and make recommendations to the client regarding additional required training. The CxA shall also review all related contractor service contracts to verify the scope is adequate for the on-going maintenance and operation of the retro-commissioned systems.

9. The CxA shall update the retro commissioning plan and compile all completed retro-commissioning documentation. The CxA shall then submit a final retro-commissioning report and record to the project manager.

   The report shall contain at a minimum the following:

   - An executive overview description of the retro-commissioning process as actually executed.
   - The current status of any critical unresolved issues.
   - Recommendations for further actions related to the retro-commissioning process.

   The retro-commissioning record shall contain at a minimum the following:

   - All previously completed and updated retro-commissioning plan documentation.
   - Copies of all completed documentation related to functional performance tests.
   - A final version of the retro-commissioning issues log showing the current resolution status of all issues, including the status of those issues still outstanding.

10. At a point several months after completion of the retro-commissioning process, the CxA shall schedule and conduct a site review to determine the sustained performance and condition of all previously retro-commissioned building systems. The CxA shall develop and submit to the project manager a report detailing the results of this review and noting any new or unresolved issues requiring additional attention.

Sample

Retro-Commissioning Cost Estimating Worksheet

Note: This worksheet automatically calculates and includes the travel related expenses within each proposed scope item fee.

Item	Description	Qty	Units	Rate	Trips	Nites	Fee
1	Prepare for and attend an initial meeting with the project team to review CxA scope and develop a list of RCx project goals.	12	Hrs	115	1	1	2,340
2	Review all existing documents. Complete a site visit. Develop and submit initial RCx plan.	40	Hrs	115	1	1	5,560
3	Conduct system investigation and analysis. Develop and submit list of recommended repairs and improvements. Meet with project team.	60	Hrs	115	1	1	7,860
4	Conduct a site visit to verify satisfactory completion of repairs & improvements.	16	Hrs	115	1	1	2,800
5	Update RCx plan and provide functional testing procedure documents. Submit for approval.	32	Hrs	115	1	1	4,640
6	Conduct functional testing procedures.	80	Hrs	115	1	9	11,360
7	Log issues and assist with resolution plan.	24	Hrs	115			2,760
8	Assess training and make recommendations.	16	Hrs	115			1,840
9	Compile and submit final RCx plan and record.	24	Hrs	115			2,760
10	Schedule and complete a post-project review of retro commissioned systems. Submit report.	60	Hrs	115	1	1	7,860
	Estimated Total Trips and Nights:				7	15	
	Estimated Round Trip Travel Time per Site Trip:	4					
	Estimated Related Expenses per RT Site Trip:	350					
	Estimated Related Expenses Per Night Stay:	150					
	Total Proposed Fee:						**$49,780**
	Travel Expense Budget (included in total fee)						4,700

Appendix 5.19: Potential Retro-Commissioning Plan Components

- Brief Project Description
- Actual Contracted Scope of Retro-Commissioning Services and Deliverable Products
- List of Systems and Equipment to be Retro-Commissioned
- Tentative Retro-Commissioning Schedule Including Major Milestones
- List of Goals for the Retro-Commissioning Process
- The Retro-Commissioning Team Member List and Description of Roles
- Description of Planning and Qualification Phase Activities
- Description of Investigative and Analysis Phase Activities
- Description of System Repairs and Improvements Phase Activities
- Description of Comprehensive Functional Testing Phase Activities
- Description of Training and Project Turnover Activities
- Description of Final Retro-Commissioning Report and Record

Appendix 5.20: Sample List of Recommendations for Repairs and Improvements

(Version 1, January. 30, 2010)

Any State Office Building Retro-Commissioning Project

Note: This list is segregated into those repairs and improvements the Commissioning Authority (CxA) deems to be critical (C) to the operation of the building system, and those that might be considered non-critical (NC) yet beneficial. Items have been listed in the priority deemed most appropriate by the CxA. The dollar estimates are for range of magnitude use only and should not be considered accurate for final budgeting purposes. The CxA has also recommended who might complete the repair/upgrade.

MC:	Maintenance Contractor
C/OS:	Contracted / Out-Sourced
CxA:	Commissioning Authority (CxA)
CSD:	D.A.G.S., Central Services Div. (in-house M&O staff)

I.N.	DESCRIPTION OF RECOMMENDED REPAIR or IMPROVEMENT and ESTIMATED COST	C or NC	WORK DONE BY			
			MC	C / OS	CxA	CSD
1	Many of the controls we tested on the older third floor fan coils were out of calibration. These controls must be recalibrated and tested to insure they are opening and closing the cooling valves properly. The chilled water valves should be approximately ½ open when the thermostat setting equals the temperature measured at the thermostat, and should be fully open or fully closed when the temperature is 2.5 degrees above or below the setpoint. The CxA estimates this work could be completed in 40 hours.	C	X			

2	The design of the lighting troffer style air diffusers is causing the air flow to be directed primarily straight down. When there is an occupant below, this causes a significant cold draft to be felt. We believe this could easily be corrected by attaching some simple sheet metal deflectors to the troffers. The CxA estimates this work could be completed in 40 hours. The cost for sheet metal would be in addition, but should be less than $500.	C	?	X		
3	On the newer units, the temperature control sensors have been placed up in the ceiling space. We don't think this is the best location for these sensors and would recommend they be placed inside a simple wall mounted conduit, with an open end at approximately 48 inches from the floor. This location would better reflect the temperature at occupant level. The CxA estimates this work could be completed in 40 hours. The cost for conduit would be in addition, but should be less than $500.	C	?	X		
4	The location is not correct for several of the older style wall mounted thermostats. We would suggest that every thermostat location be reviewed and thermostats moved to more appropriate locations if necessary. Also, some thermostats are located too near various heat generating sources such as copier machines. This "false" load causes the thermostat to cool the space below the desired setpoint. The CxA estimates this work could be completed in 40 hours.	C	?	X		
5	On some of the units, the air filter frames seem to be collapsing due to the differential pressure. When they collapse this allows unfiltered air to clog the cooling coils. The air filters should be strong enough to stay in normal form when dirty. It may also be necessary to improve the support for these filters. The CxA estimates this work could be completed in 40 hours.	C	X			
6	Many of the air supply diffusers have been blocked off or otherwise disabled. Also, many of flow (CFM) rates do not approximate design. It would be prudent to re-balance the air flow distribution and reinstate the supply diffusers per design. The maintenance contractor estimates this work could be completed in 40 hours.	C	?	X		

7	The CxA increased the flow through chiller #1 slightly as the isolation valve was nearly closed. Flow through the chillers should be balanced per design. The CxA estimates this work could be completed in 8 hours.	C	?	X		
8	The CxA reset the supply water setpoint for chillers 1 and 2 up from 44 to 50 degrees. The building is generally too cold and chiller #2 was showing a low temperature alarm that had locked out the circuit #1 cooling stages. The CxA also reset the lock-out control and the unit staged normally up to stage 4. These chillers are not running per the original design sequence and appear to both be enabled and running in parallel to satisfy their internal supply water setpoints during the occupied mode. The CxA does not see a problem with this and would suggest leaving the control as-is. It may be prudent to consider installing a supply water temperature setpoint reset option for these units as that would probably provide for better control and reduced energy usage. The CxA estimates that this work could be completed in 8 hours. The cost of the controls should be less than $1,000.	NC		X		

Appendix 5.21: Sample of Existing Documents, Plans and Other Information Review Format for Retro-Commissioning

The follow document information has been reviewed by the CxA as part of the planning and qualifying process:

- Powers Regulator Controls schematic and description of operation dated 1/11/1968.
    - CxA Review Comments:
        - This document provides good information regarding the original design intent for the main HVAC control system.
        - Note: Our initial site review would indicate these pneumatic based controls are substantially in a failed condition and it would not likely be cost-effective to reinstate the original system.

- Any State Office Building Original Construction Plans dated Aug. 15, 1966.
    - CxA Review Comments:
        - This document provides good information regarding the original design intent for the main HVAC system and also provides the original HVAC air distribution plans, including the equipment schedules and design air flows.

- Alterations to Any State Office Bldg. plans dated June, 1969
    - CxA Review Comments:
        - This document provides information regarding some changes to the main HVAC ductwork distribution plan during some alterations to the Judiciary and Probation area on the second floor.

Appendix 5.22: A Project Manager's Step-by-Step Checklist for Managing the Retro-Commissioning Process on Existing Buildings

Once it has been decided that a formal retro-commissioning process will be used on a particular existing building:

Project Planning Phase:

- Verify that all potential project team members understand the decision to implement formal retro-commissioning procedures on specific building systems and review the potential retro-commissioning related roles and responsibilities with each project team member. Verify that each current and future project team member understands that these retro-commissioning related responsibilities will be important to the success of the project.
- Develop an appropriate advertisement for requesting commissioning authority (CxA) services qualifications. (Reference sample request for retro-commissioning qualifications advertisement in Appendix 5.17 of this guide).
- Advertise and select the most qualified firm.
- Negotiate a final scope of work and fee schedule (Reference sample scope-of-work and fee development worksheet for retro-commissioning projects in Appendix 5.18 of this guide).
- Complete all necessary State of Hawaii consultant contract document requirements and verify delivery of a fully executed contract to the CxA.
- Formally introduce the CxA to your project team and review the CxA scope of work with all current project team members. Discuss communication and access protocols for the project team.
- Coordinate CxA access to all existing design documents and other information related to the systems scheduled for retro-commissioning procedures.
- Coordinate an initial site visit for the CxA.
- Review and approve the initial project retro-commissioning plan as developed and submitted by the CxA. Verify all components of the plan have been provided per the contracted scope of work. (See a sample list of typical retro-commissioning plan components in Appendix 5.19 of this guide).
- Verify distribution of the initial project retro-commissioning plan to all project team members as appropriate.

Building Systems Investigation Phase:

- Coordinate the scheduled site Investigation Phase work with the CxA and the building occupants. Verify adequate access and a workspace is available for the retro-commissioning team. Make sure the occupants understand the nature of the work and any potential disruptions that may occur.
- Review the preliminary recommendations for repairs and improvements report. Distribute the report as appropriate. (See sample report in Appendix 5.20 of this guide).

- Coordinate the necessary meeting(s) to discuss all recommendations for repairs and improvements.
- Provide final decisions in regards to those repairs and improvements approved for implementation.

Repairs and Improvements Phase

- Manage the approved repairs and improvements either through in-house staff, contractors or through a separate contract with the CxA.
- Regularly update the project team on the status of all repairs and improvements.
- Notify the project team when repairs and improvements have been reported as complete.

Comprehensive Functional Testing Phase

- Review the updated retro-commissioning plan for the proposed functional testing procedures.
- Review all final inspection and functional testing documents as provided by the CxA and included within the updated retro-commissioning plan.
- Review the commissioning issues and resolutions list as it is generated, updated and distributed by the CxA (See sample list in Appendix 5.12 of this guide).
- Verify appropriate and timely response to all issues by the individuals noted as responsible for resolution. Assist CxA with expediting resolution as necessary.

Project Turnover Phase

- Verify the M&O staff and/or maintenance contractors have received adequate training and fully understand the systems they are charged with maintaining and operating.
- Verify the scheduling of any additional retro-commissioning activities as defined by the CxA scope of work.
- Review the final retro-commissioning report and verify all remaining unresolved issues (if any) have been accepted by the owner.

Post Project Systems Review

- Coordinate the post project systems review with the CxA and building occupants.
- Review the post project report as provided by the CxA and distribute to all appropriate retro-commissioning project team members.
- Assist the CxA with developing an action plan for all new and unresolved issues.

Appendix 5.23: Low and No-Cost Energy Saving Ideas

Note: The list below was copied from the CLP Power Hong Kong Limited website @ www.clp-powerwise.com.

Lighting Systems

- Replace T12 or T10 fluorescent tubes with T8 or T5 energy efficient fluorescent tubes that are 10% to 30% more energy efficient.
- Replace incandescent light bulbs with compact fluorescent lamps (CFL) which are 70% to 80% more energy efficient.
- Replace electromagnetic ballasts with electronic ballasts which are 20% to 30% more energy efficient.
- Install lighting zone control wherever applicable to switch off unnecessary lighting in unoccupied areas.
- Install occupancy sensors to automatically control lighting in areas infrequently used, e.g. conference rooms.
- Install parabolic-type lighting reflectors to reflect sufficient light and use fewer fluorescent tubes.
- Install appropriate dimmers to adjust lighting.
- Remove excess lighting in areas that are unnecessarily bright and maintain only those lights needed for safety, security or other specific purposes in the areas that are frequently unoccupied.
- Make use of daylight whenever possible.
- Clean lighting luminaries regularly and avoid switching on unnecessary lights.

Heating, Ventilating and Air-Conditioning (HVAC) System

- Replace aging HVAC equipment with new energy-efficient equipment.
- Install variable-speed drives wherever applicable to control chilled water flow and fan speed based on actual demand.
- Use heat-recovery chillers or heat pumps to recover waste heat that can be used for heating up the hot water supply while providing cooling at the same time.

- Install occupancy sensors to automatically switch on and off the air-conditioning in those areas infrequently used, e.g. in conference rooms.
- Increase the chiller evaporator temperature and decrease the chiller condensing temperature according to the chiller manufacturer's recommendations so as to achieve higher chiller cooling efficiency.
- During cool seasons, raise the chilled water supply temperature according to the cooling demand. This improves the efficiency of the chillers running at part load.
- When outside conditions are suitable and the outdoor air is cool and dry enough, increase the intake of outdoor air as much as possible.
- Regularly clean condenser tubes, cooling coils and air filters in order to maintain cooling efficiency.

Office Equipment

- Purchase energy-efficient office machines, e.g. photocopiers and laser printers bearing the energy label.
- Adopt paper-reducing strategies such as double-sided printing, reusing paper and using e-mail instead of sending memos or faxing documents.
- Always switch off office equipment such as personal computers, printers and photocopiers when they are no longer needed, e.g. during night time and at weekends.
- Discourage the use of personal electrical appliances such as electric fans.

Building Envelope (external walls, roofs and floors in direct contact with ground)

- Install auto doors at openings to non-air-conditioned spaces to reduce excessive infiltration and exfiltration.
- Install caulking or replace worn out caulking around windows, doors and other areas of infiltration or exfiltration.
- Realign or re-hang windows or doors that do not close properly.

- Replace broken or cracked windows.
- Install outdoor shading devices, add reflective films to windows, and close interior shading devices, e.g. curtains or venetian blinds (preferably light coloured), to reduce solar heat gain in summer.

Other Machinery and Equipment

- Install energy-efficient motors and avoid using oversized motors because motors are inefficient when running at part load.
- Operate machines at maximum efficiency. Always run fewer machines at full load rather than more machines at part load.
- In applications in which loads fluctuate, install variable-speed drives to control motor speed to meet demand.
- Lubricate motors and drive bearings frequently to avoid overheating and power loss.
- Adhere to proper maintenance schedules recommended by manufacturers.
- Regularly clean the heating coils in the electric boilers.
- Use heat pumps to heat up water wherever applicable, e.g. for swimming pools and hotels.
- Consider localized hot water supply. This eliminates heat losses in long pipe runs and the need to operate large units for small, intermittent heating demands.
- Reduce the number of elevators and escalators in service after normal working hours and on holidays.

Smart Tips for Green Offices

- Pre-set the timer of your air-conditioning unit to provide cool air only during office hours. Some offices turn on their unit round the clock but their staff members only work eight to 10 hours. Does it happen in your office? Imagine, you can save more than half of the electricity by just adjusting the operating time of your unit.

- Have you heard of a trendy approach called zoning? You may not have staff working in every corner of the building. Lighting and air-conditioning are provided for working zones only. With the exception of the special material or equipment that requires cooling, lights and air-conditioners in empty conference rooms, storage rooms and multi-purpose rooms should be turned off. Alternatively, you may install lighting zone control or occupancy sensors that automatically control lighting.
- Ask your cleaners to clean lighting luminaries and filters of air-conditioners, as well as replace the dust bags of the vacuum cleaners regularly. This increases efficiency and durability of the appliances.
- Use compact fluorescent bulbs and tubes as much as possible. They consume 70% to 80% less electricity than conventional tubes. The "white" light given by the former makes the office look brighter and cleaner than the room in "yellowish" light.
- Saving energy in the common area of your office building is part of your responsibility. Consider switching off lighting, air-conditioning, escalator service (partial or whole depending on actual need) and elevator service during non-office hours such as Saturday afternoons, Sundays and public holidays.
- Achieving "zero wastage" is equally important as the target for "zero accidents". Environmental protection is a good habit to adopt, and it is also part of a good corporate culture. Make it a habit to switch off the lights when you leave the meeting room or your office, and turn off the PC after work.
- Make use of natural daylight as much as possible.
- Purchase office equipment with energy-saving features, such as photocopiers and laser printers bearing "Energy Star" labels..
- Adopt paper-reducing strategies such as double-sided printing, and sending email instead of fax.
- Install self-closing doors in non air-conditioned spaces to reduce excessive infiltration and ex-filtration.

Appendix 5.24: DBEDT Guide to Energy Performance Contracting – Section 4

The following information is an excerpt (Section 4) from the DBEDT Guide to Energy Performance Contracting – 2007 Revision. This information summarizes the energy performance contracting process as it applies to the State of Hawaii. For those with a continuing interest in learning more about the performance contracting process please contact Elizabeth Raman at DBEDT (ERaman@dbedt.hawaii.gov) to request an electronic version of the entire Guide to Energy Performance Contracting.

Guide To
Energy Performance Contracting
2007 Revision

Department of Business, Economic Development, & Tourism

Energy, Resources, & Technology Division

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4. THE ENERGY PERFORMANCE CONTRACTING PROCESS

The steps necessary to initiate and complete the process of awarding an Energy Performance Contract are summarized in Table 4-1. As shown, the process begins with the identification and refinement of a potential energy efficiency project or projects, proceeds through the designation of an EPC project team and project manager, and concludes with selection of an ESCO and award of the performance contract. Each of these steps is described in further detail in the following paragraphs.

Table 4-1
Steps in the Energy Performance Contracting Process

STEP	ACTION	DURATION
1	IDENTIFY POTENTIAL ENERGY EFFICIENCY PROJECT(S)	1-3 MONTHS
2	DEFINE AND DEVELOP THE PROJECT ▪ IDENTIFY EPC PROJECT TEAM AND PROJECT MANAGER ▪ DEVELOP PROJECT PROFILE AND OBJECTIVES	1 MONTH
3	SELECT A CONTRACTOR (ESCO) ▪ DRAFT AND ISSUE A REQUEST FOR PROPOSALS (RFP) ▪ CONDUCT PRE-PROPOSAL MEETING AND SITE VISIT ▪ EVALUATE PROPOSALS AND SELECT AN ESCO ▪ NEGOTIATE AND AWARD ENERGY PERFORMANCE CONTRACT; AUTHORIZE-INVESTMENT GRADE AUDIT	7-12 MONTHS (or longer depending on project complexity)
4	INITIATE PROJECT ▪ ESCO CONDUCTS INVESTMENT-GRADE ENERGY AUDIT ▪ REVIEW AND ACCEPT INVESTMENT-GRADE ENERGY AUDIT REPORT	6-9 MONTHS (or longer depending on project complexity)
5	SUBMIT PROJECT PLANS AND ARRANGE FINANCING	1 MONTH
6	AMEND ENERGY PERFORMANCE CONTRACT	1 MONTH

4.1 *Step One – Identify Potential Energy Efficiency Project(s)*

Before undertaking an EPC, feasible energy and water conservation measures should be identified. A feasibility evaluation can be as simple or sophisticated as

the agency wants to make it. A simple approach to determining the feasibility of an EPC is to pose the following two questions:

- Are the facilities' energy and water bills more than $100,000 a year?
- Do the energy saving opportunities add up to a project investment greater than $100,000 with a simple payback period of less than 7 years (excluding financing, ESCO fees, etc.)?

If so, an energy performance contract may be appropriate. It is likely to be of further benefit if the facilities are characterized by:

- Minimal availability of funds for energy related capital improvements;
- Aging buildings or equipment;
- Recurring maintenance problems or high maintenance costs;
- Comfort complaints;
- Scarce budget resources;
- Too little energy management expertise;
- Too many demands on maintenance staff;
- No recent upgrades of lighting, air conditioning, or controls systems; and
- Energy-using equipment that is ready for replacement.

4.2 *Step Two –Define and Develop the Project*

4.2.1 Identify EPC Project Team and Project Manager

Managing an energy performance contract will require expertise from several departments, both within and outside the agency, including facilities planning, procurement, budget and finance, maintenance, and legal. To coordinate these needs, an EPC project manager should be identified and an EPC project team formed early in the process. The project team will need diverse capabilities, including:

- Engineering expertise to evaluate energy efficiency potential, develop a scope of work, establish maintenance requirements, and help evaluate ESCO proposals and energy studies;
- Procurement and contracting expertise to ensure that the process follows applicable procurement rules during the request for proposals and contract award phases;
- Knowledge of budget and finance procedures to establish a method to budget and make payments for the duration of the contract; and

- Legal expertise to review all contract terms and assist in negotiations after an ESCO has been selected.

In addition, because a financing agreement will likely be required to fund the energy performance contract with the ESCO, the State Department of Budget and Finance and the Attorney General's office should be involved early in the process.

The EPC Project Manager should be an individual from the implementing agency who is willing, able and authorized to oversee the project and act as an internal champion and project proponent. In agencies where appropriate in-house expertise might not be available, it may be possible within the EPC budget to include an outside performance contract manager to oversee the ESCO and represent the agency's interests. Nevertheless, even with the retention of outside expertise, the regular participation and involvement of an internal Project Manager significantly enhances the prospects for a successful project.

4.2.2 Develop Project Profile and Objectives

Those facilities that will be the subject of the EPC should be profiled and relevant information regarding their operation drawn together. Generally, such information would include the facilities' size, energy use, equipment, operating schedule, maintenance problems, and any equipment replacement or renovation plans. Also included would be the utility bill history for the past three years, if available.

The objectives of the EPC program should be clearly identified. For example, what energy problems need to be solved; will ESCO or agency staff assume equipment maintenance and repair responsibilities; might the ESCO be tasked to work on non-energy projects?

Rather than pre-determining a detailed scope of work specifying what energy and water projects the ESCO should undertake, it is generally more productive to use the ESCO's technical expertise to help identify and assess the resource conservation opportunities that are most cost-effective.

4.3 Step Three –Select a Contractor (ESCO)

In accordance with Hawaii Revised Statutes Section 36-41, energy performance contracts are awarded through a public Request for Proposals (RFP) process. This process is designed to identify the organization (the ESCO) most qualified to implement the EPC program based on comparing relative abilities, experience, and expertise. In addition, as the ESCO selected to implement the EPC program will be a partner for as long as 20 years, it is important to select one that the agency is comfortable working with and that shares the agency's vision. The

RFP process is an excellent way to identify interested ESCOs, compare approaches, and evaluate compatibility and commitment.

Prior to issuing the RFP, it is important to have funds identified for temporary obligation for the initial phase of the contract: conducting an investment grade energy audit of the project facilities. The performance contract will guarantee that energy savings will pay for all project costs, including the cost of the audit. Should the agency decide not to proceed with the contract after an acceptable audit has been completed, the ESCO would be reimbursed for its efforts. Generally, the cost of an investment-grade audit ranges between 15 and 25 cents per square foot; however, in some instances, costs may be somewhat higher or lower depending upon the complexity of existing equipment and the effort required to collect accurate data.

4.3.1 Draft and Issue a Request for Proposals (RFP)

The RFP defines the scope of the project, project schedule, the procurement process, evaluation criteria, special contractual terms and conditions, and specific corporate and technical information to be submitted by the ESCO in writing. In addition, the RFP should clearly state that guaranteed energy savings must pay for all project costs for the duration of the contract. This requirement establishes the financial performance parameters of the installed project.

The RFP addresses the essential components common to an energy performance contract. It will be necessary to prepare the following project-specific information and procedures for incorporation into the RFP document.

- A project overview, describing the purpose and objective of the project; identification of the facilities to be considered; and their current energy use, facility size, and any unique conditions.
- Identification of the services desired, such as energy audit, engineering design, equipment procurement and installation, construction management, equipment commissioning, energy savings measurement and verification, project financing (sometimes, the ESCO is asked to obtain at least three preliminary bids for financing), and equipment operation and maintenance.
- Contractual terms and conditions that will apply to the project.
- A description of the required proposal format and content.
- Instructions for proposal submission, and a timetable for proposal review and ESCO selection.
- A description of the evaluation criteria that will be used as the basis for selection, including the relative importance of price and other

evaluation factors. Development of objective criteria is critical for ensuring that only the most qualified ESCO is selected.

Key information requested in the RFP should include:

- The ESCO's experience with implementing performance-contracting arrangements, and its understanding of and experience with the energy conservation measures that are likely to be installed.
- The ESCO's financial stability and experience with project financing.
- The background and EPC experience of all key project personnel specifically assigned to the project.
- The performance record of past EPC projects directly managed by the ESCO.
- The calculation methodologies used to compute base-year utility use and project savings.
- The ESCO's methods of savings measurement and verification (M&V).
- A description of the recommended operations and maintenance (O&M) program to be implemented and a detailed listing of other services provided by the ESCO.
- The proposed structure of the savings guarantee and ESCO fee payments.
- A sample investment-grade energy audit, project-commissioning plan, O&M plan, and M&V plan.
- Cost of the investment-grade energy audit should no contract be negotiated.
- Training services to be provided to facility staff.

The RFP should be sent to at least three ESCOs to ensure adequate competition among technically qualified firms. A list of accredited ESCOs is available at http://www.naesco.org/.

4.3.2 *Conduct Pre-Proposal Meeting and Site Visit*

Following release of the RFP but before submission of proposals, it is recommended that a pre-proposal meeting and a site visit be scheduled for all interested ESCOs. The purpose of these meetings is to answer any questions regarding the RFP and proposal content; and for potential proposers to become acquainted with the proposed project facilities, interview facility and agency staff, and clarify technical matters.

The site visit will provide the information necessary to prepare an accurate and credible cost estimate for the investment-grade energy audit that each ESCO must included in their proposals. Likewise, the ESCOs' ability to provide appropriate sample audit, commissioning, M&V, and O&M plans will depend on observations made during the site visit. For very large and complex projects, ESCOs may request, and should be afforded, the opportunity to make a second visit to the proposed facilities.

4.3.3 Evaluate Proposals and Select ESCO

Based on the criteria set forth in the RFP, proposers' qualifications are evaluated for skills, expertise, experience, and cost elements. The Hawaii Administrative Rules provide that the agency's procurement officer, or an evaluation committee selected by the procurement officer, evaluate proposals. Using a committee allows the evaluation to benefit not only from the expertise within the agency and the on-site knowledge of facility staff, but also from the EPC experience of personnel from other State and local agencies (such as DBEDT and the City/County of Honolulu). It is common for members of the EPC project team to also serve on the proposal evaluation committee.

Before the evaluation committee receives copies of the proposals, the procurement officer screens them to identify any that are clearly non-responsive as to content or form. In addition, the procurement officer evaluates whether the proposing ESCOs are credible organizations and meet the minimum qualifications stated in the RFP. Once responsive proposals have been identified, the evaluation committee members read, evaluate, and rank them. A numerical ranking system is used to rank the proposals.

The Hawaii Administrative Rules for competitive sealed proposals allow interviews with competing offerors and discussion of potential changes in their proposals, including price. Such discussions are optional, and a contract award can be made without any interviews; however, it is important to select an ESCO that agency and facility staff can relate to over an extended period of time. Thus, face-to-face interviews with the project teams identified in two or three of the highest-ranked proposals are strongly recommended. The use of a numerical, quantitative rating system to rank the proposers is a necessary requirement.

By tabulating the numerical rating data collected from the written proposal review and oral interview phases, a final ranking for each ESCO can be determined. The highest-ranked ESCO thus identified should be notified of its selection, and invited to enter into negotiations for the performance contract.

4.3.4 *Negotiate and Award Energy Performance Contract*

The energy performance contract is the road map for implementing and tracking the project over the term of the agreement. It should clearly define each party's roles and responsibilities and explicitly state how savings are determined and how the guarantee will function. The contract should detail the relationship between the agency and the ESCO: who is going to do what, when, at what cost, and under what conditions. Because of the long-term nature of this relationship, the contract must be carefully developed and flexible enough to accommodate both the current and future needs of the facility for the duration of the contract term.

Key topics that should be considered in developing your EPC are described below.

- **Types of Energy Performance Contracts** –The most common, and preferred, form of contracting for energy efficiency services in Hawaii is the EPC with a guaranteed energy savings provision. In this type of contract, the ESCO guarantees that the energy savings produced by the project will be greater than all project costs. If the guaranteed level of savings is not met, then the ESCO pays the agency the difference.

  A Power Purchase Agreement (PPA) is a type of Design–Build–Own–Operate contract that reflects some of the characteristics of an EPC. A PPA is a long-term agreement between an energy producer and a customer to provide electricity, hot water, etc. at guaranteed long-term rates. The power generator provides the design, financing, maintenance and support for all elements of the energy system, including management of rebates and other government financial incentives. The customer purchases the measurable output of the project (e.g., kilowatt hours) from the generator rather than from the local utility, and the generator guarantees minimum performance and services. Energy efficiency projects can be combined with renewable and on-site power generation projects into a PPA.

  It is important to note that EPCs are carefully negotiated agreements designed to meet the individual needs of the customer. They may contain components of a variety of EPC terms and conditions, and because it is rare that two customers have exactly the same needs, rarely are two agreements exactly the same.

- **Performance Contract Financing** – As discussed in Section 3, third-party municipal, or tax-exempt, leasing has developed as a tool to finance EPCs in a manner that meets the basic objective of debt -

spreading the cost of financing over the life of an asset - while avoiding statutory limitations on the issuance of public debt that exist in most jurisdictions. The Hawaii State Judiciary, as well as Hawaii and Kauai Counties, have successfully used tax-exempt leases to finance performance contracts in the recent past.

- **Required Contract Terms** – Hawaii Revised Statutes Sections 36-41 and 196-21 require that the following conditions be included in any performance contract entered into by a State agency:
  - The term of any energy-savings contract entered into pursuant to this section shall not exceed twenty years;
  - Any contract entered into shall contain the following annual allocation dependency clause:

    > The continuation of this contract is contingent upon the appropriation of funds to fulfill the requirements of the contract by the applicable funding authority. If that authority fails to appropriate sufficient funds to provide for the continuation of the contract, the contract shall terminate on the last day of the fiscal year for which allocations were made.

  - Any energy-savings contract may provide that the agency ultimately shall receive title to the energy system being financed under the contract; and
  - Any energy-savings contract shall provide that total payments shall not exceed total savings.

  The State of Hawaii Equipment-Lease Rider contains additional terms and conditions that must be applied to any lease agreement entered into by State agencies.

- **Scope of Services** - The ESCO's initial effort under the performance contract will be completing a comprehensive, investment-grade audit of energy and water use at the proposed project facilities. The purpose of the audit is to identify, quantify, and prioritize viable energy and water savings opportunities for all facets of facility operations. The investment-grade audit is addressed in further detail below, under Step 4 of the EPC process.

  The performance contract award should explicitly authorize and conditionally approve funding for the energy audit. It is important to carefully establish criteria for the factors to be addressed in the audit. The audit cost can be rolled into the energy performance contract, but it must be paid in full if the agency does not proceed with the contract

and carry out the recommended energy conservation measures. If the agency's criteria are not met, they do not pay for the audit.

In addition to formally authorizing and obligating funds for the energy audit, the performance contract should anticipate either: 1) an amendment to the contract after the energy audit has been accepted to authorize energy conservation measure design, financing, and construction; 2) payment to the ESCO for the audit should the agency choose not to proceed with the project; or 3) termination of further dealings with the ESCO should the energy audit not be acceptable.

4.4 *Step Four –Initiate Project*

4.4.1 ESCO Conducts Investment Grade Energy Audit

As described above, the ESCO's initial effort under the EPC is conducting an investment-grade energy audit (IGA), an engineering and economic analysis of potential energy and water saving projects in a facility. The IGA:

- Provides information on current energy- and water-consuming equipment and operations, and validates the facilities' utility billings;
- Identifies and recommends technically and economically feasible resource efficiency improvements for existing equipment and operations, and
- Provides the customer with sufficient information to judge the technical and economic feasibility of the recommended energy and water conservation measures.

The ESCO initiates the audit by collecting data and background information concerning facility operation and energy use for the most recent three years. It will be important for the agency to work diligently to furnish the ESCO with any operational data it may request.

The ESCO then interviews appropriate management, engineering, and maintenance personnel regarding equipment usage, operating schedules, recurring maintenance problems, significantly high maintenance costs, comfort complaints, and any energy-using equipment that is ready for replacement. The ESCO will also complete an on-site engineering survey of facilities and inspect any major energy-using equipment, including lighting, air conditioning systems, electric motors, water usage, automatic temperature control systems, hot water systems, etc. The resulting data are used to develop a preliminary list of potential energy and water conservation measures (ECMs). At this phase, the ESCO will also determine current annual, or baseline, energy and water

consumption for the individual systems that would be affected by the potential ECMs.

An IGA Report is then provided to the agency. The report describes the potential for utility savings, the approximate cost of the conservation measures necessary to achieve these savings, and a cash flow projection indicating the overall financial and programmatic effects of the project. Description of analysis methodology, supporting calculations, and assumptions used to develop a baseline and estimate savings is included.

4.4.2. *Review and Accept Investment Grade Energy Audit Report*

The agency reviews the IGA report and meets with the ESCO to discuss the proposed energy and water conservation measures and projected project costs and economics, and determine measures to further analyze. The goal of this meeting is to structure a project that includes a combination of short and longer payback ECMs that provide an acceptable simple payback and financed term, and ensures that the project can be fully funded from the resulting energy savings. The ECMs selected should reflect only those measures the agency is comfortable in pursuing.

After basic agreement is reached, the ESCO will prepare and submit a revised audit report, which will form an essential part of the energy performance contract.

4.5 *Step Five –Submit Project Plans and Arrange Financing*

Concurrent with preparation of the investment-grade audit report, the ESCO will submit a series of formal project plans, to include a:

- **Commissioning Plan** - to establish a systematic process of ensuring that the proposed array of energy conservation measures will be installed and tested to perform according to the design intent and the facility's operational needs. The plan should also address a continuous commissioning process to assure the performance of the ECMs over the life of the project.
- **Measurement and Verification Plan** – to explain how the guaranteed savings from each of the proposed ECMs will be measured and verified. Section 6 discusses the M&V process in further detail.
- **Operations and Maintenance Plan** – describing the activities the ESCO will perform related to routine, preventive, scheduled, and unscheduled actions to prevent equipment failure or decline, with the goal of increasing efficiency, reliability, and safety. Relative O&M

responsibilities of the ESCO and agency personnel should be addressed in the plan, as well as any training the ESCO will provide.

- **Financing Plan** – describing how the EPC project will be financed, including available interest rates and financing terms based on interest rates available to the agency, and how construction financing will be handled during the project development and build-out period. Further details on project financing are provided in Section 3.

4.6 Step Six –Amend Energy Performance Contract

Following the review and formal acceptance of the investment-grade audit report and draft project plans, the agency makes a decision whether to proceed to the next phase of the project: design and installation of the identified energy and water conservation measures. Should the determination be made to proceed, the performance contract would be amended in writing to establish mutual agreement on the equipment and systems the ESCO will design and install, energy baseline measurement, financing, construction, commissioning, energy savings measurement and verification, and maintenance services. Proceeding thus with the performance contract would require no additional obligation of funds, as the ESCO will guarantee that the energy cost savings produced by the installed ECMs will cover all project costs including the cost of the IGA.