Commissioning Guidelines for the Montana Energy Performance Contracting Program

1. Overview

It is the intention of the Montana Energy Performance Contracting Program to incorporate industry standard commissioning (Cx) procedures into all energy performance contracts (EPCs) implemented at public facilities in Montana. Benefits of commissioning include increased building comfort, reduced operational problems, lower installation costs, fewer contractor call-backs, and improved energy performance. The commissioning requirements outlined herein have been adapted from industry standard procedures detailed in ASHRAE's commissioning guidelines[1].

Commissioning ensures that systems are designed, installed, functionally tested in all modes of operation, and are capable of being operated and maintained in conformity with the design intent. Commissioning is a process that begins at project conception and typically ends after project acceptance. Key activities in the commissioning process include documentation of design intent, design reviews, execution of construction checklists, systematic functional testing of equipment and systems, oversight of training for operations and maintenance staff, and follow-up on any warranty issues.

2. Commissioning Process for EPC

Because of the design-build nature of EPC, the details of the commissioning activities are developed along with the project scope, rather than being explicitly defined at the beginning of the project. In an EPC, commissioning requirements must be:

1) specified in the contract,
2) defined explicitly after design,
3) implemented during construction,
4) completed prior to final project acceptance, and
5) followed-up on after acceptance.

The specifics involved in each of these five phases of an EPC are discussed below.

PHASE 1 – CONTRACT DEVELOPMENT

The scope of work for an EPC project usually evolves from an investment grade energy audit, which includes descriptions of cost-saving measures, analyses of energy and cost impacts, and the basis for a savings or performance guarantee. The contract negotiations and scope are completed based on the conceptual design presented in the investment grade audit. For complex projects, the design is typically about 30% complete at the time of contract award. Since the detailed design of the project often occurs after the contract is in place, it is impractical to define all details of the project's commissioning in the contract. It is critical, however, to include sufficient details on the commissioning process that will be followed throughout the project to ensure the benefits of commissioning are realized.

[1] ASHRAE Guideline 1-1996 The HVAC Commissioning Process and ASHRAE Guideline 0-2005 The Commissioning Process

Schedule G of the EPC contract should outline the project's specific commissioning requirements. The key items that should be specified include:

- Qualifications and affiliation of the Commissioning Agent (CxA);
- Roles and responsibilities of CxA, ESP and Entity, including witnessing of Cx activities;
- Process that will be followed to document the design intent or Entity's project requirements for each cost-saving measure or system;
- Requirements for Entity or 3rd party design reviews or submittal approvals;
- Schedule for developing and approving a Cx plan, including expected content such as:
    - Pre-functional inspections,
    - Functional testing procedures,
    - Required use of manufacturers' start-up procedures,
- Plan for seasonal testing and conditional acceptance, if needed;
- Contents and timing of periodic project reports, Final Cx Report, and Systems Manual;
- Requirements for CxA oversight of O&M training; and
- Plan for warranty walkthrough or other follow-up procedures.

Schedule G must designate both the affiliation and qualifications of the Commissioning Agent (CxA) that will lead the commissioning process for the project. The key responsibilities of the CxA are:

1) Directing the commissioning team in the completion of the commissioning requirements;
2) Overseeing or performing the commissioning tests; and
3) Verifying the adequacy of the commissioning results.

It is common practice that the CxA will be a qualified member of the ESP's staff that is doing the commissioning, making sure that sufficient time and resources are allocated for fulfillment of this role. In some cases it may be beneficial for the CxA to be from an independent third party reporting directly to the Entity.

In EPC, when the CxA is from the ESP, the CxA should NOT be part of the design or construction management team, but another individual that meets the prescribed qualifications. In some cases, however, utilizing project funds to engage a 3rd party commissioning agent, rather than have the ESP utilize internal resources, is advisable. While it is essential that contractors verify and test the installed systems, formal commissioning requires independent oversight that ensures the Entity's best interests are maintained.

Key qualifications for the individual acting as CxA include: on-site availability, experience executing the Cx process, hands-on experience testing and troubleshooting applicable systems, familiarity with a variety of testing equipment, and detailed understanding of the systems and equipment affected by the project.

The Entity should specify a representative to witness the Cx activities and to resolve any disputes that might arise. The Entity's Cx representative will also be expected to provide some oversight and approval of the commissioning activities.

Schedule G of the EPC contract should mandate the development of a written design intent for each system or cost-saving measure installed documenting the Entity's project requirements. Specific operational parameters, design details, performance requirements (conditions in addition to energy savings), or other provisions that are established by the design intent are:

- Operational parameters, such as temperature setback capabilities or operator interface features;
- Requirements for design details or ancillary items, such as sensors, valves, access, electrical, existing equipment demolition, etc.;
- Performance requirements, such as equipment efficiencies, or ton-hours of chilled water to be delivered.

PHASE 2 – PROJECT DESIGN

Once the EPC has been awarded, the design and engineering of the project scope will be completed. Commissioning related activities performed by the Cx team in the design phase include:

- ESP completes project design;
- Entity and CxA review design and approve equipment submittals;
- ESP and Entity document the design intent for each cost-saving measure or system;
- CxA develops a draft Cx Plan, including the specifics of all pre-functional inspections and functional performance tests;
- CxA develops Cx specifications for project (if needed);
- Entity and ESP review and accept Cx documents;
- CxA issues Final Commissioning Plan and specifications.

PHASE 3 – CONSTRUCTION

After the design and commissioning plan have been finalized, construction will begin. Cx related activities that occur during the construction phase include:

- Construction observation by Entity's Cx representative and CxA;
- Periodic Cx meetings are held with the project team;
- Cx progress reports are submitted by the CxA;
- Pre-functional inspections are completed and certified by the ESP prior to equipment start-up and functional testing;
- Manufacturers' start-up procedures are completed by the ESP or manufacturer's representative.

PHASE 4 – PROJECT ACCEPTANCE

Once construction is complete and ready for acceptance by the Entity, the functional performance tests are executed and the procedures are documented by the CxA. The CxA documents the test results, explicitly including how the Entity's project requirements or design intent prescribed for each system were met. Any items that did not pass shall be tracked and presented to the project team in a deficiency log. The ESP will rectify the items

and then perform a retest in the presence of the CxA to confirm that the items have been fixed. The deficiency log is then updated by the CxA, noting the date and corrective action taken. The Entity may choose to specify consequences for multiple failed re-tests to limit the possibility of excessive use of the CxA's time.

Depending on the preference of the Entity, the ESP then assembles the Final Commissioning Report or a Systems Manual, as prescribed in Schedule G of the contract. At a minimum, a Final Cx Report should be provided, which typically includes:

- Commissioning summary report;
- ESP certified pre-functional checklists;
- Completed manufacturers start-up sheets;
- Results of functional testing and verification of system performance;
- Detailed operating procedures / sequences of operations;
- Closed out deficiency log;
- Overview of training provided to O&M staff.

Some Entities may prefer to receive a more comprehensive Systems Manual, which is required for LEED certification. A systems manual typically brings together comprehensive project documentation:

- Entity's project requirements or design intent;
- Schematic system drawings;
- Approved submittals;
- Recommended record keeping procedures;
- Maintenance procedures & schedules;
- Test requirements for ongoing commissioning.

PHASE 5 – POST-ACCEPTANCE PHASE

Commissioning activities that typically extend beyond Project Acceptance include deferred functional testing and warranty verification. Often times, some functional testing may be postponed until seasonal conditions are appropriate to evaluate the system. When some functional testing has been deferred, acceptance of the project is conditional upon the success of the scheduled tests.

Most equipment installed will have a one-year warranty provided by the manufacturer. A warranty check-out with the ESP after 8 to 10 months of operation is a recommended commissioning activity. Reviewing the equipment warranties and performing a site walkthrough at this time can identify any problems that may still be covered by a manufacturer's or contractor's warranty.

3. Commissioning Plan

A Commissioning Plan should involve the following:

- Written as a user-friendly document that defines the flexibility requirements and migration path of the proposed system
- Provides complete documentation of how system design intent will meet the owner's needs

- Includes design review and post-acceptance project monitoring
- Defines design objectives for the functional use of the system
- Provides an adequate set of pre-functional test checklists to verify installation compliance with design intent
- Provides an adequate description of functional performance tests (e.g. step by step procedures)
- Do functional performance tests verify that the controls function as an integrated system congruent with design intent
- Do functional performance tests cover equipment startup, seasonal changeovers, and shut down
- Do performance tests cover system normal, alarm, and failure sequences
- Requires a master list of deficiencies and status of resolution for each item
- Are sensor accuracy tests performed with a standardized instrument
- Does performance testing include both hardware and software
- Provides effective operations and maintenance training for building operators
- Contains equipment data sheets and commissioning logs
- Contains equipment startup checklists
- Requires production of a systems manual with full documentation of the control logic in addition to O&M manuals
- Requires a final commissioning report and recommissioning schedule or continuous commissioning plan

4. Operating Parameters of Installed Equipment

Operating parameters should for the operation of the installed equipment such as sequence of operation, temperature setbacks, equipment run times, load controlling specifications and other conditions for the operation of the equipment. These should reflect the operation included in the equipment sequence of operation and the conditions specified in Schedule F Standards of Comfort in the EPC.

5. ESP's Training Responsibilities

Training is a requirement of commissioning. As such, the training program or sessions for facility personnel including the duration and frequency of the training shall be explicitly defined. Provisions for on-going training, commitments to train newly hired facility personnel, and training with respect to possible future equipment or software upgrades should also be presented. Any fees associated with the Entity's request for training beyond what the ESP is contractually bound to provide should also be defined.

Training is customized to meet the specific needs of the Entity in a cost effective manner. It is a systematic process for identifying and implementing operational and maintenance improvements and for ensuring their continued performance over time. The content of the work scope is developed to focus on optimizing the building’s systems and protecting the significant investment made by the Entity. This work scope will result in improved occupant comfort, maximum energy and operational savings and will be accomplished in a cost-effective manner.

As part of ensuring continued performance over time, the Entity should consider implementing an Asset Management software solution to optimize training and maintenance procedures. Turnover is a key concern for every building management team and an automated technology solution will assist in training maintenance personnel by automating preventive maintenance scheduling, work orders and inventory management. Maintenance personnel receive step-by-step procedures and the required parts to complete a planned or unplanned maintenance activity. In addition to saving money on unnecessary or repeated trips to equipment, the directions provide assistance to facilities personnel that do not have experience with a particular piece of equipment.

The overall goal of the training process is to assure that the HVAC, electrical and safety systems in the building are operating in accordance with the proper design intent and to maintain staff and visitor comfort during the life of the building. The process will accomplish the following:

- Building HVAC, electrical and plumbing systems will operate in accordance with the design intent that best suits the needs of the occupants and will provide a comfortable, safe and healthy environment
- Energy and operating costs will be reduced due to systems operating at maximum efficiency and through the implementation of energy efficient measures through the application of current technology
- Maintenance staff will be adequately trained to operate and maintain HVAC, electrical, plumbing and other systems in accordance with the proper design intent
- Reduction in occupant complaints reducing maintenance service calls
- Improvement in the overall building environment
- Extended service life of existing HVAC, electrical, plumbing and other systems and equipment

The key steps in the training process are outlined as follows:

- Define and document the service requirement for each system and component. Each work scope item will include the following:
    - Identify the actual work scope that is required
    - Define the frequency of service procedures
    - Identify materials required
    - Identify any special tools or skills required
    - Identify the approximate time required to perform the service
    - Identify the safety concerns for the specific work scope
- Identify the specific service scope that can be performed by in-house staff. These work items will be selected based on the following factors:
    - Availability of in-house staff.
    - Expertise required by in-house staff
    - Tools required to perform work
    - Time required to perform work
- Train the in-house staff to perform specific service scope work items. The benefits of work completion by in-house staff include:
    - The Entity will realize cost savings by self-performing work items
    - The Entity will not be dependent on outside vendors
    - Enhanced understanding of system/equipment operation by in-house staff

    - Improved job satisfaction for in-house staff due to increased responsibilities
- Identify the specific service scope to be performed by external service providers. These work items will be selected based on the following factors:
    - Requirement of specific expertise
    - Risk management of asset life
- Recommend service providers to perform work scope items. These providers will be selected based on the following factors:
    - Local presence.
    - Knowledge of Entity facilities
    - Warranty requirements
    - Specific system/equipment expertise
    - Cost of service

6. Retro-Commissioning

Retro-Commissioning is the commissioning process applied to an existing facility that was not previously commissioned. Good candidates for retro-commissioning are buildings with:

- Complex systems
- Consumption exceeding commercial building energy consumption benchmarks
- A history of operating problems
- Incomplete prior commissioning efforts
- Advanced DDC control systems
- High air change rates
- Dedicated facilities manager
- Permanent web-based metering
- Systems sub-meters
- Historical low-profile data
- Large, single HVAC systems
- Water-side economizers
- VAV systems
- Data collection to support condition-based maintenance
- Trend data from EMS
- Good utility baseline data
- Motivated and capable facility staff
- Extensive use of control strategies

Recommendations for Monitored Retro-Commissioning

- Review EMS trend logs
- Review energy use profiles
- Set alarms for savings persistence
- Continuous monitoring and optimization
- Benchmark all buildings
- Invest in staff training
- Major opportunities to resolve air system distribution noise, laboratory operational issues, better temperature control, and controls calibration
- Improved ventilation effectiveness
- Improved chiller sequence

- Improved reset controls and VAV static controls

Examples of trend logs to collect may include:

- Supply air vs. return air
- Chiller schedule
- Chiller outdoor air lockout
- Hot water supply temperature reset
- Hot water pump outdoor air lockout
- kW demand monitoring vs. outdoor air temperature
- Chiller kW vs. outdoor air temperature
- Ton hours vs. outdoor air temperature
- kWh vs. ton hours
- Run hours of ventilation fans

Monitored retro-commissioning involves three steps:

- A performance persistence tracking system
- A performance degradation review process
- A persistence problem resolution process

Examples of points that may be archived include:

- Fan static pressure
- Schedule for the fan control signal
- Air and water temperatures
- Lobby schedules
- Chiller sequences
- Chilled water valve cycling
- Supply air temperature reset