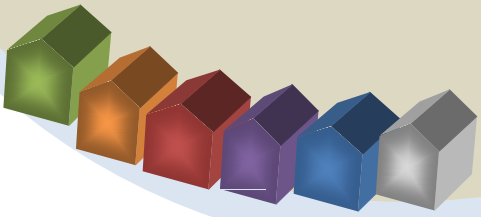
BRITISH COLUMBIA

BC Housing

Building Commissioning Guide



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Glossary of Terms

Commissioning (Cx): the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.
Commissioning Authority (CxA): the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.
Commissioning Plan: a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
Commissioning Report: a document that records the activities and results of the commissioning process, usually developed from the final Commissioning Plan with all of its attached appendices.
Basis of Design (BOD): the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.
Operations and Maintenance (O&M) Manual: a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of approved systems or assemblies.
Owner's Project Requirements (OPR): a written document that details the ideas, concepts, and criteria determined by the owner/operator to be important to the success of the project.
Maintenance and Renewal (M&R) Plan: a set of documents, based on maintenance manuals and information supplied by (sub-) contractors, that includes all the necessary information required for the owner/operator to conduct routine maintenance, meet obligations under any warranties, operate/recommission building systems, and provide the cost of future replacement for building systems/components.
Recommissioning: commissioning an existing building in follow-up to a previous commissioning process, which may be scheduled as part of an ongoing commissioning process, or which may be triggered by use change, operations problems, or other needs in an existing building.
Systems Manual: a set of documents that provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.
Test Procedure: a written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.
Training Plan: a written document that details the expectations, schedule, budget, and deliverables of the commissioning process activities related to training of project operating and maintenance personnel, users, and occupants.
Verification: the process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the OPR.

Introduction

Commissioning is an integrated set of activities intended to ensure that a project meets both the Owner's design intent and the operational needs. The Owner's goals and objectives should drive the project team. The value of commissioning lies in its power to verify and document that all building systems and assemblies are planned, designed, installed, tested, operated and maintained to meet those goals and objectives.

Historically, the term "commissioning" has referred to the process by which only the heating, ventilation and air conditioning (HVAC) systems of a building were tested and balanced according to established standards prior to acceptance by the building Owner/Operator. Today's use of commissioning recognizes the integrated nature of all building systems' performance, which impact sustainability, improve occupant comfort, productivity and indoor air quality, and reduce maintenance and operating expenses.

ASHRAE Standard 202 – The Commissioning Process for Buildings and Systems, and ASHRAE Guideline 0 – The Commissioning Process define commissioning as: "A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements". This Building Commissioning Guide provides an overall framework for building commissioning from project planning through post-occupancy, including keys to success within each phase, and roles and responsibilities of each team member to support the process. It is the Owner/Operator's way of making sure that the systems are installed properly, calibrated as planned, and performing according to project requirements. We believe this guide will streamline the commissioning process and enable Owner/Operator to improve building handover and operation.

While recognizing that every project is unique and that required activities will vary, this guide provides recommendations, minimum requirements and best practices based upon industry guidance. The level and depth of commissioning required for the project will be determined by the size and complexity of the project itself and by the needs defined in the Owner's Project Requirements.

The primary audiences for this guide are the Owner/Operator of the building, its non–profit Society, Development Team, Construction Manager/Contractor, and the Commissioning Authority. The secondary audiences for this guide include the many stakeholders in the commissioning process including the balance of the project team as well as other funding partners of the project.

This guide is organized into the following three sections:

1. ***General****:* provides commissioning benefits, roles and responsibilities of the key team members, systems to be commissioned and commissioning documents.
2. ***Commissioning Process***: details the practices and recommendations within the context of BC Housing projects, key deliverables and meeting requirements in all phases.
3. ***Appendices****:* provide tools, samples and links to further resources for additional information.

1. General

1.1 Commissioning Benefits

Because all building systems are integrated, a deficiency in one or more of the components can result in suboptimal operation and performance among other components. A properly executed commissioning process clearly expresses the Owner's Project Requirements (OPR) along with a variety of benefits including:

- fewer change orders and system deficiencies during construction
- better quality control during construction and post construction
- improved planning and coordination
- smoother handover of project from construction team to Owner/Operator
- reduced energy consumption during building operation
- improved occupant comfort, productivity and indoor air quality
- improved systems and equipment function and extended life cycle
- better building documentation and improved building operation and maintenance

In a study report prepared for the California Energy Commission analyzing energy, operations and maintenance (O&M) and energy costs of 643 commissioned and retro-commissioned buildings from 26 states across the US, the researchers found a significant improvement in building function when buildings are commissioned properly. Results from the study indicate that for existing buildings, the median building energy savings achieved through advanced commissioning is approximately 16%, while for new buildings it is about 13%. Payback times for commissioning in this study ranged from 1 to 4 years, based on the cost of commissioning and the savings related to utility and maintenance. The study also suggested that savings results persisted for a period of at least 5 years post-commissioning.

At BC Housing, the average cost of commissioning has been approximately 0.5% of the project's gross capital budget. Considering that the O&M costs for the lifecycle of a building can be up to 80% of the total project cost; a less than 1% upfront spend on advanced commissioning can lead to a savings expected within the first 5 years (or 10% of a building's lifespan) of up to 13%. This would reduce the total O&M costs by at least 1% over the course of the building's life. If recommissioning is completed every 3 -5 years, this savings in total O&M costs can increase to 5% or more.

It is therefore recommended, on both new construction and renewal projects to engage a Commissioning Authority to perform extended/advanced commissioning. Not all smaller projects will require formal commissioning but buildings with multi-purpose facilities, larger buildings, and buildings with complex mechanical or electrical systems will perform poorly without proper commissioning. Smaller high-performance buildings will need commissioning of systems, and the energy performance of the envelope should also be measured. Whatever the building type, commissioning is an all-inclusive, quality-assurance-based process, and the Owner/Operator can benefit from some level of commissioning. Recommissioning 3-5 years after completing a new building is also recommended, in order to maintain operational savings and ensure that the building operates at its optimum level.

1.2 Commissioning Roles and Responsibilities

The commissioning process is the overall responsibility of the Commissioning Authority (CxA); however it is the responsibility of the Owner/Operator and their representatives to initiate this process. The matrix in Appendix A illustrates the roles and responsibilities of the key members of the project team, with respect to the commissioning process.

It is understood that, though the CxA is responsible for reviewing the design and specifications from a commissioning perspective, the CxA is not liable for establishing design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, issuing change orders or construction management. The CxA may assist with problem-solving or resolving non-conformance or deficiencies, but ultimately that responsibility resides with the General Contractor and the Design Team under their respective contracts or professional obligations. The CxA will report to the Owner any deficiencies or discrepancies.

1.3 Systems and Assemblies to be commissioned

Modern sustainable buildings may possess sophisticated electrical and mechanical energy-efficient systems, or employ certain sustainable features that may require specialized attention to ensure they operate as designed. The following is a general list of equipment and systems to be commissioned in a typical new construction project. The Design Team and Owner/Operator should plan to work with the CxA on writing this section and making it more robust and holistic. The systems and assemblies include:

- All components of domestic water system, sprinkler system, and HVAC system
- Landscape irrigation system
- Electrical system consisting of switchboards, distribution panel boards, transformers, motor control centres, power and lighting panel boards, lighting fixtures and controls, transient voltage surge suppressors, and connections to equipment
- Refrigeration system
- Emergency power supply system
- Fire alarm system including egress system, emergency lighting systems, security/egress locking interface systems
- Equipment sound control system and testing
- Data and communication
- Security system
- Central building automation system
- Elevator including emergency recall operation and emergency in-car operation
- Building envelope including different types of wall assemblies (specific roofing, windows and doors, construction joints, etc.)
- Heat treatment room
- Commercial kitchen equipment
- Other sustainability features

While the focus includes individual equipment or systems, it is also a decidedly holistic approach emphasizing the connections between components into systems and overall building energy efficiency. The diagram below illustrates an example of how the relationship between the commissioning process and individual energy-efficiency measures are integrated.

Figure 1: Relationships between commissioning and energy-efficiency measures

KEY

Conventional efficiency measure

- Commissioning measures

Design/construction/start-up

Development and adherence to design intent documentation

- Review of submittals
- Proper equipment, thermal distribution system optimization, etc.
- Construction observation
- Training

Metering; energy management system; energy information system

- Proper/optimal application of tools and procedures
- Test and verify that systems and displays match specifications
- Trending, benchmarking, and other data for the purpose of commissioning and improved operations

Sensors for control

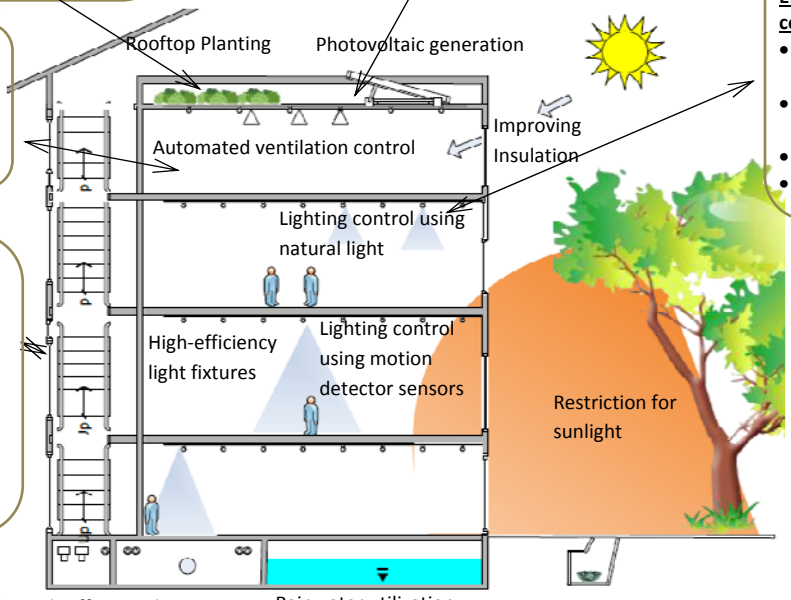
- Calibration/accuracy
- Proper placement
- Other data for commissioning

Efficient lighting equipment and controls

- Verification that equipment installed same as specified
- Controls and sensors as per design intent
- Emergency circuits always on
- Light level is appropriate

Efficient windows, insulation, other envelope components

- Verify that materials and installation match design intent
- Design and application to ensure avoidance of moisture and thermal comfort problems



Efficient HVAC equipment and controls

- Direct observation (e.g., schedules; variable-speed drive functionality disabled; time clocks not used; simultaneous heating and cooling)
- Pre-functional tests(e.g., pipe-pressure testing; duct leakage; valve leakage; witness testing in factory, if necessary)
- Functional tests (e.g., review pump and fan speeds; actuator and damper functioning; observe operation of control sequences; test extremes and crash-recovery)
- Scheduling and rests match specs; if necessary seasonal testing

1.4 Commissioning Documents

1. Commissioning Plan

The Commissioning Plan establishes the framework for how commissioning will be implemented and managed on a given project. This includes a discussion of the commissioning process, schedule, team and team member responsibilities, communication structures and a general description of the systems to be commissioned. The preliminary version of the Plan shall be developed at the pre-design Phase. During the design Phase, the Commissioning Plan is updated and incorporated into the construction contract documents. As an overview, the commissioning plan should include information on the following:

Table 1: Commissioning Plan Contents

Introduction	Purpose and general summary of the plan
General Project Information	Overview of the project, emphasizing key project information and delivery method
Commissioning Scope	Building assemblies, systems, subsystems and equipment to be commissioned on the project
Team Contacts	Project-specific commissioning team members and contact information
Communication Plan & Protocols	Documentation of the communication channels to be used throughout the project
Commissioning Process	Detailed description of the project-specific tasks to be accomplished during the pre-design, design, construction and operational phases, with associated roles and responsibilities
Commissioning Documentation	List of commissioning documents required to identify expectations, track conditions and decisions, and validate/certify performance
Commissioning Schedule	Specific sequences of events and relative timeframes, dates and durations for commissioning

2. Commissioning Report

The Commissioning Report, in contrast, shall include information on how all of the above transpired, in addition to including Issues Log, submittals, a general description of testing and verification methods, O&M manuals, M&R plans, and warranty information. Table 2 below details the contents expected in the Commissioning Report.

Table 2: Commissioning Report Contents

Commissioning Report	
Document	**Phase Started**
Commissioning Plan	Pre-design
Commissioning Plan Appendices	
• Owner's Project Requirements	Pre-design
• Basis of Design	Design
• Commissioning Specifications	Design
• Design Review	Design
• Submittal Review	Design
• Test Procedures	Design
• Issues Log	Construction
• Construction Checklists	Construction
• CxA Site Visit and Commissioning Meeting Minutes	Construction
• Functional Performance Tests & Seasonal Testing	Construction
• Training Documentation	Construction
• Warranty Review	Post-construction and Operational
• Test Data Reports	Construction, post-construction and operational
• O & M Review	Post-construction and operational
Summary (Final) Report	Post-construction and operational
Systems Manual and Recommissioning Report	Post-construction and operational

For each piece of commissioned equipment and system, the report shall contain the disposition of the Commissioning Authority regarding the adequacy of the equipment, documentation, and training that meets the contract documents.

The commissioning process is complete when a Final Commissioning Report is submitted to the Owner/Operator, after all equipment and systems are commissioned including seasonal testing. Recommissioning should take place 3-5 years post-occupancy, and will require an additional Commissioning Report, or an addendum to the initial report, with updates for all major systems and assemblies that have been recommissioned.

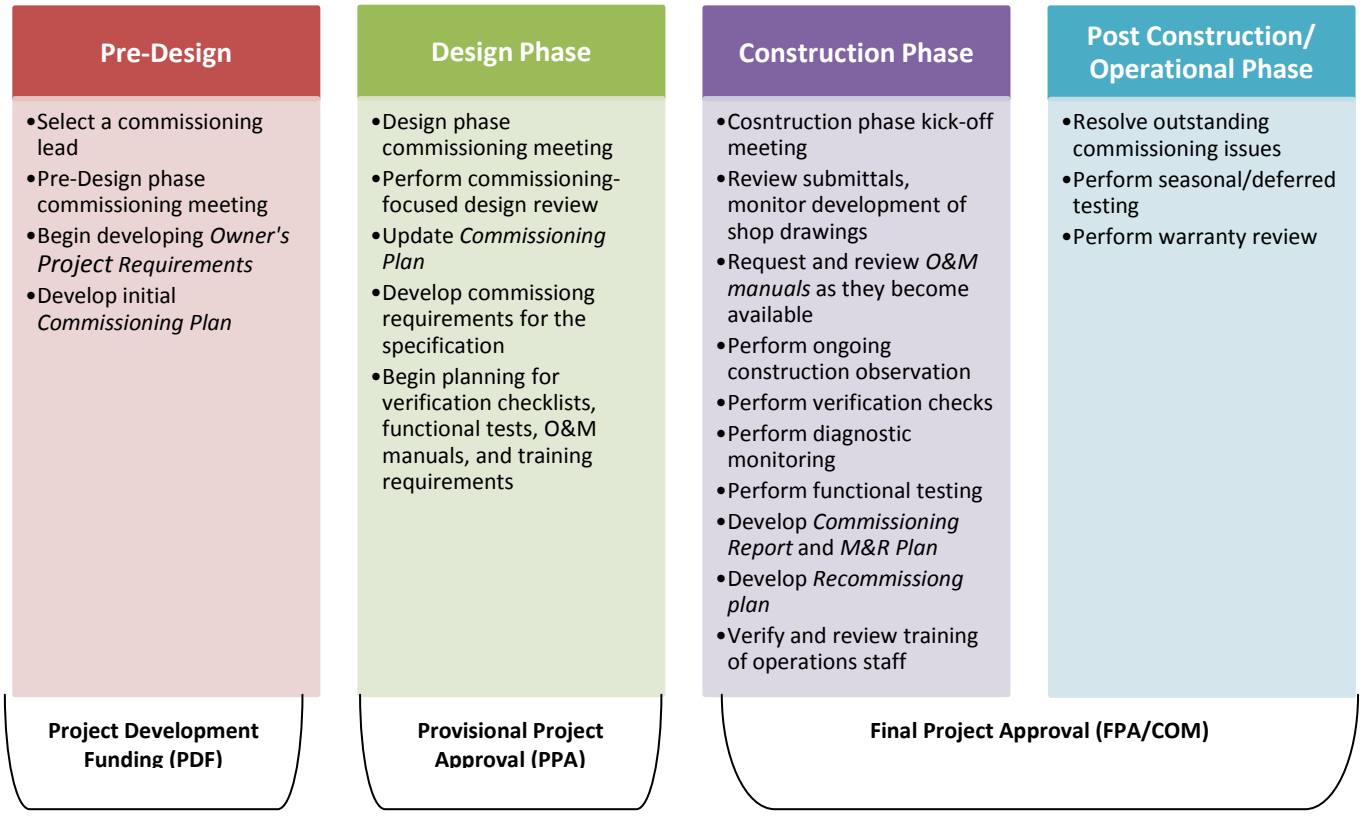
2. Commissioning Process

2.1 Overview

The commissioning process should begin in the early design stage, when the commissioning team is developed, and assists the Owner/Operator in developing the Owner's Project Requirements (OPR). Significant opportunities are lost due to the lack of integration between the Design Team and Owner/Operator needs in building, when the commissioning process is not started early enough.

Figure 2 below illustrates the typical responsibilities of a commissioning team throughout the development process and within the context of BC Housing project approval stages.

Figure 2: Commissioning overview in context to BC Housing's project approval stages



BC Housing Project Approval Stages

2.2 Commissioning Processes

It is Owner/Operator's commitment to conduct commissioning services to systematically optimize the building and ancillary systems so that they operate efficiently and effectively in accordance with the OPR, and to provide operational staff with adequate system documentation and training. It is the intent of the Owner/Operator to ensure that the fundamental systems are calibrated and operating as required to deliver functional and efficient performance.

The CxA will plan, manage, perform and report on the commissioning activities, utilizing the reporting formats and standardized forms provided by the CxA whenever required. The CxA will submit deliverable reports to Owner/Operator according to a project schedule set by CxA and agreed upon by the Owner/Operator. It is extremely important that all commissioning tasks be conducted in a transparent manner and involve the Design Team, Owner/Operator and operation staff to the greatest degree possible.

This subsection outlines the necessary steps within the commissioning process including key deliverables, specific responsibilities of the CxA and meeting requirements at a minimum, without detailing all of the project delivery process steps.

I. Pre-Design Phase:

1. Key Deliverables

- Preliminary Commissioning Plan
- Owner's Project Requirements

During this stage, adequate consideration for commissioning scope, budget and schedule shall be included in the feasibility study. Even though it is likely that all the team members (i.e. full Design Team, Construction Manager or CxA) will not be on board at this stage, completion of a project-specific roles and responsibilities matrix will help in developing the contract scope for commissioning services (refer to Appendix A for more detail). This initial roles and responsibilities matrix will be updated and confirmed during the design and construction stages once all team members are contracted.

If hired at this stage, the CxA is responsible for helping the Owner/Operator establish OPR and developing the preliminary Commissioning Plan.

2. Review Requirements

If hired, the CxA shall carry out the review of the design intent document and verify the initial design intent with the Owner/Operator and Design Team. If the project is to be LEED certified, the commissioning process activities must comply with the prerequisite requirements for fundamental commissioning and the project team may opt to pursue an added 2 LEED points for enhanced commissioning in LEED NC 2009 and 2 to 6 points in LEED v4. The CxA conducts specific review of documents pertaining to it.

3. Meetings Requirements

- Kick-off meeting at schematic design phase

A commissioning-based meeting, or portion of the kick-off meeting, should include the creation of the preliminary Commissioning Plan.

II. Design Phase

1. Key Deliverables

- Preliminary Commissioning Plan (if not completed at pre-design stage)
- Owner's Project Requirements (if not completed at pre-design stage)
- Basis of Design
- Full Commissioning Plan
- Commissioning requirements of design drawings and specifications (design development, 50% and 90% construction document)
- Written testing protocols for all commissioned equipment/systems

Regardless of the construction contracting method, the CxA shall be on board by the beginning of the design phase if not hired at pre-design phase. If a Preliminary Commissioning Plan has not been developed in the pre-design phase, the CxA will develop this plan in consultation with the Owner/Operator and Design Team. The CxA will review the OPR documentation for the project with support from the commissioning team for clarity and completeness, identify the scope and review budget for the commissioning process. The CxA will develop the initial Commissioning Plan, document the Basis of Design with support from the design professionals and verify the Basis of Design in regard to the OPR. These documents should be considered "living documents" as changes to project requirements and scope may be approved throughout the life of the project.

The CxA will develop full commissioning requirements of design drawings and specifications for all equipment and systems that are to be commissioned. They will coordinate with the Design Team and make sure the commissioning specifications are integrated into the overall project specifications package. The commissioning specifications also need to clearly reflect who is responsible for writing, directing, conducting and documenting regulatory-required tests, functional and seasonal tests. This may vary between systems, especially between electrical and mechanical. The specifications shall follow the intent of ASHRAE Guideline 0- The Commissioning Process.

The commissioning specifications will include:

- detailed description of the responsibilities of all parties, and commissioning process
- reporting and documentation requirements, including formats
- alerts to coordination issues and deficiency resolution
- construction checklist and start-up requirements
- functional testing process, adjusting and balancing for equipment and systems including seasonal testing
- comprehensive controls submittals, full Control Contractor accountability for documented point-to-point checkout commissioning participation
- specific functional test requirements, including testing conditions and acceptance criteria
- full Contractor documentation of start-up and detailed training to operational staff
- O&M manual and M&R plan documentation
- warranty requirements

The CxA is responsible to write step-by-step functional test protocols and documentation formats for all commissioned equipment, systems and assemblies. This must include examples of normal parameters under different standard operating conditions, and the relationship with other components according to the sequence of operations, not just instructions on individual pieces of equipment, systems or assemblies. Test procedures will include manual functional testing, energy-management control system trending and stand-alone data-logger monitoring. Specific tests and procedures designed to verify the performance of systems and assemblies are also to be developed and incorporated into the contract documents in this phase.

2. Review Requirements

It is recommended that the CxA shall provide at least three (3) reviews at this phase:

- During design development phase
- End of 50% construction documents phase, and
- End of 90% construction documents phase

The CxA will perform focused reviews of the drawings and specifications during various stages in design development and contract document phases. In the review process, the CxA may identify and recommend any improvements that can be made in areas such as energy efficiency, indoor environmental quality and operations and maintenance. It is the architect's (the prime consultant) responsibility that these recommendations are reviewed with the design team and incorporated in the contract documents as required.

3. Meeting Requirements

The CxA should have a minimum of three (3) review meetings and is responsible for leading review meetings and working collaboratively with the Design Team:

- Review meeting at design development phase
- Review meeting(s) at construction documents phase, and
- Controls integration meeting at construction document phase

The CxA will coordinate a controls integration meeting where the electrical and mechanical consultants, architect, and any other technical specialists shall discuss integration issues between equipment, systems and assemblies to ensure that integration issues and responsibilities are clearly described in the specifications. Additional meetings may be required to resolve any outstanding issues.

III. Construction Phase

1. Key Deliverables

- Commissioning work coordination with Design Team and Contractor
- Verification check and functional testing procedures
- Sample testing records
- Commissioning progress reports
- Owner/Operator training process

The two overarching goals of the construction phase are to coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, clear

and regular communications, consultations with all necessary parties, and to ensure the requirements of the contracts are met. It is the architect's responsibility to make sure that the commissioning activities are being incorporated into Contractor's schedule.

The CxA will perform site visits, as necessary, to observe component and system installation, review construction meeting minutes for revisions/substitutions relating to the Owner's design intent, and assist in resolving any discrepancies. The CxA will coordinate the verification check and functional test, witness and record testing, and recommend approval of test procedures performed by the installing contractor for all commissioned equipment and systems. The intent of functional testing as a whole is to evaluate the ability of the components in a system to work together. Some smaller equipment may be tested and documented by the Contractor at the CxA's discretion. The functional testing shall be conducted to:

- each of the written sequences of operation
- other significant modes and sequences, including start-up, shutdown, unoccupied mode, manual mode, staging, miscellaneous alarms, power failure, security alarm when impacted
- interlocking with other equipment, system or assemblies
- both heating and cooling seasons

After manual testing and initial troubleshooting are complete, the CxA will monitor system operation and performance by, for example, requesting trend logs provided by the Contractor, if necessary.

The CxA will prepare monthly progress reports that include:

- list of participants and roles
- brief building description
- overview of commissioning
- testing scope, general description of testing and verification methods for each piece of commissioned equipment, with the report containing the following areas:
    - equipment installation
    - equipment meeting the specifications
    - functional performance and efficiency including test data
    - equipment verification documentation including trend logs
    - operator training
- all outstanding non-compliance items and recommendations

The CxA is responsible for facilitating the entire owner-training process. This process begins in the design development stage by assuring that appropriate levels of training are planned and included in the specifications. It is expected that the CxA shall review agendas and material developed by the Contractor in advance of the training for quality, completeness and accuracy, and shall oversee the process. It is highly recommended that all training be videotaped. It is critical that operation and maintenance personnel have the knowledge and skills required to operate the facility.

Training should include:

- step-by-step procedures required for normal day-to-day operation
- adjustment instructions including information for maintaining operational parameters

- troubleshooting procedures including instructions for diagnosing operating problems
- maintenance and inspection procedures
- repair procedures including disassembly, component removal, replacement and reassembly
- upkeep of maintenance of documentation logs
- emergency instructions for operating the facility during various nonstandard conditions and/or emergencies
- key warranty requirements

This testing and documentation will also serve as an important benchmark and baseline for future re-commissioning of the facility.

2. Review Requirements

The CxA review process shall include:

- Submittals (including training process) and change orders
- Construction Checklist
- Master Issues Log

The CxA reviews submittals (i.e. coordination drawings, as-built, product data and key operations data, systems manuals and training program) concurrently with the design professional's review, reviews the change orders and verifies that the Basis of Design documents are kept up to date by the design consultants, incorporating the changes to the design that impact the building's intended performance. The CxA also identifies potential coordination issues.

The CxA writes and distributes the Construction Checklist that is to be maintained by the Contractor for commissioned equipment and systems. The intent of the Construction Checklist is to convey pertinent information to the Owner/Operator from when equipment is delivered to the job site until the point that the equipment or system is started up and operational. This includes testing, adjusting, balancing and control system tuning.

If equipment or systems are found to be malfunctioning, the problems shall be documented and listed in the Issues Log for team resolution. The CxA will maintain the Master Issues Log and provide all issues to the Contractor and Owner/Operator as they occur with test results and recommended actions. All comments and issues should be documented and logged in a format as follows:

- description of issues
- cause
- recommendation
- cost and schedule implications
- priority
- action taken
- final resolution

The Issues Log must be sufficiently detailed so as to provide clarity and a point of future reference for comments. Commissioning progress report should document the correction and retesting of non-compliance items by the Contractor.

3. Meeting Requirements

- Monthly commissioning meetings
- Selected planning and job-site meetings

It is recommended that the CxA plan and conduct commissioning meetings on a monthly basis and distribute minutes including discussion on action items, outstanding issues, schedule review, new issues, etc. These monthly meetings could be conducted as part of regular job-site construction meetings. It is also required that the CxA attend selected planning and job-site meetings to obtain information on construction progress relating to commissioning, and assist in resolving any discrepancies.

IV. Post Construction and Operational Phase

1. Key Deliverables

- Seasonal testing report
- Final/Summary Commissioning Report
- Recommissioning report

This phase will help the Owner/Operator to familiarize with the building and its systems in order to smooth their learning curve upon handover, and should not be viewed as activities focused on compliance. Refer to BC Housing Guide to Building Handover (P-GNPH-1000) for details on overall building handover process. An early stage of this process may have some overlap with the tasks identified in the construction phase.

Due to weather conditions, not all systems can be tested at or near full load during the construction phase. The CxA must use the Issues Log as a guide during post-construction or operational phase to complete all deferred testing. The CxA is responsible for delivering a final or summary Commissioning Report when all equipment and systems are commissioned and must verify a final submission of the Basis of Design in conjunction with as-built drawings and O&M manuals. This report shall include at a minimum:

- a statement that systems have been completed in accordance with the contract documents and are performing in accordance with the OPR, final Basis of Design and contract documents
- identification and discussion of any substitutions, compromises or variances amongst the final design intent, contract documents and as-built conditions
- description of components and systems that exceed OPR and those that do not meet performance (and why)
- summary of all issues resolved and unresolved and any recommendations for resolution
- post construction activities and results including deferred and seasonal testing results, test data reports and additional training documentation
- lessons learned for future commissioning project efforts

At the end of this phase, the CxA is expected to deliver a separate report of a preventative maintenance plan or a detailed operating plan that provides guidance and information needed to understand and optimally operate the commissioned systems, and establishes timelines for recommissioning in future.

2. Review Requirements

The CxA review process shall include:

- Warranty, O&M manuals and M&R plan review
- Deferred seasonal testing report review
- Operational Issues Log

The CxA critically reviews warranty, O&M manual, M&R plan and assists operational staff in developing an Operational Issues Log for documenting operational issues during the warranty period and requesting for services to remedy outstanding problems. The CxA also performs any deferred and seasonal testing as needed, reinspects and reviews the performance before the end of warranty period, and provides additional training or reports, if necessary.

During the warranty period, the CxA reviews with operational staff the current building operation and the condition of outstanding issues in the Operational Issue Log related to the original and seasonal commissioning. Any suggestions related to system improvements and changes to the O&M manuals must be made at these reviews. The CxA also identifies areas that may come under warranty or under the original construction contract.

3. Meeting Requirements

- Warranty review meetings
- Final satisfaction review meeting

At around the 6-month and 10-month marks during one year warranty period, the CxA completes the inspections with operational staff to identify problems or concerns they have with operating the building as originally intended and any items that must be repaired or replaced by the Contractor under warranty. The systems with two year warranties should be reviewed at 2 months prior to end of warranty period.

It is important that CxA leads a final satisfaction review meeting with the Owner/Operator 1 year after occupancy to obtain honest, objective and constructive feedback on what worked well throughout the commissioning process and what could have been done better. Specific discussion topics may include OPR, systems selected for commissioning, coordination issues, commissioning budget and costs, commissioning schedule, operational issue log and lessons learned.

2.3 Recommission Facility Every 3-5 Years

It is important to recognize that at 3-5 years after occupancy, the Owner/Operator will take the lead on recommissioning. Recommissioning shall include commissioning authority services. While there are obvious benefits of familiarity, the Owner/Operator may or may not bring back the project Commissioning Authority.

Appendix A

Commissioning Responsibilities Matrix

Legend: R= Responsible A = Approval C=Consult I = Inform	Project Manager / Development Consultant	Operations Personnel	Owner Rep/BC Housing	Technical Experts /Design Team	Construction Manager (CM)/ General Contractor	Commissioning Agent	Architect
Pre-Design Phase							
Identify Commissioning Team	R	I	A	C/I			C
Develop Owner's Project Requirements	R	C	A	C			C
Develop preliminary commissioning scope	R	C	A	C			C
(If hired at this stage) Contract for Commissioning Authority services	R		A	I			I
Develop preliminary Commissioning Plan	C	I	C	I		R	I
Establish budget for all Cx work and integrate costs for commissioning into project budget	R		A	C		C	C
Include time for Cx in initial project schedule	R	I	C	C		C	C
Include Cx responsibilities in Design Team and CM scope of services	R		A	C		C/I	C
Design Phase							
(If not hired at pre-design stage) Contract for Commissioning Authority Services	R		A	I			I
Hold design stage Cx meetings	I	I	I	I	I	R	I
Identify project specific responsibilities	R		I	I	I	C	C
Review Owner's Project Requirements documentation for completeness and clarity	C	C	I	I	I	R	I
Develop Basis of Design	C	C	A	C/A	I	C	R
Develop Commissioning Plan	C	I	C	C		R	C
Perform focussed Cx reviews of design drawings and specifications	I	I	I	C	C	R	C
Incorporate appropriate changes to contract documents based upon design reviews	I/C		C	I	I	C	R
Create Cx specifications including testing protocols for all commissioned equipment/systems	I	I	I	C	C	R	C
Develop functional test procedures and documentation formats for all commissioned equipment and systems	A	I	I	C	C	R	C
Integrate Cx activities into project schedule	A	I	I	I	R	C	I
Coordinate integration issues and responsibilities between equipment, systems and disciplines	A	I	I	C	C	C	R
Update commissioning plan	A	I	I	I	C	R	I
Incorporate commissioning requirements into construction Contractor's scope of work	A		I	C	C	C	R

Legend: R= Responsible A = Approval C=Consult I = Inform	Project Manager / Development Consultant	Operations Personnel	Owner Rep/BC Housing	Technical Experts /Design Team	Construction Manager (CM)/ General Contractor	Commissioning Agent	Architect
Construction Phase							
Revise Commissioning Plan as necessary	A	I	I	C	C	R	C
Review submittals applicable to equipment/system being commissioned	I		I	C	C	R	A
Develop Construction Checklists for equipment/systems to be commissioned	A			C	I	R	C
Install components and systems	I		I		R		
Review changes of systems	A		A	I/C	C	C	R
Complete (fill in) Construction Checklists as the work is accomplished	I			I	R	C	I
Continuously maintain record drawings (as-built) and submit as detailed in the contract documents	I			I	R	C	C
Coordinate functional testing for all commissioned systems and assemblies	I	I	I	C	C	R	C
Perform quality control inspections	I		I	R	C	R	C
Maintain record of functional testing	I	I/C	I/C	I/C	C	R	C
Prepare Cx progress reports	I	I	I	I	I	R	C
Hold construction phase Cx meetings	C	C	C	C	C	R	C
Maintain Master Issues Log	I	I	I	C	C	R	C
Review equipment warranties to ensure responsibilities are clearly defined	I	I		C	I	C	R
Implement training program for operating personnel	I	C	C	I/C	R	C	C
Post-Construction and Operations Phase							
Coordinate and supervise deficiency corrections	A	I/C	I/C	I/C	C	C	R
Coordinate and supervise deferred and seasonal testing	A	I/C	I/C	I/C	C	R	C
Review and address outstanding issues	A	I/C	I/C	I/C	I/C	C	R
Review current building operations at warranty review meetings	I	I/C	I/C	I/C	I/C	R	C
Complete Final Commissioning Report	A	I	I	I	I	R	I
Recommission the facility at 3-5 years after handover to reset optimal performance			R			I	

Appendix B

Commissioning Authority's Desired Qualifications

The CxA will be under direct contract to the Owner/Operator for providing commissioning services in the project so selecting a qualified CxA represents one of the most important commissioning decisions that a building Owner/Operator makes. The CxA leads the commissioning process, and works cooperatively with the architect, consultants, contractor and operational personnel but always in the Owner's interest. In particular, the CxA facilitates communication and coordination among the parties. The CxA should be well experienced and have the requisite qualifications for the project that is being commissioned.

It is the Owner's desire for the person designated as the CxA to satisfy the following requirements at a minimum:

- A bachelor's degree in mechanical or electrical engineering is strongly preferred, and P.Eng license is desired; however, equivalent technical training, past commissioning and field experience will be considered.
- Leadership in Energy and Environmental Design (LEED) Accredited Professional is desired.
- Acted as the principal commissioning authority for at least three (3) building projects of comparable size, type and scope. The experience must extend from early design phase through at least 10 months of occupancy.
- Extensive field experience is required. A minimum of five (5) full years in this type of work is required.
- Extensive experience in the operation and troubleshooting of HVAC systems and energy/building management control systems.
- Knowledgeable in building operation, maintenance and O&M training.
- Demonstrated experience with total building commissioning approach including building envelope, data and communication systems, fire protection and fire alarm systems, and other specialty systems.
- Knowledgeable in test and balance of both air and water systems. Direct experience in monitoring and analyzing system operation using energy management control system trending and stand-alone data logging equipment.
- Excellent verbal and written communication skills. Highly organized and able to work with Non-Profit Societies, Design Team, Construction Manager and other trade contractors in large scale projects.
- Experienced in writing commissioning specifications.
- Membership and certification as a Certified Building Commissioning Professional with the Building Commission Association is desired.

Appendix C

Resources and Standards

1. ASHRAE Guideline 0-*The Commissioning Process* (latest version)
2. *ASHRAE Standard 202-The Commissioning Process for Buildings and Systems* (latest version)
3. ASTM E2813-*Standard Practice for Building Enclosure Commissioning* (latest version)
4. *The Building Commissioning Guide* 2005 - U.S. General Services Administration
5. Building Commissioning: *A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*- Evan Mills, Ph.D. prepared for California Energy Commission
6. LEED Canada-NC version 4.0 - 2014

History

Version #	Procedure Guide # and Name	Reason	Date
1.0	195-00/P-GNPH-1001 Building Commissioning Guide	Original guide	March 12, 2015

Approvals

Authorized: _____

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