



# A School District's Guide to **Building Commissioning**

Alabama Department of Economic and Community Affairs,  
Energy Division  
September 2009



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# 1. Introduction

Building commissioning is the process of assuring that buildings operate as intended. This simple definition suggests two aspects intrinsic to the process — intent and assurance. Intent is a combination of building owner requirements for the facility and the established standards governing the type of building being designed and constructed. Assurance is the combination of actions taken to establish that the intended design has been achieved. This guide addresses K – 12 schools, the required standards that apply to their design and construction, and the process of assuring that those standards are met.

## Intent

To determine how well a school should operate, officials should consider key performance criteria for building systems, including energy efficiency, comfort, and indoor air quality. Building codes and industry standards have metrics by which these criteria can be assessed. The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) has published a number of guidelines that are used by the building industry and code agencies to establish minimum standards for various types of facilities. These standards set a basic framework for the design of new schools. Within the framework of these standards, school officials identify other features such as arrangement of classroom space, size, orientation, and other qualities needed for their specific situation. These all become the owner's project requirements (OPR).

## Assurance

Delivering a school facility is similar to an on-site manufacturing process: there are many points along the way where things can go wrong. The building commissioning process provides a structure for assuring the completion of critical tasks, assessing performance, and communicating key information at the needed time. To assure that a building performs as intended, a proscribed set of tasks must be accomplished at various points of the project. The tasks include knowing the right equipment to request (design); asking for the equipment (procurement); getting and properly installing the equipment (construction); and using it all correctly (operations & maintenance). Lastly, in any project, many people are involved and a lot of communicating is required. The building commissioning process should facilitate timely and efficient communications throughout the project completion. ASHRAE has also established guidelines for assurance during the commissioning process. This guide closely follows the provisions of ASHRAE Guideline 0-2005, which can be consulted for further information and more detailed guidance.

## Benchmarking

The ultimate test will be in the hands of the owner — the school system. That test will be measured by utility bills and occupant satisfaction. A school that has been successfully designed, built, and operated will have lower-than-average energy bills and will be an excellent environment for teachers to teach and students to learn.

### STANDARDS GUIDING INTENT

**International Energy Conservation Code**  
Chapter 5 – Commercial Energy Efficiency

**ASHRAE Standard 90.1**  
Energy Standard for Buildings Except Low-Rise Residential Buildings

**ASHRAE Standard 62.1**  
Ventilation for Acceptable Indoor Air Quality

**ASHRAE Standard 55**  
Thermal Environmental Conditions for Human Occupancy

### GUIDELINES FOR ASSURANCE

**ASHRAE Guideline 0-2005**  
The Commissioning Process

The U.S. Environmental Protection Agency (EPA) has created an energy performance rating system for benchmarking commercial buildings (including K-12 schools). The 1-100 rating is normalized for statistically significant attributes (including weather) and can therefore serve as a national benchmark. A rating of 50 is considered the national average. A building that receives a rating of 51 or higher is considered to have an energy performance that is above the national average. Using this rating system, EPA developed its no-cost online tools, Target Finder and Portfolio Manager. Target Finder is used in the predesign phase of a project to help building owners establish a level of energy efficient performance for their proposed building. This information is then given to designers as part of the owner's project requirements (OPR). Portfolio Manager is used to assess and track actual performance after a building has been operating for at least 12 months. Buildings that are designed based on the International Energy Conservation Code (IECC) or ASHRAE 90.1 should be able to achieve a rating better than 55. Buildings that achieve an energy performance rating of 75 or higher may be eligible to earn the ENERGY STAR.

EPA's energy performance rating system is an effective way to establish the intent of an energy-efficient school (using Target Finder) and assure that it has been attained (using Portfolio Manager). It is also a very inexpensive way to both specify and verify the energy performance level during the design of new schools or the renewal of aging schools.

### **Purpose of this Guide**

A well designed commissioning effort will include tasks that involve school district staff, the architect, engineers, and a third-party commissioning agent. Not all commissioning-related tasks are performed by a commissioning agent. The purpose of this guide is to help school officials understand the decision-making process that is essential for consistently delivering and operating high performing schools. High performing schools use less energy than the national average while providing an indoor environment that is safe, healthy, comfortable, and conducive to learning.

This guide does not attempt to cover all the issues that should be considered relating to the commissioning of K-12 Schools. Nor does it attempt to educate the community of building professionals on all technical details associated with the building commissioning process. Building commissioning has become increasingly popular in the building industry and has been addressed by many architectural and engineering professional associations across the nation. Those organizations have developed an extensive collection of reference materials and educational programs to help guide professionals through the building commissioning process.

This guide was developed to coincide with International Energy Conservation Code (IECC), which has been adopted by the State of Alabama. As this is only a guide, any conflicts found between this guide and any governing code should be resolved in favor of the governing code. It has also been designed to accommodate the processes outlined in the U.S. Green Building Council's (USGBC's) LEED for Schools green building certification program covering fundamental and enhanced building commissioning.

This guide represents a beginning step of a continuing series of resources for building commissioning in the State of Alabama.

## 2. Quick Start Guide

The Quick Start Guide is intended to provide a brief definition of building commissioning and highlight the primary components and steps that school districts can follow to ensure that they receive the appropriate level of quality and completeness during the commissioning process. More detailed information is provided throughout the rest of this guide. The “Checklist” in this section can be used by school officials to identify commissioning tasks to include in the project.

Seven major components of the commissioning process help to ensure that project requirements are clearly stated, that these requirements are accurately addressed in design and construction documents, that construction and equipment installation meeting requirements are verified, and that any deficiencies found have an opportunity for resolution.

ENERGY STAR tools help to establish a target for energy performance (Target Finder) and assess the level of performance that has actually been achieved (Portfolio Manager).

### The Seven Major Components of the Building Commissioning Process

#### 1. Commissioning Agent

A third-party qualified professional with experience in building commissioning should be retained early in project development in order to benefit from the range of services that can be provided. However, a commissioning agent should be involved in the project not later than prior to the verification of equipment installation and functional performance testing. The commissioning agent can be a resource for the Owner and the design team helping to guide the development of the Owner’s Project Requirements and the Basis of Design. The commissioning agent can develop the specifications for commissioning that will be included in the construction documents.

#### 2. Owner’s Project Requirements (OPR)

The OPR is the first step of a fundamental commissioning process. It provides a clear and concise definition of the project’s functional requirements. It can be developed as early as the pre-design phase, but must be completed before approval of contractor submittals for equipment to be commissioned. The Owner is responsible for developing the OPR, but can be assisted by the commissioning agent or project team. A template for the OPR is included in this guide as Appendix I.

#### 3. Basis of Design (BOD)

The BOD is the next step of a fundamental commissioning process. The design team is responsible for developing the BOD, which builds on the OPR and adds greater detail on how requirements will be met. The BOD should be completed before approval of contractor submittals for ordering equipment that will be commissioned. The BOD is a dynamic document that is updated throughout the design and construction process as greater detail becomes available. Another related document, the Building Operating Plan, provides a summary of key operational aspects of the major building systems and can be a valuable document for building operators once the school is completed.

#### **4. Specifications for Commissioning Requirements**

Commissioning tasks that will be required during the project, as well as the building systems to be commissioned, should be defined in the construction contract specifications. Commissioning specifications should, at a minimum, be contained in the general requirements section of the contract. System specific language can be included in related specification sections.

#### **5. The Commissioning Plan**

The Commissioning Plan is prepared by the Commissioning Authority in coordination with all commissioning team members. Ideally, the team begins preparing the Commissioning Plan in the design development phase and updates it throughout the project. A Commissioning Plan should be established prior to approval of contractor submittals of equipment to be commissioned. In addition to the minimum essential topics listed above, school officials should select the additional topics that meet their specific needs.

#### **6. System Installation and Performance Verification**

Verification of proper installation of equipment and building systems is one of the most important steps in the commissioning process. Verification of installation and system testing can be performed by a combination of the Commissioning Authority, Contractor, or Engineer of Record depending on the specifications that are directing this aspect of commissioning. Another important aspect of this step is assessing conformance with the OPR/BOD — confirming that the owner's intent has been met.

#### **7. Summary Commissioning Report**

A summary commissioning report provides the results of the commissioning effort. The report should provide the results of functional tests. It should highlight significant observations, conclusions, and outstanding issues that have not been resolved. It should note any testing scheduled in the future due to seasonal conditions. Other items can be summarized and included in the report depending on the scope of commissioning, such as, training agenda and participants of completed training, etc.

### **The Two ENERGY STAR Tools for Energy Performance Management**

#### **1. Target Finder**

Target Finder enables the Owner to establish an energy performance target for the building, which can be communicated to the designer through the Owner's Project Requirements. Based on EPA's 1 to 100 rating system, the Owner selects a desired Target Finder Score for the building's energy performance, .

#### **2. Portfolio Manager**

Portfolio Manager is also based on EPA's energy performance rating system and enables the Owner to assess the actual performance of the facility after 12 months of normal operating conditions. The building is benchmarked against a national average to determine its relative energy performance on a scale from 1 to 100 (a rating of 50 is considered average).

## Commissioning Process Checklist for School Districts

### 1. Secure the services of a qualified third-party commissioning agent.

- 1.1 The services of a third party commissioning agent have been secured.
- 1.2 The commissioning agent meets the owner's desired qualification level.
- 1.3 A well defined scope of commissioning services has been established.
- 1.4 The RFQ procurement process for professional services was used for securing commissioning services.

### 2. Complete Owner's Project Requirements (OPR)

- 2.1 The Owner has documented the functional requirements for the school and the expectation of the school's use and operation relating to the systems to be commissioned (see Appendix I – Owner's Project Requirements (OPR) Template).
- 2.2 The OPR has been completed prior to approval of contractors' submittals for ordering equipment to be commissioned.

### 3. Document the Basis of Design (BOD)

- 3.1 The design team has documented primary design assumptions, standards, and narrative descriptions concerning the performance requirements of all major building systems to be commissioned.
- 3.2 The BOD includes assumptions about space use, redundancy, equipment or load diversity, climatic design conditions, space zoning, occupancy, operations and space temperature & humidity requirements.
- 3.3 The BOD includes references to applicable standards, codes, guidelines, regulations and other references that will be followed.
  - 3.4 The BOD has been completed prior to approval of contractor's submittals for ordering equipment to be commissioned.
  - 3.5 The BOD includes performance criteria for major building systems and other supplementary components.
    - The BOD includes performance criteria for (select all that apply):
      - 3.5.1 the building envelope (see IECC, Section 502).
      - 3.5.2 for mechanical systems (IECC, Section 503).
      - 3.5.3 for service water heating (IECC, Section 504).
      - 3.5.4 for electrical power and lighting systems (IECC, Section 505)
      - 3.5.5 the total building performance (IECC, Section 506)
- 3.6 The BOD includes energy targets based on the owner's desired ENERGY STAR Target Finder Score.
- 3.7 A Building Operating Plan has been completed for the school that summarizes the BOD for use by operations and maintenance personnel (See Appendix J – Building Operating Plan Template).

### 4. Specifications for Commissioning Requirements

- 4.1 Commissioning requirements are incorporated into the project's construction documents.
- 4.2 Commissioning is addressed in General Requirements Section (see Appendix G – Sample Contract Specifications for Commissioning)

- 4.3 Commissioning is addressed in other places (select all that apply):
  - 4.3.1 Commissioning is addressed in special sections related to the systems to be commissioned (e.g. HVAC, Electrical, etc.).
  - 4.3.2 Commissioning requirements are referenced on drawings for applicable systems.
  - 4.3.3 Commissioning requirements are referenced on bid forms.
- 4.4 Commissioning requirements address the following (select all that apply):
  - 4.4.1 The commissioning team is designated.
  - 4.4.2 Submittal review procedures are described for equipment being commissioned.
  - 4.4.3 O&M documentation and systems manuals are addressed.
  - 4.4.4 The Start-up Plan (development and implementation) is described.
  - 4.4.5 Equipment/system installation verification (pre-functional or “start-up” inspection) procedures are established.
  - 4.4.6 Test, Adjust, and Balance (TAB) procedures are established.
  - 4.4.7 Functional performance tests are identified and described.
  - 4.4.8 Acceptance and closeout procedures are described.
  - 4.4.9 Training of operations and maintenance personnel is described.
  - 4.4.10 An on-site warranty review is addressed.

## 5. The Commissioning Plan

- 5.1 A Commissioning Plan has been developed for the project.
- 5.2 The Commissioning Plan was established prior to approval of contractors’ submittals.
- 5.3 The Commissioning Plan addresses the following topics at a minimum (select all that apply):
  - 5.3.1 Systems to be commissioned have been identified.
  - 5.3.2 The commissioning team has been identified.
  - 5.3.3 The process of verifying the proper installation of equipment to be commissioned (pre-functional or “start-up” inspections) has been described.
  - 5.3.4 Functional performance testing procedures have been described.
  - 5.3.5 The process for reporting and resolving deficiencies has been described.
- 5.4 The Commissioning Plan addresses the following additional topics (select all that applies):
  - 5.4.1 The process for reviewing contractors’ submittals of equipment to be commissioned has been described.
  - 5.4.2 The process for building system acceptance has been described.
  - 5.4.3 Systems Manual development has been addressed.
  - 5.4.4 Procedures for verifying the training of operations and maintenance personnel have been described.
  - 5.4.5 The process for assessing building operation and performance after acceptance (10-month within warranty period) is described.

## 6. System Installation and Performance Verification

- 6.1 A Commissioning Agent has been designated to verify the installation and performance of building systems to be commissioned.
- 6.2 The number of systems to be inspected/verified has been established.
- 6.3 The sample size for number of systems to be inspected by the commissioning agent has been established (select any that apply):
  - 6.3.1 A minimum sample size of systems to be inspected has been established at \_\_\_\_\_ [10% minimum, or other percent chosen by the owner].

- 6.3.2 Special instructions on the sample size of systems to be inspected has been applied to specific portions of the project and specified in the construction documents.
- 6.4 A Commissioning Agent has verified that equipment and building systems to be commissioned have been installed properly (pre-functional “start-up” inspection) based on designated sampling.
- 6.5 A Commissioning Agent has overseen/reviewed the functional performance testing of equipment identified for commissioning based on designated sampling.
- 6.6 A Commissioning Agent has evaluated the results of the functional performance testing compared to the requirements of the OPR/BOD based on designated sampling.
- 6.7 Discrepancies found during inspection and testing have been recorded and tracked for resolution.
- 6.8 The results of the commissioning effort verify that commissioned school building systems are performing as intended according to the OPR/BOD.

**7. Summary Commissioning Report**

- 7.1 A Commissioning Report has been completed for the project.
- 7.2 The Commissioning Report addresses the following topics at a minimum (select all that apply):
  - 7.2.1 The Executive Summary describes the overall process and results of the commissioning effort, including an indication of whether commissioned systems meet the performance requirements of the OPR/BOD.
  - 7.2.2 A list of deficiencies found during the commissioning effort and how they were resolved, including future testing that must be done during a particular season, are included in the report.
  - 7.2.3 Results of the functional performance tests and evaluation are included in the report.
- 7.3 The Summary Commissioning Report addresses the following additional topics (select all that apply):
  - 7.3.1 A summary of design review issues is included in the report.
  - 7.3.2 A summary of construction documents review issues is included in the report.
  - 7.3.3 A summary of contractor submittal review issues and significant highlights are included in the report.
  - 7.3.4 A list of the O&M documentation being provided to the owner is included in the report.
  - 7.3.5 The training syllabus that was accomplished and a list of participants is included in the report.
- 7.4 A supplemental commissioning report for end of warranty review has been completed, which includes a summary of the issues of the building operation and performance assessment conducted after acceptance (10-month within warranty period).

**Energy Performance Benchmarking for School Districts**

**1. Target Finder**

- 1.1 An ENERGY STAR Target Finder Score was established for the project:

**2. Portfolio Manager**

- 2.1 An ENERGY STAR rating for the project was determined to be:

### 3. Benefits of Building Commissioning

Commissioning creates benefits for both new and existing buildings. It not only ensures that major building systems in new schools are designed, installed, tested and operated in accordance with the owner’s intent, it can also restore existing buildings to optimum performance through renovation and tuning of existing systems. More and more examples of the benefits of commissioning in schools can be found every day. These benefits include reduced energy use, lower operating costs, reduced contractor callbacks, better building documentation, improved occupant productivity and verification that the systems perform as intended.

When implemented correctly, the commissioning process focuses on quality control and high performance building principles from project inception through operation. New building commissioning projects can include the broad range of systems — building envelope, mechanical, lighting and fire safety. Commissioning of existing buildings, also termed “re-commissioning” or “retro-commissioning,” typically results in optimized mechanical and electrical systems — maximizing energy efficiency and thereby minimizing environmental impacts.

<b>Examples of School Commissioning Projects</b>			
<u>School</u>	<u>SF</u>	<u>Cx Costs</u>	<u>Annual Savings</u>
Idlewild Elementary	46K	\$37,550	\$6,600
Oakbrook Elementary	49K	\$37,950	\$7,000
East Valley Middle		\$8,700	\$6,100
North Clackamas High		\$85,000	\$13,700
Riverside High/Chattaroy El	48K	\$32,400	\$6,900
Sexton Mountain Elem		\$14,014	\$9,100
North Thurston High	170K	\$42,180	\$24,300
Yelm Prairie Elementary	40K	\$25,760	\$2,160
Total:		\$283,554	\$75,860

This list represents both new and existing school commissioning projects.

[Information obtained from BetterBricks, the commercial building initiative of the Northwest Energy Efficiency Alliance, which is supported by local utilities.]

A properly designed and executed Commissioning Plan can reduce errors and omissions in the design and installation process, improve coordination, reduce change orders, and generate substantial operational cost savings compared to systems that are not commissioned. In the chart above, the average simple payback for the energy savings that can be attributed to commissioning is less than 5 years. The benefits will last much longer.

Researchers at Lawrence Berkeley National Lab (LBNL) completed a meta-analysis of 85 new construction commissioning projects in 2004. LBNL developed a detailed and uniform methodology for characterizing, analyzing and synthesizing the results. For new construction, this study found a median payback time of 4.8 years from quantified energy savings alone (excluding savings from non-energy impacts and other benefits of commissioning).

- Benefits of Commissioning**
- Early detection of potential problems
  - Fewer change orders
  - Precise tune-up of HVAC systems and controls
  - Better building documentation
  - Trained building operators
  - Shortened occupancy transition period
  - Lower operation and maintenance cost
  - Lower utility bills
  - Healthy and comfortable work environment

This study further concludes—

“Some view commissioning as a luxury and ‘added’ cost, yet it is only a barometer of the cost of errors promulgated by other parties involved in the design, construction or operation of buildings. Commissioning agents are just the ‘messengers’; they are only revealing and identifying the means to address pre-existing problems. We find that commissioning is one of the most cost-effective means of improving energy efficiency in commercial buildings.”

## 4. ENERGY STAR Tools

The purpose of ENERGY STAR's free Web-based tools is to provide an independent third-party verification of a school's energy performance. *Target Finder* is a predictive tool that enables school officials to specify a level of energy performance for a new school to building designers. *Portfolio Manager* is an assessment tool that enables school district officials to track and measure the energy performance of a school once it's been operating for at least 12 months.

EPA's energy performance rating system is based on the Commercial Building Energy Consumption Survey (CBECS) conducted by the Energy Information Administration (EIA), which surveys thousands of buildings across the nation. A statistical analysis is performed on this large sample size to determine which school building space attributes are significant in determining the energy performance of a school.

Figure 4-1 shows K-12 school space attributes that have been determined to be the most statistically significant in determining energy performance. Based on the formulas used by EPA, the attribute data for any school can be compared to a national average to obtain an overall rating (from 1 to 100). A rating of 50 is considered to be the national average.

The rating system works like this: A school official enters location and space attribute data (described in Figure 4-1). Based on these data, the system accounts for the impact of weather variations as well as changes in key physical and operating characteristics for each building. If *Target Finder* is used, that information will be used to determine the level of energy use intensity will achieve the target rating. If *Portfolio Manager* is used, the actual energy use data entered by the school official will be compared to energy use data for similar buildings across the nation from the CBECS database. If the actual energy use intensity, determined from data entered from energy utility bills, is lower than the calculated national average energy use intensity for the school, then the school will achieve a rating greater than 50, indicating that it is above average.

**Figure 4-1**  
**Statistically Significant School Space Attributes**

- Zip Code
- Gross Floor Area
- Open Weekends?
- Number of PCs
- Number of walk-in refrigeration/freezer units
- Presence of cooking facilities
- Percent cooled
- Percent heated
- High School?

### Target Finder

Target Finder should be used early in the pre-design phase to give school designers the key criteria necessary to make design decisions about energy efficiency. Some of the space attribute data shown in the chart above may have to be estimated. Once all the requisite data is fed into the tool, a site energy use intensity (EUI) is generated that should be given to the design team. Their design will be based on delivering a school that can achieve the level of energy performance indicated by the specified site EUI. The following general steps are used to complete the process for determining a desired site energy use intensity for a school.

- **Step 1 – Facility Information**  
Enter facility information (zip code and location).

- **Step 2 – Facility Characteristics**  
Enter space type (K-12 School) and fill in the space attribute information (estimating, if necessary, some of the values).
- **Step 3 – The Target**  
Enter the target rating — anything above 50 will be above average. A rating of 69 or above meets the U.S. Green Building Council’s LEED for Existing Buildings: Operations & Maintenance Rating System minimum performance level for energy performance. A rating of 75 or above may be eligible to achieve Designed to Earn the ENERGY STAR.
- **Step 4 – View**  
Click on “View” to see the results of your rating target.
- **Step 5 – Estimated Design Energy**  
As the design progresses and more information becomes available, enter estimated energy fuel sources (electricity, natural gas, etc.) that result from actual design criteria. This information will reveal a projected rating once you click on “View.”

**Figure 4-2**  
**Sample Target Finder Results for Proposed High School near Montgomery, AL**

<b>Target Energy Performance Results (estimated)</b>			
<b>Energy</b>	<b>Design</b>	<b>Target</b>	<b>Top 10%</b>
Energy Performance Rating (1-100)	61	70	90
Energy Reduction (%)	10%	17%	38%
Source Energy Use Intensity (kBtu/Sq. Ft./yr)	173.4	159.5	119.7
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	75.9	69.9	52.4
Total Annual Source Energy (kBtu)	17,339,796.0	15,951,914.3	11,965,424.0
Total Annual Site Energy (kBtu)	7,594,400.0	6,986,542.3	5,240,558.5
Total Annual Energy Cost (\$)	\$170,750	\$157,083	\$117,827
<b>Pollution Emissions</b>			
CO2-eq Emissions (metric tons/year)	1,001.6	921.4	691.1
CO2-eq Emissions Reduction (%)	10%	17%	38%

Figure 4-2 presents an example of a proposed 100,000 SF high school near Montgomery, AL. The data output in the column labeled “Target” appears after Step 4. A rating of 70 was selected in the tool, and the estimated annual cost of energy was calculated to be \$157,083. Later, as the design progressed, the designer was able to enter more complete data on projected energy use (amounts and costs of electricity and natural gas). The data output in the column labeled “Design” appeared after Step 5. A rating of 61 is projected to be achieved by the project based on its current design energy performance.

The output results of the tool include estimated energy utility costs based on the various design rating scenarios. Based on the above information, the school will spend \$13,667 more per year on energy using

the current design rating of 61 than the design with the target rating of 70. This information can be used by school officials to determine whether the additional investment in more efficient technologies in the new school will be worth the additional cost based on their priorities.

## Portfolio Manager

The Portfolio Manager benchmarking tool is used to obtain a rating for how a school is actually performing once it has been operating normally for at least 12 months. After the school and all building systems are operating as intended, this rating will verify how well the school actually performs. The following general steps are used to complete the process for determining the actual site energy use intensity and ENERGY STAR energy performance rating for the school.

- **Step 1 – Register/Establish a Portfolio Manager Account**  
Follow the steps starting from the Portfolio Manager Login Page and complete the online form on the subsequent screens. Further details are provided in Appendix H.
- **Step 2 – Add a Property**  
Click on “Add a Property” and enter the data for the school being rated.
- **Step 3 – Add a Space**  
Click on “Add a Space” on the newly created school facility page and enter requested space attributes and other data.
- **Step 4 – Add an Energy Meter**  
Click on “Add Meter” to set up the energy account for billing information. A meter for each energy fuel type must be established with at least 12 months of data.
- **Step 5 – View Current Rating**  
Once all the data have been entered, the current rating will appear on the “My Portfolio” page and on the school’s facility page. Figure 6-3 is an example of a Portfolio Manager “View.”

**Figure 4-3**  
**Sample Portfolio Manager Results for Example High School near Montgomery, AL**

12 Months Ending	Current Rating (1-100)	Current Source Energy Intensity (kBtu/SF)	Current Site Energy Intensity (kBtu/SF)	Current Total Site Energy Use (kBtu)	Annual Energy Cost (US Dollars (\$))	Current Total GHG Emissions (MtCO <sub>2</sub> e)
September 2009 (Current)	42	201.4	87.8	8,776,800.0	\$198,000	1,164.1

The example in Figure 4-3 shows that the actual energy performance is lower than anticipated. Instead of a rating of 61, the school only achieved a rating of 42. Compared to the estimated design annual energy cost of \$170,750, the school experienced actual energy bills totaling \$198,000 — over \$27,000 more per year. Something has gone wrong between the initial design and the post-construction operation period. If the school facility was designed, constructed and operated in accordance with the applicable building codes and standards, it should receive a rating of at least 55. If the designers were given a Target Finder rating of 61, the resulting rating should be much closer to the projected rating than a 42. This indicates

that some action should be taken to resolve this problem. If the problem is not addressed, then the school district will continue to pay as much as \$27,000 or more per year in annual energy costs for what is essentially wasted energy.

Once a school is up and running, there are many factors that may affect the school's energy performance. Proper functioning of all building systems is just one of these factors. The following series of action responses shown in Figure 4-4 are recommended if this occurs for a newly constructed school. The steps are presented in order of the least expensive to the more costly.

**Figure 4-4  
Response Steps for Lower Than Expected Energy Performance**

1. Check for 12 consecutive months of normal operation.	In the first month or two of new occupancy, energy use at the school will likely not be optimal. Systems are still being adjusted, furniture is being moved in causing doors to remain open, and final occupancy schedules (and equipment runtime schedules) may not have been set. Using utility bills covering this period will skew the results of the ENERGY STAR performance rating. Select utility bills for the period when normal operation began.
2. Check Portfolio Manager Data for errors.	Key data elements include zip code, all space attribute entries, and utility bill data entries. Check to make sure proper units and decimal point placement for utility bill data were properly entered.
3. Check for utility bill errors.	Several things can happen to the metering of a new school. Check the utility bill to confirm the correct rate. Assess whether readings seem reasonable (demand and consumption). Ask the utility company to make sure that the correct multipliers have been used for converting meter units to kW and kWh.
4. Use load profiles to pinpoint power usage.	If the school has a digital meter, it may be possible for the utility company to provide a load profile for a one- or two-week period. A load profile uses interval data from the utility meter to project a graph of power usage during a 24-hour period. If there is unusually high power demand at night, it could be caused by unnecessary loads that should be turned off.
5. Check system operational settings.	Assuming that all building systems are functioning properly, check all equipment and system run times and how well they are matched to occupied periods. Building Automation Systems (BAS) may have been set at defaults that don't match current requirements. Original settings may have been overridden at some point during the 12 or so months since initial occupancy. Depending on the complexity of the mechanical systems, a number of sensors and controls may need to be re-checked for proper settings. Some components may have undergone premature failure.  Some operations will be handled manually. School staff will be

	learning new procedures and schedules, especially for outdoor lighting — sports field lighting, exterior grounds lighting and parking lot lighting. Systems that are manually controlled are vulnerable to being left unattended or left in override states.
6. Use portable data-logging equipment to monitor major sub-systems.	If the problem still has not been found, then using portable monitoring devices may help isolate the problem area. Such devices can easily measure equipment run times, amount of current or power, temperature and humidity settings. Submetering for power use can help determine if a system is drawing more power than should be expected based on the manufacturer's specifications.
7. Check for component failures.	Small system component failures may not cause the entire system to fail, but it may cause it to operate inefficiently. These kinds of problems may also be difficult to spot. A systematic inspection routine should be used to check each component to ensure its proper functionality.
8. Check past Commissioning Report and Issues Log.	If the school's major energy consuming systems have gone through a commissioning process, then review the final Commissioning Report and Issues Log to make sure that all issues were in fact corrected.
9. Check Design and Construction Documents.	If components were not properly installed in the system, check for errors in the original design. Complex systems will be more vulnerable to this type of problem.
10. Isolate specific equipment for technical analysis and commissioning.	If the school's major energy consuming systems have not gone through a comprehensive commissioning process, then isolate potential problem systems for further technical analysis and commissioning. Some complex systems will require a specialist to investigate the problems. Fan units or pumps accidentally installed backward, incorrect piping, or mis-wiring of controls or other components can be difficult to spot without a specialist that knows what to look for. Even if the warranty period has expired, the original contractor may still have an interest in resolving the problem if it is due to improper installation. Otherwise, an independent technical expert will need to assess the problem.

If school officials get to the final step of this list and are still not satisfied with the school building's energy performance, they should consider conducting an ASHRAE Level II Energy Analysis or the investigation and analysis phase of a retro-commissioning process.

## 5. Standards for Design and Construction of K-12 Schools

The purpose of design and construction standards for K – 12 Schools in Alabama is to ensure that students, educators and staff have a safe and healthy place for learning. Another important purpose is to ensure that these facilities are designed and constructed to be durable, efficient in their operation and a reasonable value for the community. These form the “intent” of design.

Building standards are established to control how the space is used, as well as how it is constructed. Space use addresses issues such as number of students that can be housed in a given floor area, size of common areas compared to number of students, and other matters related to the occupants of the school. The building structure itself also has to meet various standards. These standards address issues such as fire safety and security (for example, access to the outside and fire retardant materials). Four physical aspects of the building that directly relate to energy efficiency are the building envelope, mechanical systems, service water heating and lighting systems. These are the four most significant building systems that affect the building’s energy efficiency performance. Therefore, standards that address these areas will impact how efficiently energy will be used.

The State of Alabama does not adopt or enforce a statewide building code for all structures. However, the State does require that state buildings, hotels, schools and motion picture theaters meet the requirements set forth in the 2006 International Building Code.

The Alabama Building Commission has adopted the International Energy Conservation Code (IECC). This code establishes the minimum requirements for key aspects of new school construction — the building thermal envelope, mechanical systems, service water heating and lighting systems. The code also allows for the use of ASHRAE 90.1 in lieu of IECC during the design of new buildings.

The IECC and ASHRAE 90.1 are very similar and address the same building systems. The table below shows how sections in the IECC compare to ASHRAE 90.1.

Comparison of IECC to ASHRAE 90.1	
<b>ASHRAE 90.1</b> Energy Standard for Buildings Except Low-Rise Residential Buildings	<b>IECC</b> Chapter 5 – Commercial Energy Efficiency
Section 5 – Building Envelope	Section 502 – Building Envelope Requirements
Section 6 – HVAC	Section 503 – Building Mechanical Systems
Section 7 – Service Water Heating	Section 504 – Service Water Heating
Section 8 – Power	Section 505 – Electrical Power & Lighting Systems
Section 9 – Lighting	
Section 10 – Other Equipment	

### Building Thermal Envelope

The building envelope consists of all the elements of the building that provide a barrier between the inside conditioned space and the outdoor environment. These elements include walls, floors, windows, doors, penetrations, insulation, and roofs and ceilings. The early design choices for these elements in many cases will be locked in for the life of the building. Therefore, it is essential to ensure that the design and

construction of these elements are consistent with energy efficiency standards. As much as 5% of the energy used in a school can be attributed to a poor building envelope. For a 100,000 SF school facility in Alabama, that could equate to additional energy costs of as much as \$10,000 per year or more.

### **Mechanical Systems**

Mechanical systems include all components used to heat, ventilate, air-condition and control the temperature of the space inside the building envelope (HVAC systems). The early design choices for these systems, including type and size of systems, will have an impact on the cost of energy needed for the system as well as the cost of operating, servicing and maintaining such systems. Operational conditions such as requirements for maximum heating and cooling set points within the occupied space will also have a significant impact on energy use. Energy for HVAC systems can average about 55% of the total annual energy cost of a school. Using the 100,000 SF school example above, decisions on types of systems can range from between 5% and 10% in their impact on school energy costs, adding as much as an additional \$10,000 to \$20,000 per year or more.

### **Service Water Heating**

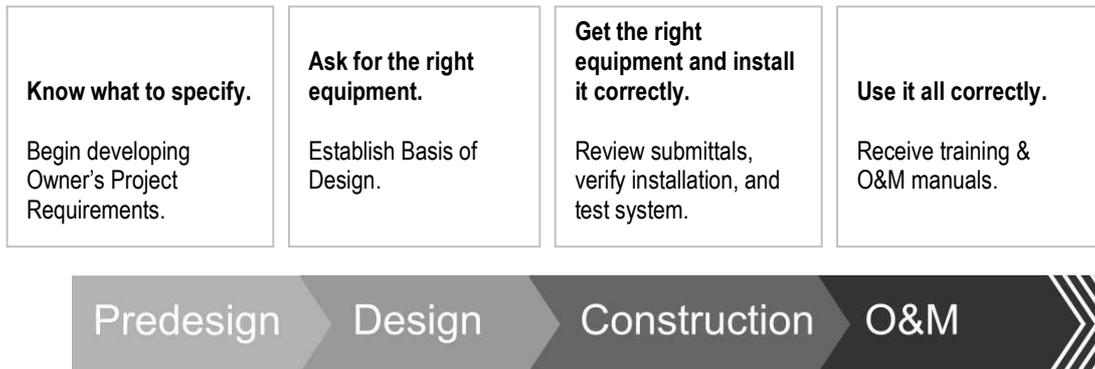
Water heater efficiency is solely dependent on the manufacturer supplied system. The National Appliance Energy Conservation Act (NAECA) supersedes the minimum efficiency requirements addressed in the 2006 IECC. Manufacturers must comply with NAECA; therefore, the equipment purchased by the contractor should automatically comply with the provisions in the IECC.

### **Electrical Power & Lighting systems**

Lighting systems include both interior and exterior systems, how they are controlled and the intensity of illumination. Under-lit spaces can cause problems for reading and other learning tasks. Over-lit spaces can also be a problem for learning activities as well as a waste of energy. Successful lighting control schemes allow occupants to reduce lighting when not needed as well as automatically turn it off during periods of non-occupancy. The early design choices for these systems can lock in a pattern of energy use that could be hard to modify after systems are installed. Energy for lighting can average as much as a third or more of the annual energy cost of a school. As much as 5% in additional energy use could result from poor lighting design and control. Using our sample school of 100,000 SF, this could equate to as much as \$10,000 per year or more.

In the worst case scenario, as much as \$40,000 per year in energy costs could be wasted in our 100,000 SF school example due to poor design and construction performance. These problems could emerge at any point during the design and construction process. Figure 5-1 shows the four major project phases of a new school project — pre-design, design, construction, and operations and maintenance. Mistakes made in any one of these phases will have a direct impact on the overall performance of the school.

**Figure 5-1 Project Phases**



**New School Delivery – Project Phases**

**Pre-design – Know what to specify.**

Building system features and space function requirements form the basis of the Owner's Project Requirements (OPR). The OPR document embodies the design intent and marks the beginning of the project journey. Each step of the way demands close communication as the project passes from one phase to another and to different groups of people. School officials should know that they can ask for more than just a school with a given number of classrooms, interior and exterior treatments, and siting. They can specify that certain project development practices be performed throughout the project cycle. They can ask that the school facility be designed to achieve a specified level of energy performance.

**Design – Ask for the right equipment.**

Once the design team is on board, the OPR will be translated into the Basis of Design (BOD). The BOD provides the next level of specificity. It identifies the type of building systems that will be needed in the design. These systems will be specified in the construction documents given to the contractor. The designer will need to determine which systems and configurations will achieve the OPR and the level of building energy performance specified by school officials.

**Construction – Get the right equipment and install it correctly.**

The BOD eventually gets translated into construction documents that are given to the construction contractor. During construction, all building components have to be procured based on the instructions given to the contractor. This process involves selecting manufacturers, selecting the right product and model, as well as ordering, receiving, inspecting, storing, installing, and testing. Problems at any point during this process can affect the success of the project and the level of building energy performance that is achieved. Having a process that inspects, tests, identifies problems, corrects problems and rechecks the new installation (if required) will be critical to assuring that all systems perform as intended.

**Operations & Maintenance – Use it all correctly.**

Even the best designed school facilities need to be operated correctly to achieve high levels of building energy performance. Once the building systems have been installed by the contractor, operating manuals and training support need to be provided to the school building operators. Checks should be made to ensure that all outstanding issues are resolved (or at least identified) prior to the end of the warranty period.

One of the objectives of this guide is to provide information on how to establish a systematic and cost-effective process for ensuring that schools are designed and built to meet required standards for health, safety and efficiency. The process itself should also be efficient and matched to the degree of complexity associated with the school's building systems. This building commissioning process begins at the earliest phase of the project. Some commissioning tasks can be performed by in-house school district professionals. At some point, school officials should seek the qualified services of a building commissioning professional that will report directly to them and represent their interests. The building commissioning process is essentially a quality assurance function and is most successful when conducted by a qualified third party.

## 6. The Building Commissioning Process

This section provides additional information on the building commissioning process and how it helps assure school officials that schools will function as required and as intended.

### Essential Elements of Building Commissioning

- *Owners Project Requirements (OPR)* – School officials establish this document, which describes their needs and expectations for the cost, use and performance of a facility. This document is the basis for the design and the goal for the commissioning of a facility. The OPR is a foundational document for the commissioning process. A commissioning agent can assist the owner in developing this document if consulted during the pre-design phase. This assistance is especially valuable if complex building designs are being considered.
- *Basis of Design (BOD)* – The design team establishes this document, which lists calculations, assumptions, codes, standards, systems, options, selection reasoning and narratives detailing the designer's response to the Owner's Project Requirements. This is another essential document for the commissioning process. The OPR and BOD are continually reviewed and updated throughout the project to ensure that the original intent for design is followed.
- *Commissioning Team* – Individuals who are involved with overseeing the commissioning of the facility are members of this team. Members typically are the owner's representative, the architect, the General Contractor or Construction Manager, the sub-contractors, the Commissioning Agent, and anyone else who is responsible for implementing the Commissioning Plan.
- *Commissioning Plan* – Depending on when the Commissioning Agent/Authority (CxA) joins the project team, this document is initiated at the beginning of the project by the design team or CxA and describes how a facility should be commissioned. The Commissioning Plan is a living document that will be modified during project delivery and will become the Final Commissioning Report at the end of the project.
- *Reviews of Design Development (DD) and Construction Documents (CD)* – Reviews are conducted by the CxA on behalf of school officials to ensure that key design elements noted in the OPR are properly translated to the BOD during design development and to the construction documents that will eventually be given to the construction contractor.
- *Contractor Submittal Reviews* – The CxA, on behalf of school officials, also reviews the manufacturer's specification sheets of specially identified equipment before the contractor orders it to ensure the right item is being purchased.

#### Essential Elements of Commissioning

- Owners Project Requirements (OPR)
- Basis of Design (BOD)
- Commissioning Team
- Commissioning Plan
- Reviews of Design Development (DD) and Construction Documents (CD)
- Reviews of Contractor Submittals
- Verification of Installation and Testing
- Issue and Resolution Tracking
- Training Verification
- Systems Manual
- Final Commissioning Report

- *Verification of Installation and Testing* – The CxA, on behalf of school officials, witnesses specifically identified equipment installations and tests that demonstrate the system operates as intended. This may also include validating test reports.
- *Track Issues and Resolutions* – The CxA maintains an Issues Log, or a compilation of Issues Report, which is used to list the issues and discrepancies observed on a project and record the status of resolutions.
- *Verify Training* – The CxA, on behalf of school officials, ensures that a formal, pre-approved syllabus for training of the owner's staff and Operations and Maintenance personnel has been established and that training has been accomplished as required.
- *Develop Systems Manual* – The CxA develops a manual consisting of the important documents of a facility, including the operational and maintenance information for systems installed in the facility, checkout data, specifications, as-built drawings, warranties, training information, and other data that will allow the owner to operate and maintain the facility. Typical O&M manuals that come with installed equipment do not always explain the system-level operation, where many problems can occur. The Systems Manual can be developed based on the complexity of the system itself.

#### Systems Manual

- Final BOD
- System Single-line Diagrams
- As-built Sequences of Operation, Control Drawings, Original Set-points
- Operating Instructions for Integrated Building Systems
- Schedule of Maintenance
- Retest Schedule
- Calibration Schedule for Sensors and Actuators

- *Final Commissioning Report* – The CxA prepares this document, which begins as the Commissioning Plan, at the conclusion of the project. Each phase of the project adds to the Commissioning Plan relevant information pertaining to that phase of the project. The final report may include the OPR, BOD, team meeting minutes and notes, a copy of the submittals review log, witnessing and inspection results, test results, training verification, a copy of the issues and resolutions log (or summary), and any other item deemed appropriate or requested by school officials. The contents will vary depending on whether a Systems Manual was produced for the project.

## Levels of Commissioning

The level of effort for building commissioning will vary depending on the complexity of the school's building systems, particularly the mechanical systems. There are two levels of commissioning that apply primarily to HVAC systems that are addressed in this guide. Table 6-1, Commissioning Level Matrix, shows which commissioning services may be needed based on the complexity level of systems being installed in new schools. Regardless of which level is chosen, or whether the CxA is retained during the pre-design or construction phase, the OPR and BOD must be developed and provided to the CxA for use in the commissioning process. Without these two documents, effective commissioning cannot be performed.

The two levels of commissioning for HVAC systems are based on the International Energy Conservation Code (IECC), Section 503.3 Simple HVAC systems and equipment and Section 503.4 Complex HVAC systems and equipment.

## **Level 1 – Simple HVAC Systems**

This level is for facilities with the least complex systems. The HVAC systems in these buildings will typically be standalone air conditioning or heat pump systems with electric or gas heat. Normally, these systems will be serviced by the owner's staff or by a local subcontractor. Temperature control will typically be regulated by individual thermostat or in some cases, by a building automation system.

IECC, Section 503.3 Simple HVAC systems and equipment, defines simple systems as follows:

“... buildings served by unitary or packaged HVAC equipment listed in Tables 503.2.3(1) through 503.2.3(5), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed.”

## **Level 2 – Complex HVAC Systems**

This level is typical of water source heat pumps (WSHP) or variable refrigerant flow systems. The potential for energy savings is higher with the WSHP systems, which should be designed, installed, serviced and commissioned with that goal in mind. If the systems are interfaced throughout the building with outside air delivered by an energy recovery unit, the control sequences are critical for energy conservation. An important part of the services provided by the CxA will be to examine the interaction of the temperature controls (with input from the owner) to determine when the systems enable the boiler, circulation pumps, cooling towers and the energy recovery units. Improper operation of these systems can cause unnecessary energy usage which may be overlooked by the operating personnel.

This level also includes systems such as boilers (electric or gas), chillers, circulation pumps, variable air volume (VAV) air handlers, and VAV boxes with or without reheat. These systems have even greater potential for energy savings (cost per square foot). They are more complex to maintain and will have more sophisticated temperature control systems due to the equipment interfacing required and the complex control schemes used to achieve maximum energy savings. These systems will require additional commissioning services beyond Level 1 but will offer a much quicker payback in terms of their potential for energy savings.

IECC, Section 503.4 Complex HVAC systems and equipment, defines complex systems as follows:

“... buildings served by HVAC equipment not covered by section 503.3.”

The suggested commissioning services indicated on the matrix are not intended to limit the owner's options for choosing services but are a guide based on practical experience and should help in negotiating with the commissioning services provider.

**Figure 6-1  
Commissioning Levels – Commissioning Tasks Responsibilities Matrix**

Commissioning Tasks	Level 1		Level 2	
	Cx A	Owner	Cx A	Owner
Owner's Project Requirements		X		X
Target Finder Rating		X		X
Basis of Design		X <sup>2</sup>	X <sup>1</sup>	X <sup>2</sup>
Establish Cx Team		X <sup>2</sup>	X <sup>1</sup>	X
Develop Cx Plan	X		X	
DD and CD Reviews		X <sup>2</sup>	X	
Contractor Submittals Cx Reviews		X <sup>2</sup>	X	
Verification of Installation and Testing	X		X	
Track Issues and Resolutions	X		X	
Verify Training		X <sup>2</sup>	X	
Develop Systems Manual			X	
Final Cx Report	X		X	
ENERGY STAR Portfolio Manager		X		X

CxA – Commissioning Authority  
Owner – School System Project Manager

DT – Design Team

- 1 – Assistance provided by the Commissioning Agent
- 2 – Responsibility delegated to the Design Team by the Owner

## Overview of the Building Commissioning Process

Each new school project goes through four phases of project development — pre-design, design, construction and operations (during the warranty period). Each of these major phases is described in more detail below.

**Figure 6-2**  
**Project Phases and Responsibilities**

### School Officials' Project Responsibilities

<p><b>Know what to specify.</b></p> <p>Begin developing Owner's Project Requirements.</p>	<p><b>Ask for the right equipment.</b></p> <p>Review Basis of Design.</p>	<p><b>Get the right equipment and install it correctly.</b></p> <p>Review submittals, verify installation, and test system.</p>	<p><b>Use it correctly.</b></p> <p>Receive training &amp; O&amp;M and System Manuals.</p>
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### ENERGY STAR Tools

<p><b>Target Finder</b></p> <p>Establish Target Finder rating.</p>			<p><b>Portfolio Manager</b></p> <p>Use Portfolio Manager to assess performance.</p>
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### Comprehensive Commissioning Tasks

<ul style="list-style-type: none"> <li>• Identify the Commissioning Team.</li> <li>• Develop Owner's Project Requirements.</li> <li>• Establish scope and budget.</li> <li>• Develop preliminary Cx Plan.</li> <li>• Retain CxA for comprehensive Cx.</li> </ul>	<ul style="list-style-type: none"> <li>• Include Cx in contract documents.</li> <li>• Develop Basis of Design.</li> <li>• Develop preliminary Systems Manual requirements.</li> <li>• Identify training needs.</li> <li>• Review design intent documents.</li> <li>• Develop concept, DD and CD documents.</li> <li>• Review 90% CDs.</li> </ul>	<ul style="list-style-type: none"> <li>• Participate in pre-bid meeting.</li> <li>• Conduct precon and other Cx meetings.</li> <li>• Review submittals concurrently.</li> <li>• Develop construction checklists.</li> <li>• Verify installer checklists and tests.</li> <li>• Witness testing and conduct site observations.</li> <li>• Prepare issues log.</li> <li>• Track issues and resolutions.</li> <li>• Prepare Cx reports.</li> <li>• Verify training.</li> <li>• Turn over Systems Manual.</li> </ul>	<ul style="list-style-type: none"> <li>• Track contractor callbacks.</li> <li>• Deliver final Cx report.</li> <li>• Update final systems manual.</li> <li>• Schedule/witness seasonal and deferred tests.</li> <li>• Schedule/witness deferred training.</li> <li>• Continue evaluation of systems and assemblies.</li> </ul>
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## The Commissioning Process

The Commissioning Process is a quality-based process designed to provide guidance to owners who wish to reduce the cost of building a new facility and to add value to an existing building for the owners and occupants of a facility. The intent of commissioning is to create a process that is rigorously documented during each step, includes defined areas of responsibility, and results in the delivery of a facility that meets the owner's expectations and requirements and has systems and assemblies that work from the day of delivery.

The process described here is brief and generic in scope and can be applied to systems and assemblies of all kinds to verify that the design and construction of the facility meet the owner's requirements. Specific tasks that should be followed are listed for each phase of construction. These tasks will establish a consistent approach to commissioning a project and can be replicated on other projects, which will aid building owners in achieving a quality-based and cost-effective process.

A Commissioning Agent, who can serve as the Commissioning Authority (CxA), should be retained during the pre-design phase of the project delivery process. This allows for the creation of an integrated design team with the owner, Architect, Design Engineers, and the Commissioning Agent. These entities will form the Commissioning Team, which will later include additional contractors and subcontractors as the project progresses. In many cases, the owner will wish to delay retaining a Commissioning Agent until the construction phase. This is a less-than-optimum decision since most of the cost savings will be achieved during the design process. One of the primary responsibilities of the CxA is to review the Design Intent Documents and Construction Documents before they are released for pricing to identify discrepancies that may result in Change Orders or in systems that will require re-work before operating correctly. Part of this process is to look for energy savings that might be achieved through changes in sequences of operation of temperature control systems.

The process for retaining a Commissioning Agent should be by Request for Qualifications (RFQ) followed by a Request for Proposal (RFP). The owner can then negotiate directly with the Commissioning Agent for the scope of services required for a given project. The preferred process is for the Commissioning Agent to work directly for the owner, allowing the CxA to perform the commissioning responsibilities with objectivity on behalf of the owner. If the CxA is retained through the Construction Manager or General Contractor, lines of responsibility become clouded and the Owner's Project Requirements (OPR) becomes less clear for the Commissioning Team. It is important that the CxA have free access to the owner without impediment by any contractor or project participant, so that issues regarding the OPR and Basis of Design (BOD) may be freely documented and resolved.

It is important to note that the focus of the CxA should be on the OPR and BOD throughout the project. These documents should be developed during the pre-design and design stages of the project, and if possible, the CxA should participate in the development of the OPR and BOD. If the CxA is retained during the construction phase, these two documents must be provided by the owner and reviewed by the CxA. Achieving these requirements is the primary reason the Commissioning Agent is retained: without the OPR and BOD, true commissioning cannot take place.

## **The Four Phases of the Project Delivery Process and Related Commissioning Activities**

### **1. Pre-Design Phase**

This phase includes information gathering and the development of the Owner's Project Requirements (OPR). These requirements should be documented and should form the basis from which all design, construction and acceptance decisions are made.

The OPR is the most important document produced during the pre-design and design process. These requirements should be developed by the owner with input from the different user groups. Methods used to gather the information can be by interview, workshops, surveys or any other method deemed appropriate by the owner. Developing the OPR is an interactive process that can be greatly facilitated by the presence of a Commissioning Authority. Failure to develop and document the Owner's Requirements allows each of the team members — the owner, designer, future occupants, the maintenance and operation staff, and sometimes the community — to interpret the building requirements from their own individual standpoints, which can sometimes be very diverse. By documenting the Owner's Requirements and including them in the design documents, a common goal is established, and the constant reference to these requirements throughout the design and construction process will simplify the delivery process. The OPR should ultimately result in a facility that meets the owner's needs, budget, operational goals and construction schedule.

The OPR workshop is typically conducted by the Commissioning Authority using the Nominal Group Technique workshop format. This format allows participants to address general needs and move to more specific concerns as identified by consensus of the participating group.

The OPR should include the following, as a minimum, with other requirements as defined by the owner/users. (See ASHRAE Guideline 0-2005, Table J-1 for additional guidance.)

- Facility function
- Schedule and budget
- Codes and standards to be followed
- Technology to be used in the facility
- Community requirements and expectations
- Occupants' needs
- Owner maintenance plans, capabilities and need for training
- Energy efficiency requirements
- Anticipated future changes in use
- Acoustical requirements
- IAQ expectations
- Security requirements
- Project documentation
- Facility energy performance level (Target Finder)
- Other

## **Pre-Design Phase Commissioning Activities**

### **1.1 Commissioning Authority is hired and begins to work with the owner and design team.**

The Commissioning Authority has the overall responsibility for overseeing and coordinating the commissioning efforts during the project delivery process, which will include chairing commissioning team meetings, reviewing the OPR, reviewing design and construction documents, reviewing submittals, developing the Commissioning Plan, preparing Issues Reports, preparing or arranging for the development of pre-startup and functional test checklists, scheduling training for the owner's staff, and arranging for the delivery of the project Operations and Maintenance manuals. The Commissioning Authority can assist the owner in selecting the Commissioning Team members from within the owner's organization and may lead the process to determine the OPR.

### **1.2 A commissioning team is formed to oversee the commissioning process, which will be defined in the Commissioning Plan.**

The owner will appoint representatives as needed from within his or her organization. Other team members will typically include the architect's representative, a representative from the general contractor or construction manager, a knowledgeable person from the mechanical contractor and electrical contractor, and other contractors depending on the systems to be commissioned. In all cases, the HVAC systems, including any building automated controls, will be commissioned, with other systems such as the fire alarm system, the security system, the local LAN system or other systems as desired by the owner.

### **1.3 The owner selects representatives for the Commissioning Team.**

The individuals who participate on the Commissioning Team must be free to attend commissioning meetings, make binding decisions for those they represent, and be knowledgeable and able to contribute to the development of the OPR.

### **1.4 The preliminary commissioning plan is developed.**

The commissioning plan defines the process by which the building will be commissioned. Included are schedules, a list of equipment or systems to be commissioned, roles and responsibilities of the Team members, milestones for different commissioning processes, examples of commissioning documents, protocols for communications, and a contact list of Commissioning Team members and individuals who are participating in the project delivery process.

### **1.5 The scope of commissioning is determined.**

The scope of work to be performed by the Commissioning Team should be based on the perceived needs of the owner. Each facility and owner will have different requirements based on the intended use of the facility, past experience with systems, complexity of the systems to be installed, and the criticality of specific systems to the owner's intended use.

### **1.6 The budget for commissioning is developed.**

A well-defined scope of work enables appropriate budgeting for the Commissioning Process. The budget should be realistic based on the size and complexity of the facility and systems to be installed in the facility and on the previous experience of the programming team, designers, Commissioning Authority, and the owner. Whenever possible, the Commissioning Agent should be interviewed to ascertain the amount of experience with facilities of like size and complexity. The personal experience of the Agent should weigh heavily in the hiring/budgeting process due to possible cost savings based on the Commissioning Agent having experienced many of the problems associated

with commissioning a facility of similar size and intended use. Practical experience is one of the primary differentiators among Commissioning Agents.

### **1.7 The Issues Report procedures are defined.**

During the commissioning process, issues and discrepancies will be discovered that are not in line with the OPR. Commissioning issues are typically those that affect performance or maintainability of the building or systems as defined by the OPR. These items need to be logged and tracked, and their resolution must be verified. A standardized form should be developed for the Commissioning Authority to use that will enable him or her to describe the issue, propose a solution, and verify that the issue was resolved. Each issue should have an identification number so that it may be tracked, and each issue should be added to the Commissioning Log and forwarded to the Commissioning Team immediately upon discovery.

### **1.8 The Commissioning Issues Log Procedure is established.**

The Commissioning Issues Log is maintained by the Commissioning Authority and is provided to the Commissioning Team, design team and installing contractors on a regular basis. The Commissioning Issues Log should list each issue by number, the status of the issue (open or closed), date that the issue is reported, building name, floor, area on floor, drawing sheet or specification section, a detailed description of the issue, proposed action to resolve the issue, the responsible party, target date for resolution, the resolution, and the date of resolution. The Commissioning Issues Log should be published for each Commissioning meeting and will serve as a tool to keep the focus on unresolved issues.

## **2. Design Phase**

During the design phase, the Owner's Project Requirements (OPR) are translated into the Basis of Design (BOD), typically during design development (DD). The BOD is then translated into the construction documents (CDs).

The BOD is a compilation of design assumptions made by the designers and may include codes, standards, equipment model numbers, etc., and becomes part of the project files. The goal for the Commissioning Team is to capture this documentation and to make it available to the owner and owner's staff, to be used for the life of the building. The Building Operating Plan (see Appendix J – Building Operating Plan Template) is a summarized version of the BOD that could also be useful to the owner. Having the BOD or the Building Operating Plan greatly simplifies future troubleshooting and optimization of major building systems.

Facility systems and assemblies are described in narrative form by the design team, clearly indicating how the systems fulfill the OPR. The narratives are included in the commissioning plan in the form of checklists and system test plans to verify that the systems perform as intended by the designers.

The assumptions made during the designer's review of the OPR are translated into specifications and construction drawings reflecting the Owner's Requirements. The specifications and construction documents should be carefully reviewed by the Commissioning Team before being sent to contractors for pricing to ensure that the plans and specifications do reflect the owner's intent.

## **Design Phase Commissioning Activities**

### **2.1 Commissioning-focused design reviews are conducted.**

The Commissioning Authority must examine the construction documents (plans and specifications) prior to the documents being issued for pricing to verify the inclusion of the means of testing and verifying system and assembly operation. There needs to be means and access to allow testing, adjusting and balancing (TAB) work to be performed. The inclusion of commissioning-related specifications into the general specification must also be verified.

### **2.2 Calculation/sizing assumptions are made a part of the CDs.**

Many of the design calculations and assumptions should be included in the construction documents (CDs) so that the installation team will be aware of system requirements. The design assumptions and calculations may be noted on informational drawings or in the specifications. It is normal for a description of system components and reason for selection to be included. Also, the designer should describe how maintainability issues were addressed and which codes and standards were followed in the design.

### **2.3 Verification of operational assumptions is conducted.**

Most systems in buildings are interfaced and interrelated to others in some way. The drawings and sequences of operation should reflect the intended operation of the systems and should be verified by knowledgeable professionals prior to being priced during the bid process. Areas that are unclear about functionality or about contractor responsibility should be corrected.

### **2.4 A cursory design review is performed by the Commissioning Authority.**

A design review should be performed by the Commissioning Authority to verify that the design meets the documented OPR. The review should also verify coordination among the different design disciplines and help the design team identify and fix problems on paper, not during the construction phase. The design review is not intended to be a peer review or for value engineering. Typically, a design review would be a statistical sampling of up to 20% of the whole design, with emphasis on the systems to be commissioned.

### **2.5 Construction checklists are developed.**

The Commissioning Authority is responsible for developing checklists to verify that systems are being installed per the design documents — both the drawings and the specifications. The checklists are typically used by the installing contractors to inspect their own work or to supplement the contractors' checklists normally used to document the installation, startup and performance of installed equipment and systems. The ideal situation is to work with the contractors to use the manufacturers' pre-startup and startup checklists for component verification, then to work with the installing contractor to develop system performance tests to verify that all interrelated systems work together.

### **2.6 The OPR is updated.**

During the design process, it is likely that the OPR will change due to many different factors, such as budget requirements or intended use changes. The OPR changes must be documented in a formal fashion that will enable the Commissioning Team to track the changes throughout the project delivery process.

### **2.7 Training program requirements are developed.**

As the project design progresses, the need for training on specific systems and operational requirements will become evident. It is the responsibility of the Commissioning Authority to interface

with the installing contractors and equipment vendors to establish training programs for the owner's staff and Operations and Maintenance personnel. The training needs to begin prior to the system functional tests and the occupancy phase.

### **3. Construction Phase**

During this phase, the systems and assemblies are installed, inspected, started up and verified to meet the OPR. Bidding, contracting, installation, inspections and equipment submittals are completed during this phase.

If the Commissioning Authority is hired and the commissioning process begins during the construction phase, all commissioning activities described in the pre-design and design phases must be completed before the construction phase processes can begin.

#### **Commissioning Objectives:**

- Updating the Commissioning Plan
- Verifying submittals
- Developing checklists and testing plans
- Maintaining the Commissioning Issues Log
- Conducting Commissioning Team meetings
- Verifying system and assembly installation
- Testing system performance
- Verifying system maintainability
- Verifying training of owner's staff and Operations and Maintenance personnel

#### **Construction Phase Commissioning Activities**

##### **3.1 Commissioning meetings are conducted.**

During the construction phase, the Commissioning Team works to verify that the installation of systems and assemblies meets the OPR. This process often requires that the team meets on a regular basis to schedule site observation visits, review open issues, and track change orders, etc., that occur during the construction process. The commissioning meetings are scheduled by the Commissioning Authority.

##### **3.2 Site visits are conducted.**

The Commissioning Authority makes regular visits to the site to observe the installation of the systems and to make note of any irregularities or discrepancies in relation to the OPR. Any issues that arise are discussed with the installing contractor and, if not resolved, will be added to the Issues Log.

##### **3.3 Pre-startup checklists are developed.**

There are two kinds of checklists — one is component-oriented, the other is system-oriented. The component section should be kept as short as possible and will normally be in the form of a yes/no checklist with room for comments. The component checklist, also called the construction or pre-startup checklist, should have a pre-installation and an installation section. The pre-installation portion is used to verify the condition of the equipment as it is received at the site and prior to its installation, and that the equipment is the equipment that was submitted by the installing contractor. The

installation section is used to verify that the equipment is installed properly and typically is used as the initial startup document to verify that all the necessary tasks have been performed for the equipment to operate. All equipment installed will have a pre-startup checklist that will be used by the installing contractor(s) to verify that all contractor installation tasks have been completed. After the contractor(s) have inspected each piece of equipment and filled out the associated checklist, the pre-startup checklist will be signed by an individual from each trade and will be returned to the administrator of the construction checklists. The Commissioning Authority will randomly select up to 20% of the equipment and will re-verify that the pre-startup checks were actually performed.

#### **3.4 Functional Tests are performed.**

When the individual systems are installed and are ready for checkout, the Commissioning Authority schedules a system test, and, working with the installing contractors, verifies that the systems operate according to the design intent. The system tests should be developed with the input of the installing contractor and, if possible, with the input of the equipment manufacturer. If the system manufacturer provides a recommended performance test, that test should be used to verify system performance. If the system being tested is interfaced to other systems, then the performance test should include the other systems also. In some cases, several contractors or vendors may be needed to develop a thorough system-wide test (e.g. the fire alarm contractor, the controls contractor, the electrical contractor, the HVAC contractor, et al). Tests start at the component level, proceed to the assembly level, and then move to the system level. The final test should be a facility-wide test in which all interfaced systems are tested to verify that all equipment and systems operate per the design intent and meet the OPR and BOD.

#### **3.5 Percentage of Equipment and Systems Tested.**

All systems will be tested by the installing contractor using checklists developed by the Commissioning Team. As equipment components are installed, the Commissioning Authority observes 10 – 20% of the systems to verify that the necessary components are installed prior to equipment startup. After the pre-startup tests are complete and the checklists have been verified, Functional Performance Tests will be performed on a minimum of 10% of the commissioned systems. The results of all tests will be verified by the CxA and any equipment that fails to meet the design intent will be re-tested. All equipment seasonal tests will be re-conducted during the appropriate season.

#### **3.6 Changes in the commissioning plan are updated and documented.**

As changes occur during the construction process, they should be tracked on as-built drawings and updated in the Commissioning Plan and the OPR. Many of the changes will result from the Issues Reports and should be documented in the Issues Log as well. At the end of the project, the owner should receive drawings and contract documents reflecting the building as constructed, which will aid in maintaining the facility and will facilitate future modifications to the building.

#### **3.7 Changes in the OPR are tracked and documented.**

Often during the construction process, which may take a year or more, the needs of the owner will change, necessitating changes in the OPR. The Commissioning Authority should update the OPR to reflect these changes. If the changes are the result of value engineering, the Commissioning Team should closely evaluate the proposals to determine if they compromise the OPR.

#### **3.8 Submittals are reviewed for compliance with OPR and BOD.**

A designated Commissioning Team member should review the drawings, shop drawings and submittals concurrent with the designers for compliance with the OPR and BOD. Special attention

should be paid to any deviations from the Contract Documents and the BOD that would indicate a possible deviation from the OPR.

### **3.9 Issues Reports and Log are updated and disseminated.**

During site visits, discrepancies and issues will be discovered that should be brought to the attention of the Commissioning Team and the appropriate contractors. These should first be discussed with the installing contractors, and if not reconciled, should be added to the Issues Log. A Commissioning Issues Report should be filled out at the time of the site visit and should be delivered to the contact person for the General Contractor or Construction Manager while the person making the observation visit is at the site. This will allow action to be taken on the issue immediately and may prevent work from being performed that may have to be redone.

### **3.10 The training agenda is coordinated and scheduled.**

The training for the owner's staff and Operations and Maintenance team should begin prior to the functional tests taking place. This training will allow the owner's staff to be aware of the operational aspects of the different systems and will afford them the opportunity to observe systems tests as they take place.

## **4. Occupancy and Operations Phase**

The occupancy and operations phase will normally begin at the time of substantial completion. During this phase, the operation, maintenance, and modification of the systems will continue to be verified against the OPR and BOD. The owner's staff will continue to familiarize themselves with the facility and the installed systems, and any off-season testing will take place. Some deferred training will take place during this phase as the final irregularities and issues are resolved. The documented turn-over of equipment and systems begins at this time, as does the warranty period on equipment accepted by the owner.

### **Occupancy and Operations Phase Commissioning Activities**

#### **4.1 Warranty documentation is collected and organized.**

As the owner begins to accept the equipment and systems installed in the facility, the warranties on the equipment begin. The Commissioning Authority is responsible for collecting and organizing the warranty information for the systems that have been commissioned. This information, including model and serial numbers, the date the warranty begins, checkout sheets, inspection forms, and manufacturers' start-up forms (if available) should be signed by the individuals with personal knowledge of the equipment and systems and included in the project Systems Manual, which is delivered to the owner.

#### **4.2 Seasonal testing is conducted.**

Often tests have to be deferred until the proper weather conditions exist before a complete test can be performed on a system. These tests may be performed during the occupancy/operations phase. These tests should be scheduled during the performance and scheduling of the construction phase functional tests. Where deferred tests are required, arrangements must be made with the installing contractors to ensure that qualified personnel will be available to perform the tests.

#### **4.3 System operation is fine tuned.**

There will normally be a period of time between the functional performance test and the full occupancy of the facility. During that time period, the weather may change from one season to another, heating and cooling loads may change, occupancy of the building may change, and owner use of the facility may change. All these changes must be taken into account in the operation of the systems within the facility. This may require additional training, problem resolution, system evaluation and updating of the drawings and system data provided by the installing contractors.

#### **4.4 The commissioning process is completed and accepted by the owner.**

During the occupancy and operations phase, the owner officially accepts the commissioning process as being complete. The Commissioning Authority completes the closeout steps of the process. This normally includes formal acceptance of any deferred training, the final project Systems Manual, and the Final Commissioning Report. The final Systems Manual and the Final Commissioning Report are the primary documentation requirements for the occupancy and operations phase of the commissioning process.

## Appendix A – References and Information Resources

1. The International Energy Conservation Code was adopted by the Alabama Building Commission in November 2008. It contains the minimum standards for energy-efficient design and addresses building envelopes, mechanical systems, and lighting and power systems.
2. ASHRAE's *90.1 User's Manual* contains compliance forms that can be specified for use during the development of the project. Following this manual could prove to be an alternative or supporting parallel process to ensure compliance with ASHRAE 90.1 requirements. The commissioning process would then complement this compliance measure by ensuring that after mandatory and prescriptive design elements are included in the design, they are properly installed and constructed.
3. Through ENERGY STAR, EPA provides free tools to help measure energy performance and ensure that designs for school facilities meet a desired level of building energy performance. For example, ENERGY STAR Target Finder is a free online tool that can be specified for use by the school district to determine, prior to design, the level of energy efficiency performance desired by the owner. Another ENERGY STAR tool, Portfolio Manager, can be used after construction is complete, but prior to the end of the warranty period, to determine the level of site energy use intensity and how closely it matches the original, intended intensity. If the level of performance is not within a specified range, actions can be taken to review and correct deficiencies prior to the end of the warranty period. These are both very cost-effective ways to define and assess building energy efficiency performance and can help economize the commissioning effort.
4. ASHRAE 0-2005, *ASHRAE Guideline, The Commissioning Process*
5. ASHRAE 1.1 – 2007, *ASHRAE Guideline, HVAC&R Technical Requirements for The Commissioning Process*
6. National Institute of Building Sciences (NIBS) Guideline 3 – 2006, *Exterior Enclosure, Technical Requirements for the Commissioning Process*
7. Associated Air Balance Council Commissioning Group, *ACG Commissioning Guideline*
8. The Building Commissioning Association ([www.bcx.org](http://www.bcx.org)) *Building Commissioning Attributes*
9. U.S. General Services Administration, *The Building Commissioning Guide*
10. National Institute of Building Sciences, Whole Building Design Guide, "Building Commissioning" (<http://www.wbdg.org/project/buildingcomm.php>)
11. American Institute of Architects (AIA) Best Practices "Building Commissioning: Analyzing Costs and Benefits" ([http://www.aia.org/aiaucmp/groups/ek\\_members/documents/pdf/aiap016668.pdf](http://www.aia.org/aiaucmp/groups/ek_members/documents/pdf/aiap016668.pdf))

## Appendix B – Definitions

**Acceptance**: A formal process where a person with appropriate authority agrees that a portion of the project meets predefined objectives.

**Basis of Design**: A document that lists calculations, assumptions, codes, standards, systems, options, selection reasoning and narratives detailing the designers response to the Owner's Project Requirements.

**Checklists**: A list of items to be verified by the Commissioning Team to ensure that systems, training or processes meet the Owner's Project Requirements and the design intent.

**Commissioning Agent (CxA)**: A professional consultant certified as qualified to perform commissioning activities by the Building Commissioning Association (BCA), Associated Air Balance Council Commissioning Group (ACG), National Environmental Balance Bureau (NEBB) or other professional organizations.

**Commissioning Authority (CA)**: The person with overall responsibility for the Commissioning Process.

**Commissioning Plan**: A document that describes how a facility should be commissioned. The Commissioning Plan is a living document that will be modified during project delivery and will become the Final Commissioning Report at the end of the project.

**Commissioning Process**: A quality-oriented process with the goal of delivering to the owner a facility that meets the Owner's Project Requirements.

**Commissioning Team**: Individuals who are involved with overseeing the commissioning of the facility. Members typically are the Owner's representative, the architect, the General Contractor or Construction Manager, the sub-contractors, the Commissioning Agent, and anyone else who is responsible for implementing the Commissioning Plan.

**Construction Checklist**: A form used to verify the installation of systems and components.

**Construction documents**: Any document used in the planning and construction of a facility. Typically this includes drawings, specifications, submittals, checklists and reports.

**Contract Documents**: These include contracts, pricing agreements, schedules and the Construction Documents.

**Design Intent**: The designer's concept of how systems and the facility should operate during the occupancy phase. The DI is the direct response to the Owner's Project Requirements.

**Issues Log**: A compilation of Issues Reports that is used to list the issues and discrepancies observed on a project, and is used to record the status and resolution of the different issues.

**Issues Report**: A form describing a Commissioning issue, the recommended action to resolve the issue, and the verification that the issue was resolved.

**Nominal Group Technique**: A process used to define the Owner's Project Requirements.

**Owner's Project Requirements**: A document that describes the Owner's needs and expectations for the cost, use and performance of a facility. This document is the basis for the design, and the goal for the commissioning of a facility.

**Systems Manual**: A manual made up of the important documents of a facility including the operational and maintenance information for systems installed in the facility, checkout data, specifications, as-built drawings, warranties, training information and other data that will enable the Owner to operate and maintain the facility.

**Test Procedure**: A written sequence of testing to prove that equipment and systems meet the design intent.

**Training Plan**: A formal, pre-approved syllabus for training the owner's staff and Operations and Maintenance personnel.

**Verification**: The process of confirming that equipment and systems meet the design intent.

## Appendix C – Commissioning Levels – Detailed Matrix

The table below shows a list of commissioning tasks that could be performed for a project. Recommendations are provided on which task should typically be found in Level 1 (simple systems) and Level 2 (complex systems). Each owner and project team should evaluate the requirements and needs of their project to develop the optimum list of commissioning tasks that will be most beneficial for their project. The designation of “Level 1” and “Level 2” is to provide a range of tasks expected for simple and complex projects. Project teams may find that their project falls somewhere in between and should choose the set of tasks appropriate for their project individual project level.

<b>LEVEL 1: DX systems with gas or electric heat LEVEL 2: Water Source Heat Pump or Variable Flow Refrigerant Systems, Four pipe systems with Boilers, Chillers, VAV Air Handlers</b>	<b>LEVEL 1</b>	<b>LEVEL 2</b>
<b>TASK: Pre-Design Phase</b>		
Retain Commissioning Agent		X
Develop Owner's Project Requirements		X
Develop Preliminary Commissioning Plan		X
Energy Use Plan (Target Finder)		X
Develop Systems Manual Outline		X
Develop Preliminary Training Program		X
Prepare Issues Log		X
Prepare Cx Issues Report Document		X
<b>TASK: Design Phase</b>		
Review Basis of Design		X
Review OPR		X
Develop Construction Specifications for Commissioning		X
Systems Manual Further Defined		X
Add Training to Specifications	X	X
Design Review — 50%		X
Design Review — 90%		X
Issues Log Expanded and Used in Reviews		X
Commissioning Issues Report Used in Reviews		X
Design Phase Commissioning Process Report		X
<b>TASK: Construction Phase</b>		
Retain Commissioning Agent	X	X
Identify Commissioning Team	X	X
Owner's Project Requirements Update	X	X
Basis of Design Update	X	X
Develop Commissioning Plan	X	X
Commissioning Plan Update		
Submittal Review	X	
Submittal Review — Concurrent		X

Shop Drawing Review		X
Construction Checklists	X	X
Pre-startup Checklists	X	X
Pre-startup Verification	X	X
Functional Checklists	X	X
Functional Tests	X	X
Control system/BAS Sequences of Operation — Review for Energy Savings		X
Verify Equipment to System and System-to-System Operation		X
Commissioning Process Meeting	X	X
Commissioning Team Meetings		X
Training Plan		X
Schedule Training (by contractors for Owner's staff)	X	X
O&M Data — Review for Accuracy and Completeness		X

<b>TASK: Construction Phase (Continued)</b>		
Semi-final Systems Manual — Review Contents. Collect data as Needed.		X
Verify that O&M Manual is Complete and Delivered to Owner.	X	
Final Construction Phase Commissioning Process Report		X
Warranty Documents		X
<b>TASK: Occupancy/Operations Phase</b>		
Update Owner's Project Requirements		X
Update Basis of Design		X
CxA to Request and Document Delivery of As-Built Drawings		X
CxA to Verify As-Built Drawings for Accuracy	X	X
CxA to Verify Control/BAS/EMCS Drawings		X
CxA to Verify Software Backup for Control Systems		X
Verify Receipt of Warranty Documents		X
Final Issues Log		X
Re-commissioning Plan		X
Deferred Testing		X
Deferred Training		X
System Evaluation		X
Lessons Learned		X
Energy Use Tracking (Portfolio Manager)	X	X
Update Systems Manual		X

## Appendix D – Commissioning Agent Qualifications

### Desired Qualifications for Commissioning Agent

The CxA should have as many of the qualifications listed below as possible:

- Membership with the Building Commissioning Association
- Certification by the Associated Air Balance Council Commissioning Group
- Certification by an accredited University
- A bachelor's degree from an accredited University
- A bachelor's degree in mechanical or electrical engineering
- Certification by the Alabama Board of Heating and Air Conditioning Contractors
- A minimum of five years experience with system construction or maintenance
- Extensive experience in troubleshooting and repairing of systems
- Knowledge of building codes and standards
- Knowledge of test and balance of air and water systems
- Experience in energy-efficient equipment and design and control strategies
- Familiarization with national and local fire codes
- Familiarization with Building Automation systems, design, programming and maintenance
- Experience in monitoring and analyzing system operation using control system trending
- Excellent verbal and writing communication skills
- Demonstrated experience in dealing with owners, contractors and others

A Commissioning firm may have one or more highly qualified individuals who supervise less highly qualified individuals. It is important that the individuals performing field observations and witnessing functional tests be qualified to assess system and assembly installation for correctness and best practices. Their qualifications and experiences will have more of an impact on the Owner's Project Requirements than those of office personnel. The CxA and technicians should be interviewed by the Owner before contracting for commissioning services and a determination should be made that the commissioning personnel should be the same for the duration of the project. If personnel are changed, the Owner should approve the replacement.

## Appendix E – Commissioning Costs

Depending on the size of the building and the complexity of the systems installed, the price of Commissioning will vary. Some of the factors that can affect a Commissioning Agent's fees are duration of construction, project meeting requirements, number of site visits and inspections, system complexity, scope of services required, capability of the general contractor and the sub-contractors, documentation requirements, and the level of detail required during the commissioning process. The prices shown are based on a percentage of the mechanical costs, which is a widely used pricing method. However, *these guidelines must be use with great caution*. Owners should contact a commissioning agent to discuss costing before finalizing a budget for commissioning. The numbers listed below reflect the costs to expect for commissioning a building beginning in the pre-design stage. Construction phase commissioning will be about 80% of these costs, with the minimum cost being no less than 1%.

HVAC with Thermostat, standalone	1% to 2.5% of the total mechanical costs
HVAC with building automation system	1.5% to 3% of the total mechanical/BAS costs

Level 2 systems with Water Source Heat Pumps or Variable Refrigerant Flow systems require more effort to commission, which will be reflected in the costs. The energy efficiency of these systems is such that the costs are more quickly recovered, normally within five years of operation.

HVAC with Thermostat, standalone	1.5% to 2.5% of the total mechanical costs
HVAC with Building Automation system	2% to 3% of the total mechanical/BAS costs

Level 3 systems with Boilers, Chillers, VAV Air Handlers, VAV boxes and variable frequency drives are more complex than the previously mentioned systems and require more effort to commission and a much higher technical level. These systems are more energy-efficient than the Level 1 or Level 2 systems and should be commissioned to take advantage of the energy savings and the shorter pay-back time.

HVAC with Building Automation System	2% to 3% of the total mechanical/BAS cost
Electrical systems, Security systems	1% to 2% of total system cost
CCTV system, Fire Alarm systems	1.5% 2% of total system cost

### Cost of Commissioning References:

- The Commissioning Guide, GSA, pages 17-19.  
[www.wbdg.org/ccb/GSAMAN/buildingcommissioningguide.pdf](http://www.wbdg.org/ccb/GSAMAN/buildingcommissioningguide.pdf)
- ACG Commissioning Guideline, AABC Commissioning Group, page 9.  
[www.commissioning.org/commissioningguideline/](http://www.commissioning.org/commissioningguideline/)
- Portland Energy Conservation Inc., white paper, New Construction Commissioning Costs, pages 1-10, [www.peci.org/Library/PECI\\_NewConCx1\\_1002.pdf](http://www.peci.org/Library/PECI_NewConCx1_1002.pdf)
- Whole Building Design Group, white paper, [Building Commissioning – A Resource for Sustainable Building](http://www.buildingcommissioning.wordpress.com/2008/04/28/commissioning-costs-and-budgets), [www.buildingcommissioning.wordpress.com/2008/04/28/commissioning-costs-and-budgets](http://www.buildingcommissioning.wordpress.com/2008/04/28/commissioning-costs-and-budgets)

- Building Commissioning Power Point training.  
[http://www.bcx.org/southeast/pdf/louisville005\\_Kimball\\_Cx\\_101\\_Final.ppt#282,27](http://www.bcx.org/southeast/pdf/louisville005_Kimball_Cx_101_Final.ppt#282,27), The Economics of Commissioning

## Appendix F – Roles & Responsibilities

The commissioning process involves many people performing key roles during the course of all project phases. Understanding what is included in those roles is an important key to success.

### 1. Owner's Representative (OR):

- a. Assign operations and maintenance personnel and schedule them to participate in the various meetings, training sessions and observations/inspections as follows:
  - Construction Phase coordination meetings.
  - Initial owner training session at initial placement of major equipment.
  - Maintenance orientation and inspection.
  - System testing verification meetings.
  - Procedures meeting for testing systems.
  - Owner's training session.
  - Verification demonstrations.
  - Systems and assemblies tests.
  - Final review at acceptance meeting.
- b. Review and approve any changes made to Owner's Project Requirements.
- c. Review and approve the Construction Documents.
- d. Provide qualified personnel for videotaping and editing of training sessions.
- e. Review and comment on the Commissioning Authority's Commissioning Process Progress Reports.
- f. Review and comment on the Commissioning Authority's verification reports.
- g. Review and accept the Commissioning Authority's Commissioning Process Report.

### 2. Commissioning Authority (CxA):

- a. Organize and lead the Commissioning Team.
- b. Identify specialists who will be responsible for accomplishing the Commissioning Process activities for specific systems and assemblies.
- c. Provide Commissioning Process activities to the GC for inclusion in the project schedule.
- d. Update the Design Phase Commissioning Plan, which describes the extent of the commissioning process to accomplish the Owner's Project Requirements. Update the Commissioning Plan to incorporate changes and additional information.

#### Abbreviations

**A/E** – Architect/Design Engineers  
**CxA** – Commissioning Agent/Authority  
**CC** – Controls Contractor  
**Cx** – Commissioning  
**EM** – Energy Manager  
**Cx Plan** – Commissioning Plan Document  
**EC** – Electrical Contractor  
**FM** – Facility Manager  
**TP** – Test Procedure  
**GC** – General Contractor  
**MC** – Mechanical Contractor  
**CCK** – Construction Checklist  
**OR** – Owner's Representative  
**Subs** – General Contractor's Subcontractors  
**TAB** – Test, Adjust, & Balance Contractor  
**MS** – Maintenance Staff

- e. Execute the Commissioning Process through the writing and review of Commissioning Process Reports, organization of all Commissioning Team meetings, tests, demonstrations, and training events described in the Contract Documents and approved Commissioning Plan.
- f. Carry out organizational responsibilities, including preparing agendas, attendance lists, and arranging for facilities, and providing timely notification to participants for each Commissioning Process activity.
- g. Act as chair at all commissioning events and ensure execution of all agenda items.
- h. Prepare minutes of every Commissioning Process activity and send copies to all Commissioning Team members and attendees within five workdays of the event.
- i. Schedule the pre-construction Commissioning Process meeting at some convenient location and at a time suitable to the attendees. This meeting will be for the purpose of reviewing the complete Commissioning Process and establishing tentative schedules for the Construction Phase commissioning activities.
- j. Develop and verify completion of Construction Checklists (and/or pre-start up checklist).
- k. Review the following submittals for compliance with the Owners Project Requirements: coordination drawings, shop drawings, product data and training program.
- l. Review and recommend approval of contractor's start-up plan.
- m. Develop Functional Test Procedures to carry out the tests that are accomplished during this phase.
- n. Develop the initial format to be used for Issues Logs throughout and for each phase of the Commissioning Process.
- o. Facilitate the scheduling of the initial owner training session so that it will be held immediately before the contractor training. This session will be attended by the owner's O&M personnel, the design professionals, the contractor and the Commissioning Authority. The Commissioning Authority will review the Owner's Project Requirements, and the design professionals will review the Basis of Design.
- p. Review proposed contractor-provided training program to verify that the Owner's Project Requirements are achieved.
- q. Update the Systems Manual to incorporate materials generated during the Construction Phase. Update materials that originated in earlier phases of the project. Add new materials to the manual, such as Test Procedures and test data records, training plans, training records and record drawings. Verify that the manual achieves the Owner's Project Requirements. Insert systems descriptions in the Systems Manual as provided by the design professional(s).
- r. Witness system and assembly testing. Verify the results and include a summary of deficiencies.
- s. Identify, diagnose and track issues and deviations relating to the Construction Documents and the Owner's Project Requirements and document resolution of same.
- t. Supervise the Commissioning Team members in completion of tests. The test data will be part of the Commissioning Process Report.
- u. Periodically review Record Drawings for accuracy with respect to the installed systems. Request revisions through the owner to achieve accuracy.

- v. Verify that the Systems Manual and all other design and construction records have been updated to include all modifications made during the Construction Phase.
- w. Repeat implementation of tests to accommodate seasonal tests or to correct any performance deficiencies. Revise and resubmit the Commissioning Process Report as required.
- x. Prepare the final Commissioning Process Report.
- y. Update the Basis of Design to reflect any changes to the design during the Construction Phase. Verify that design changes comply with the Owner's Project Requirements. If necessary, update the Owner's Project Requirements.
- z. Assemble the final documentation, which includes the Commissioning Process Report, the Systems Manual and all record documents. Submit this documentation to the owner for review and acceptance.
- aa. Recommend acceptance of the individual systems and assemblies to the owner (in accordance with the defined project requirements).
- bb. Keep the Commissioning Team informed of decisions that result in modifications to the Owner's Project Requirements.
- cc. Return to the site 10 months into the 12-month warranty period to review building operations and identify any problems with the building with facility staff. Identify any warranty problems under contract, suggest ways to improve them and record these changes.

**3. Design Professional (A/E):**

- a. Document the Basis of Design.
- b. Review and incorporate as appropriate the Commissioning Authority's comments from submittal reviews.
- c. Participate in the initial Operation and Maintenance personnel and occupant training session by presenting the project Basis of Design.
- d. Participate in other training as detailed in the training program.
- e. Review Test Procedures submitted by the Commissioning Authority.
- f. Review and comment on the Commissioning Authority's periodic Commissioning Process Progress Reports and Issues Log reports.
- g. Review and accept record documents as required by Contract Documents.
- h. Review and comment on the final Commissioning Process Report.
- i. Recommend final acceptance of the systems to the owner.

**4. Construction Manager (CM):**

- a. Include Commissioning Process requirements and activities in all contractor's contracts.
- b. Provide acceptable representation with the means and authority to prepare and coordinate implementation of the Commissioning Process as detailed in the Contract Documents.

- c. Issue a statement certifying that all work has been completed and that the facility is operational, in accordance with Contract Documents.
- d. Issue the appropriate final reports to the design professionals for review and acceptance.
- e. Facilitate the remedy of deficiencies identified by the Commissioning Authority during verification of the installation or testing.
- f. Review and comment on the final Commissioning Process Report.

**5. General Contractor (GC):**

- a. Include Commissioning Process requirements and activities in each purchase order or subcontract written.
- b. Obtain cooperation and participation of all subcontractors and manufacturers.
- c. Provide safekeeping for the construction checklists and provide to subcontractors as needed.
- d. Attend the pre-construction and Commissioning Team meetings.
- e. Include Commissioning Process milestones in the project schedule.
- f. Implement the training program as detailed in the Contract Documents.
- g. Provide submittals to the owner, design professionals and the Commissioning Authority.
- h. Notify the Commissioning Authority when systems and assemblies are ready for testing.
- i. Demonstrate the performance of assemblies and/or operation of systems to the Commissioning Authority.
- j. Complete the Construction Checklists as the work is accomplished. Provide the completed Construction Checklists to the Commissioning Authority through the owner.
- k. Continuously maintain the Record Drawings and submit as detailed in the Contract Documents.

**6. Manufacturers, Vendors, Suppliers (Mfr.):**

- a. Provide all information required for the operation and maintenance of the system or assembly as part of the initial submittal.
- b. Provide the requirements to maintain the warranty as part of the initial submittal.
- c. Coordinate and accomplish factory tests as detailed in the Contract Documents.
- d. Provide training as detailed in the training program contained in the Contract Documents.
- e. Demonstrate operation and performance of the system or assembly as detailed in the Contract Documents.

**7. Mechanical Contractor (MC):**

- a. Include in the quote for mechanical systems and services the cost of participating in the Commissioning Process.
- b. Cooperate with the Commissioning Authority to complete the Commissioning Process.

- c. Provide a contact person to participate in the Commissioning meetings and to represent the Mechanical Contractor.
- d. Provide Operation and Maintenance manuals to the Commissioning Authority early in the construction process to facilitate development of the construction, pre-startup and functional tests.
- e. Provide the requirements to maintain the warranty as part of the initial submittal.
- f. Ensure the cooperation of subcontractors such as piping, sheet metal, controls, test and balance (TAB) contractor, and water treatment contractor, where applicable.
- g. Provide personnel trained and knowledgeable of the systems to be commissioned to assist in the Commissioning Process.
- h. Coordinate the activities of the TAB Contractor to allow ample time for the Commissioning Authority to witness the TAB measurements, as noted in the Contract Documents.
- i. Coordinate and accomplish factory tests as detailed in the Contract Documents.
- j. Provide training as detailed in the training program contained in the Contract Documents.
- k. Demonstrate operation and performance of the system or assembly as detailed in the Contract Documents.

**8. Electrical Contractor (EC):**

- a. Include in the quote for mechanical systems and services the cost of participating in the Commissioning Process.
- b. Cooperate with the Commissioning Authority to complete the Commissioning Process.
- c. Provide a contact person to participate in the Commissioning meetings and to represent the Electrical Contractor.
- d. Provide Operation and Maintenance manuals to the Commissioning Authority early in the construction process to facilitate development of the construction, pre-startup and functional tests.
- e. Provide the requirements to maintain the warranty as part of the initial submittal.
- f. Provide personnel trained and knowledgeable of the systems to be commissioned to assist in the Commissioning Process.
- g. Coordinate and accomplish factory tests as detailed in the Contract Documents.
- h. Provide training as detailed in the training program contained in the Contract Documents.
- i. Demonstrate operation and performance of the system or assembly as detailed in the Contract Documents.

## Appendix G – Sample Contract Specifications for Commissioning

The Commissioning Agent's contract should directly reflect the scope of work needed to commission the HVAC systems of a school facility. Use the following guide specifications to define the level of commissioning effort based directly on the cost and complexity of the systems being installed. In some cases, it may be beneficial to bring the commissioning agent onto the design team early in the project, and in other cases, it may make more sense to bring the agent on to do construction phase commissioning only.

During the bidding process, the contractors who are bidding on a project must be made aware of their responsibilities regarding commissioning should they win the project. Also, the process for hiring the commissioning agent should not impact the contractors' bids. Guidelines for contractors to help them understand their contractual obligations and the specific tasks to be performed during the commissioning process are noted below.

[Note to Design Team: Contractor notification to be inserted in Division 15995.]

15995

- 1.1 The Commissioning Agent has been retained directly by the Owner for this project. Overall planning and coordinating for the Commissioning Plan will be performed by the Commissioning Agent; however, all parties involved with the design and construction of the project will be involved with the Commissioning Process, including the Division 15 contractors.
- 1.2 The Division 15 contractor's responsibilities regarding Building Commissioning have been defined in Division 1 of the specifications. These responsibilities apply to all subcontractors and vendors of the mechanical contractor, and all subcontractors and vendors should review the Division 1 requirements and include the price for commissioning in their quote.

[Note to Design Team: Contractor notification to be inserted in Division 16995.]

- 1.1 The Commissioning Agent has been retained directly by the Owner for this project. Overall planning and coordinating for the Commissioning Plan will be performed by the Commissioning Agent; however, all parties involved with the design and construction of the project will be involved with the Commissioning Process, including the Division 16 contractors.
- 1.2 The Division 16 contractor's responsibilities regarding Building Commissioning have been defined in Division 1 of the specifications. These responsibilities apply to all subcontractors and vendors of the electrical contractor, and all subcontractors and vendors should review the Division 1 requirements and include the price for commissioning in their quote.

## **SAMPLE COMMISSIONING SPECIFICATION**

(Include in Division 1)

### **PART 1: GENERAL**

#### **1.01 DESCRIPTION:**

- A. General provisions and mechanical and electrical systems are specified in Divisions 15 and 16.
- B. These Division(s) cover the commissioning of mechanical, electrical and specialty systems.
- C. Commissioning is the systematic process of ensuring that all building mechanical and electrical systems perform interactively according to the Owner's Project Requirements and the operational requirements specified in other Divisions. The Commissioning Authority shall inspect the installation and coordinate equipment start-up, system performance, testing, adjusting and balancing, control system calibration, construction and system documentation, and Owner training.
- D. Specific requirements of the commissioning process and responsibilities, duties and obligations of the Commissioning Authority are described in this Section. To accomplish these duties, the Commissioning Authority shall coordinate his or her activities with other entities.

#### **1.02 REFERENCES:**

- A. ASHRAE Guideline 0-2005, The Commissioning Process.
- B. ASHRAE Guideline 1.1-2007, The HVAC Commissioning Process.

#### **1.03 DEFINITIONS:**

- A. The following terms are used in this Section:
  - 1. Acceptance – A formal process to declare that some phase of the process meets predetermined requirements.
  - 2. Basis of design – The documentation of the primary thought processes and assumptions behind design decisions that were made to meet the Owner's Project Requirements. The basis of design describes the intent of the project and the systems, components, conditions, and methods chosen to meet the Owner's Project Requirements.
  - 3. Commissioning Authority – An entity who has the overall responsibility for the commissioning process.
  - 4. Commissioning plan – A plan that provides the structure, schedule and coordination planning for the commissioning process.
  - 5. Commissioning team – The group responsible for accomplishing the commissioning

process.

6. Data logging – Monitoring flows, currents, status and pressures of equipment using stand-alone recording equipment, separate from the control system. Additional monitoring may be provided through the capabilities of the control system.
7. Deferred functional tests – Functional tests that are performed after the date of substantial completion due to site conditions that do not allow meaningful testing of a system or piece of equipment during the normal commissioning sequence.
8. Owner's Project Requirements – A document prepared by the Owner that lists the Owner's expectations and requirements for the project. Achieving the Owner's Project Requirements is the purpose behind every step of the commissioning process. Without the Owner's Project Requirements, Building Commissioning cannot occur as defined by this document.
9. Factory testing – Testing of equipment at the factory (or on-site) by factory personnel with an Owner's representative present.
10. Functional tests – Tests of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chilled water pump is tested interactively with the chiller functions to determine if the pump ramps up and down to maintain the differential pressure set point). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied modes, varying outside air temperatures, fire alarm modes and power failure. The systems are run through the control system's sequences of operation, and components are verified to respond properly. The Commissioning Authority develops the functional test procedures in a sequential written form, and coordinates, oversees and documents the actual testing, which is performed by the Contractor. Functional tests are performed after prefunctional checklists and start-up is complete.
11. Indirect indicators – Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.
12. Manual tests – Using hand-held instruments, immediate control system read-outs or direct observation to verify performance (as opposed to analyzing monitored data taken over time to make the "observation").
13. Monitoring – The recording of parameters (flow, current, status or pressure) of equipment operation using data loggers or the trending capabilities of control systems.
14. Over-written value – Manually overriding a sensor value in the control system to determine the response of a system (e.g., changing the outside air temperature value from 50°F to 75°F to verify economizer operation). Also see "Simulated Signal."
15. Owner-contracted tests – Tests paid for by the Owner which the Commissioning Authority does not oversee. These tests are not repeated during functional testing if properly

documented.

16. Phased commissioning – Commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, to minimize the total construction time.
17. Pre-functional checklists – Lists of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the Contractor to the Commissioning Authority. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels, labels affixed, gauges in place, sensors calibrated). However, some prefunctional checklist items may entail simple testing of the function of a component, a piece of equipment or system (such as checking rotation on a pump or fan). The word “pre-functional” refers to testing to be accomplished prior to the formal functional testing of the installed equipment. Prefunctional checklists augment and are often combined with the manufacturer’s start-up checklist. For most equipment, the Contractor will execute the checklists.
18. Retesting – Testing due to the failure of a component or system due to part failure, incorrect installation, etc.
19. Sampling – Functional testing of only a fraction of the total number of identical or near identical pieces of equipment.
20. Simulated condition – A condition that is artificially created for the purpose of testing the response of a system (e.g., applying a hair dryer to a space temperature sensor to determine the response of a variable volume terminal unit).
21. Simulated signal – Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and control system to simulate a sensor value.
22. Start-up – The initial starting or activating of dynamic equipment, including executing prefunctional checklists.
23. Test, adjust and balance (TAB) – The process of measuring the actual flows of the air and hydronic systems, adjusting these flows to the values required by the construction documents and documenting the results.
24. Trending – Monitoring of equipment performance over a period of time, using data logging equipment or the building control system.

#### 1.04 QUALITY ASSURANCE:

- A. Supervision, coordination and documentation of the commissioning process shall be the direct responsibility of the Commissioning Authority, who shall work under the direct supervision of a licensed professional engineer or a certified member of the Building Commissioning Association, and have a minimum of 10 years experience in the design and/or construction of mechanical and electrical systems, or of automated building control

systems. The Commissioning Authority shall become familiar with the Owner's Project Requirements, the Basis of Design documentation, and project documents, and shall assume responsibility for the overall system commissioning effort.

1.05 COORDINATION:

- A. The Commissioning Authority shall be hired by the Owner. The Commissioning Authority shall direct and coordinate the activities of the commissioning team.
- B. The commissioning team shall consist of the Commissioning Authority, the Owner, the design team, the Contractor, and associated subcontractors. The Contractors and Subcontractors shall appoint employees with the required experience and skill sets to work with the Commissioning Authority to demonstrate the required sequences of operation of the systems being commissioned.
- C. The Commissioning Authority shall schedule the commissioning activities of the Project and shall coordinate this schedule with the Contractor.

1.06 COMMISSIONING PROCESS:

- A. The primary role of the Commissioning Authority shall be to develop and coordinate the execution of a commissioning plan; observe and document the installation, checkout, start-up, and testing of equipment and systems to establish that they are functioning in accordance with the requirements of the construction documents; and to assist in developing correct and complete documentation of the construction effort. *The Commissioning Authority shall not be responsible for design concept, design criteria, compliance with codes, design, construction scheduling, cost estimating, construction management or construction supervision.* The Commissioning Authority may assist the design team with problem-solving, or the Contractor with the correction of non-conformance items or deficiencies. The Commissioning Authority is not responsible for providing tools required to start, checkout and perform functional tests of equipment and systems.
- B. Design Phase: Ensure that the Project requirements are met and achieve the following specific objectives prior to the Construction Documents being sent for pricing.
  - 1. Review the Design Intent and Contract Documents for alignment with Owner's Project Requirements.
  - 2. Review the contract documents for completeness and clarity.
  - 3. Identify project specific responsibilities.
  - 4. Provide the Owner and design team with specification(s) to be included in the construction contract documents to address commissioning during construction, acceptance and warranty.
- C. Construction Phase: Ensure that the Project requirements, as defined by the construction documents, are met, and achieve the following specific objectives:

1. Within 60 days of receipt of contract or purchase order: Schedule, plan and conduct a commissioning process meeting to review the commissioning process and the preliminary commissioning plan with the commissioning team.
2. Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using centralized documentation, periodic communications and consultations with the commissioning team. Schedule additional commissioning meetings as needed during the Commissioning process. Commissioning meetings shall be held bi-weekly when pre-startup checklists are being verified. Record and distribute the meeting minutes for commissioning meetings.
3. Ensure that commissioning activities are included in the master project schedule.
4. Review submittals applicable to systems being commissioned concurrent with the Engineer's reviews and provide comments to the Engineer and the Owner. The review shall be for compliance with commissioning needs, and to aid in the development of functional testing procedures and only secondarily to review for compliance with equipment specifications.
5. Request and review additional information as required to perform the assigned commissioning tasks, including review of operations and maintenance materials and Contractor start-up and checkout procedures. Incorporate into the documents checks for system maintainability and serviceability, and inspect for installation supporting, and not interfering, with these requirements.
6. Develop specific functional test procedures and forms to document the proper operation of each piece of equipment and system. Submit the proposed functional tests to the Architect, the design engineer and the installing contractor for review and comment. Required performance testing may include control system trending, stand-alone data logger monitoring, and/or manual logging of system operation to demonstrate proper operation.

Functional test forms shall include (but not be limited to) the following information:

- a. Date
- b. Project name
- c. System and equipment or component name(s)
- d. Equipment location and identification number
- e. Unique test identification number and reference to unique prefunctional checklist and start-up documentation identification numbers for the piece of equipment
- f. Participating parties
- g. A reference to the specification describing the specific sequence of operations or parameters being tested or verified
- h. Formulae used in calculations

- i. Required pre-test field measurements
  - j. Instructions for setting up the test
  - k. Special cautions or alarm limits
  - l. Electrical breaker and panel serving the equipment.
  - m. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
  - n. Acceptance criteria of proper performance with provisions for clearly indicating whether or not proper performance of each part of the test was achieved
  - o. A section for comments
  - p. A signature and date block for the Commissioning Authority and participating parties
7. Review the Contractor's start-up and prefunctional testing reports and provide on-site observation of start-up and prefunctional testing as specified herein (20%).
  8. Review the proposed testing, adjusting and balancing (TAB) execution plan for completeness and determine if it meets the requirements of the commissioning process. Provide comments to the Contractor, Engineer and Owner.
  9. Perform site visits — **bi-weekly** until pre-functional testing of equipment and systems begins, then **weekly** through the completion of the Project — to review component and system installations. Observe the burial of underground piping or duct to verify that it is being done per specification. Concurrently, schedule and conduct commissioning planning and coordination meetings to review the construction progress and to assist in resolving discrepancies or issues relating to the commissioning process.
- E. Occupancy/Operations Phase: Demonstrate that the performance of the equipment and systems installed during the construction phase meets the requirements of the construction documents. Notify the Owner and Architect of deficiencies in results or procedures. Commissioning activity shall achieve the following specific objectives:
1. Witness 25% (Level 1, 2) of the HVAC piping testing and flushing procedures.
  2. Witness 10%-20% (Level 1, 2, 3) of the prefunctional test procedures for each type and/or size of equipment. If issues are discovered with the installation after the installer has inspected the systems, 100% of the systems shall be checked.
  3. After the test, adjust and balance (TAB) effort has been completed, witness 25% (Level 1) or 10% (Level 2, 3) of the functional test procedures for each type and/or size of equipment. If issues are discovered with the installation after the installer has inspected the systems, 100% of the systems shall be checked.

4. Witness the testing and adjusting of any boilers by the factory representative.
  5. Oversee the point-to-point testing of the control system and approve it for use for the TAB effort before the test and balance procedures begin. After the TAB work is complete, perform a Functional test of the Control System (may be combined with a Functional test of the Mechanical equipment, if a factory startup form was used to start the mechanical equipment).
  6. Oversee at least 25% (Level 1) or 10% (Level 2) of the TAB process by observing, at a minimum, the first test of each system type (e.g., air handling units, diffusers and grilles, terminal units, pumps), and **spot testing 25% (Level 1) or 10% (Level 2) of all TAB readings**. Test subsequent equipment sufficiently to be confident that proper procedures were followed, and review the Contractor's completed reports.
  7. Coordinate, witness and approve functional tests of equipment and systems performed by the Contractor. Review functional test reports and analyze any trend logs, data logger reports and other monitoring data to evaluate equipment and system performance. Document the performance of the functional testing, and provide a comparison to the required performance, as defined by the construction documents.
  8. Coordinate retesting as necessary until satisfactory performance is demonstrated.
  9. Maintain a master Commissioning Issues Log with all issues logged, along with the resolution and date for each item. Provide to each contractor or team member every two weeks, minimum. Continue to monitor the CIL until each item is resolved or accepted as is by the Owner.
  10. Review the Contractor's proposed training of the Owner's operating personnel, and provide comments to the Architect and Owner.
  11. Coordinate and attend the Contractor-provided training sessions. Verify that the approved training has been properly completed.
- F. Warranty Period: Assist the Owner in identifying defects in the installed equipment or system operation and in accomplishing the following specific objectives:
1. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.
  2. Verify that warranty items have been corrected properly.
  3. Coordinate and supervise required seasonal or deferred testing and deficiency corrections, as specified or required by the commissioning plan.
  4. Return to the site approximately 10 months into the warranty period and review with the Owner the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Assist the Owner in reviewing the failure and repair records of equipment during the warranty period and in the evaluation of the

Contractor's corrective actions. Identify areas that may come under warranty or under the original construction contract. Interview the Owner and identify problems or concerns regarding operating the building as originally intended and make suggestions for improvements. Assist the Owner in developing reports, documents and requests for services to remedy outstanding problems

5. Assist the Owner in tracking energy costs during the first 12 months of occupancy.

## PART 2: PRODUCTS

### 2.01 TEST EQUIPMENT:

- A. All services requiring tools, measuring devices or specialized equipment to start-up, test, adjust, verify or otherwise bring equipment or systems into fully operational state, or proof of correct operation state, shall be provided by others. Test equipment provided by the Commissioning Authority is at the discretion of the CxA and is not to be used in place of that provided by the installing contractors.
- B. Data logging equipment, monitoring devices, specialized equipment and software not specified in other Divisions to be provided by the Contractor, and provided by the Commissioning Authority to monitor, confirm or verify the Contractor's testing procedures shall remain the property of the Commissioning Authority.
- C. Test equipment shall be of the quality and accuracy required to test and/or measure system performance within the tolerances specified and shall have been calibrated within the last 12 months, or as specified herein. Equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates available on request.
  1. Temperature sensors and digital thermometers shall have a certified calibration within the past 12 months and a resolution of  $\pm 0.1^{\circ}\text{F}$ . Accuracy of temperature test equipment shall be at least twice that of the instrumentation being tested.
  2. Humidity sensors shall have a certified calibration within the past 6 months and a resolution of  $\pm 1\%$ . Accuracy of humidity test equipment shall be at least twice that of the instrumentation being tested.
  3. Pressure sensors shall have a certified calibration within the 12 months and a resolution of 0.05% of sensor range. Accuracy of pressure test equipment shall be at least twice that of the instrumentation being tested.
  4. Accuracy of other Commissioning Authority sensors shall be at least twice that of the installed sensors being tested

## PART 3: EXECUTION

### 3.01 REPORTING:

- A. Provide regular reports to the Owner and members of the commissioning team as construction and commissioning progresses, keeping them apprised of commissioning progress and scheduling changes.
- B. Provide periodic commissioning reports to the commissioning team **monthly** until the first system test, and **weekly** thereafter until the completion of the Project. These reports shall include as a minimum the following:
  - 1. Minutes of the previous commissioning meeting.
  - 2. Copies of requests for submittals by the Commissioning Authority.
  - 3. List of upcoming commissioning activities, as noted on project schedule.
  - 4. Copies of functional test requirements scheduled for the following 4 weeks.
  - 5. A list of outstanding discrepancies and the party responsible for corrective action.
- C. Provide a final commissioning report to the Owner. The final commissioning report shall contain at a minimum:
  - 1. Copies of periodic commissioning reports.
  - 2. Copies of prefunctional test reports.
  - 3. Copies of functional test reports.
  - 4. Copies of the training report.

### 3.02 SYSTEMS TO BE COMMISSIONED:

#### 3.03 A. The following shall be commissioned if applicable:

- HVAC Systems
- Building Automation Systems
- Freezer Alarm Systems
- Specialty systems as defined in the contract with the Owner

- B. The following systems including all components and controls shall be commissioned **in this project:** (edit as needed) in addition to those mentioned in 3.03.A. .

#### Mechanical Equipment and/or Systems

Air handlers  
Split system heat pumps  
Ductless split system heat pumps  
Finned water boilers  
Building pressurization  
Rotary screw chillers, air cooled packaged  
Fans

Kitchen range hoods  
Make up air units  
Roof top air conditioning with gas heat and hot gas reheat w/ temp. & humidity control  
Pumps  
Variable speed drives  
Domestic water heating system  
Domestic water booster system  
Hydronic flow systems for building heating and cooling  
Electric unit heaters  
Building automation system

Electrical Equipment and/or Systems

Electrical distribution system  
Electrical switchboard  
Electrical switchgear  
Emergency power system  
Fault current protection system  
TVSS system

Specialty Equipment and/or Systems

Stair pressurization systems  
Fire and smoke alarm system including fireman's control panel  
Fire protection system including fire pump  
Fuel Alarm Systems  
Laboratory Vacuum Systems  
Class Change Bell Systems

3.03 START-UP, PRE-FUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT:

- A. Contractor shall be responsible for the initial checkout and pre-functional testing of installed equipment and systems. The Commissioning Authority shall deliver to the CM or GC the construction checklists (pre-functional or pre-startup) for administration. The Commissioning Authority shall monitor the activities of the parties responsible for executing the required start-up, and pre-functional testing, as identified in the commissioning plan. All equipment to be commissioned will have a pre-startup checklist filled out by the installer. The Commissioning Agent shall field verify 20% of the pre-startup checklists to confirm that the work has been done and that the equipment is ready for a functional test. The Commissioning Authority shall review the Contractor-furnished documentation of the start-up, initial checkout, and pre-functional test procedures for equipment and systems to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Construction Contractor shall furnish Operation and Maintenance manuals early enough in the project so that the Commissioning Agent can prepare the pre-startup and functional checklists.
- B. Observe 10% of the first pre-functional test procedures for each type and size equipment to ensure that the approved procedures are being followed.

- C. Observe 10% of the point-to-point checkout of the controls system.

#### 3.04 FUNCTIONAL TESTING:

- A. Functional testing of equipment or systems shall be conducted only after pre-functional testing and start-up has been satisfactorily completed. The Commissioning Agent (CxA) shall schedule functional tests with the Contractor and **direct, witness and document** the functional testing of equipment and systems to be commissioned. The Contractor shall be responsible for the execution of the functional tests.
- B. The functional testing shall demonstrate that each item of equipment and each system is operating according to the requirements of the construction documents. Each item of equipment and system undergoing functional testing shall be operated through all modes of operation where there is a required system response. Verify each action required in the sequences of operation has been accomplished according to the requirements.
- C. Functional testing shall proceed from components to subsystems to systems. When the proper performance of interacting individual systems has been achieved, the interface or coordinated responses among systems shall be tested.
- D. The proper and accurate operation of the control system shall be proven by functional testing and approved by the Commissioning Authority before it may be used for testing, adjusting and balancing activities or to verify performance of other components or systems. If authorized by the Commissioning Authority, portions of the control system may be tested and approved for these uses before the functional testing of the entire system is completed.
- E. Air and water balancing shall be completed and corrected as necessary before functional testing of air-related or water-related equipment or systems.
- F. Test Methods:
  - 1. Functional testing and verification shall be achieved by manual testing (direct manipulation of the equipment and observation of its response and performance), by monitoring the performance using the control system's trend log capabilities, or by analyzing the results of stand-alone data loggers. Functional test procedures shall specify which methods shall be used for each test. Determine which method is most appropriate for tests that do not have a method specified. The Commissioning Authority may substitute specified methods or require an additional method to be executed, other than that specified, if required to demonstrate the proper operation of the equipment or system being tested. Develop functional testing plans that define the allowable sampling procedures and that specify the procedures to be followed in the case of observed discrepancies or failures in the sample chosen for functional testing.
  - 2. Sampling: Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy, as defined in the functional test procedures. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their

common identity. A small size or capacity difference, alone, does not constitute a difference. The following equipment serving individual suites may be sample tested: bathroom exhaust fans, VAV boxes.

3. If 10% of the identical pieces of equipment (size alone does not constitute a difference) fail to perform to the requirements of the construction documents (mechanically or substantively) due to manufacturing defects or application errors that render it unable to meet its performance specification, identical units may be considered unacceptable by the Commissioning Authority. In such case, the Contractor shall provide the Commissioning Authority with the following:
  - a. Within 1 week of notification from the Commissioning Authority, the Contractor or manufacturer's representative shall examine other identical units and record the findings. The findings shall be provided to the Commissioning Authority within 2 weeks of the original notice.
  - b. Within 2 weeks of the original notification, the Contractor shall provide a signed and dated, written explanation of the problem, cause of failures, and proposed solution, including full equipment submittals for corrective or replacement equipment, if appropriate. The proposed solutions shall meet the specified requirements of the original installation.
  - c. The Commissioning Authority shall evaluate the proposed solution and submit his or her recommendation of approval or disapproval to the Owner and Architect.
  - d. When approved, two examples of the proposed solution shall be installed by the Contractor, and the Commissioning Authority shall schedule and conduct functional testing of the proposed solution. Upon completion of the functional testing of the proposed solution, the Commissioning Authority shall recommend the acceptance or disapproval of the proposed solution to the Owner. The Commissioning Authority shall provide a copy of his or her recommendations to the Architect.
  - e. Upon acceptance of the proposed solution by the Owner, the Contractor shall replace or repair identical items and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within 2 weeks of approval of the proposed solution.
4. Ensure that each functional test is performed under conditions that simulate actual operating conditions as closely as is practically possible.
5. Simulation of operating conditions (not by an overwritten value) shall be allowed, at the Commissioning Authority's discretion, though timing the testing to experience actual conditions is encouraged wherever practical. Simulation of conditions shall be accomplished by subjecting the equipment to actual operating conditions by artificial means whenever possible.
6. Where actually achieving a simulated operating condition is impractical, as

determined by the Commissioning Authority or identified in the functional test procedure, a signal generator that creates a simulated signal to test and calibrate transducers and DDC constants shall be used instead of using the sensor to act as the signal generator via simulated conditions or overwritten values. Signal generators or simulators shall be provided by the Contractor.

7. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be different than it really is, shall be allowed when approved by the Commissioning Authority, but shall be used with caution and avoided when possible. Simulation of the operating condition is preferable. Where a Building Automation System is installed, the functional tests for the control system should be performed as a system-wide, total building performance test with the mechanical system online and the BAS system complete and 100% functional. The intent of the test is to verify that the controls are functioning per design intent on the local equipment and as a total building system, with correct interfacing of the fire alarm system and any other systems with which they are intended to interface.
8. Altering set points: Rather than overwriting sensor values, and when simulating conditions is difficult, altering set points shall be used to test a sequence.
9. Indirect indicators: Relying on indirect indicators for responses or performance shall be allowed only after the Commissioning Authority has visually and directly verified that the indirect readings represent actual conditions and responses over the range of the tested parameters.

G. During the functional testing process, recommend solutions for identified deficiencies.

### 3.05 RETESTING OF EQUIPMENT AND/OR SYSTEMS:

- A. Prior to retesting of any functional performance test found to be deficient, submit the data indicating that the deficient items have been completed and/or corrected to the Commissioning Authority. After review of the submitted data, if the corrective measures are acceptable, the Commissioning Authority shall schedule and conduct a recheck. If during the retesting it becomes apparent that the deficient items have not been completed and/or corrected as indicated in the data provided by the Contractor, the retesting shall be stopped. Costs for the commissioning team to further supervise the retesting of a functional performance test shall be the responsibility of the Contractor.

### 3.06 DOCUMENTATION, NONCONFORMANCE AND APPROVAL OF TESTS:

- A. Documentation: Witness and document the results of functional tests using the specific procedural forms developed for this purpose. Deficiencies or nonconformance issues shall be noted and reported with the test results. Include the completed test forms in the final commissioning report.
- B. As functional testing progresses and a deficiency is identified, discuss the issue and attempt to resolve the discrepancy with the Contractor.

1. When there is no dispute about the deficiency and the Contractor accepts responsibility for correcting it, document the deficiency and the Contractor's response and intentions, and the testing shall proceed, if possible. Corrections of minor deficiencies identified may be made by the Contractor during the functional testing, at the discretion of the Commissioning Authority. In such cases, the deficiency and resolution shall be documented on the functional test form. Every effort shall be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the commissioning effort. When the Commissioning Authority determines that the required corrective actions will delay the testing process, document the observed deficiency and the proposed corrective action on the functional test form.
  2. When the identified deficiency is corrected, the Contractor shall sign the statement of correction at the bottom of the noncompliance form, certifying that the equipment is ready to be retested, and return the form to the Commissioning Authority. The Commissioning Authority shall schedule the retest of the equipment or system involved.
  3. If there is a dispute about an identified deficiency, document the deficiency and the Contractor's response, and submit the noncompliance report to the Owner and Architect, with a copy furnished to the Contractor. Every attempt shall be made to resolve the dispute at the lowest management level possible. Other parties shall be brought into the discussions by the Commissioning Authority as needed. Document the resolution process. When the dispute resolution has been decided, the appropriate party shall correct the deficiency, sign the statement of correction on the noncompliance form and return the form to the Commissioning Authority. The Commissioning Authority shall schedule the retest of the equipment or system involved. Final interpretive authority for any issue in dispute shall be the Architect. Final acceptance authority shall be the Owner.
  4. Retain the original nonconformance forms until the end of the Project. The completed forms shall be delivered to the Owner as a part of the final commissioning report.
- C. Approval: Note each satisfactorily demonstrated function on the functional test form. Formal approval of the functional tests shall be made after review of the test reports by the Commissioning Authority and Owner. Recommend acceptance of each test to the Owner using a standard form. The Owner shall give final approval on each test using the same form, providing a signed copy to the Commissioning Authority and the Contractor.

### 3.07 DEFERRED TESTING:

- A. If any required prefunctional or functional test cannot be completed as scheduled, execution of checklists and functional testing may be delayed upon approval of the Architect and the Commissioning Authority. These deferred tests shall be conducted in the same manner as the seasonal tests as soon as possible.
- B. Schedule and coordinate any required seasonal testing, tests delayed until weather or other conditions are suitable for the demonstration of the equipment or system's

performance. Seasonal testing shall be executed, documented and deficiencies corrected as specified herein for functional testing. Any adjustments or corrections to the operations and maintenance manuals and record documents required by the results of the testing shall be made before the seasonal testing process is considered complete. Schedule deferred testing with the Contractor, the Architect and the Owner.

### 3.08 OPERATION AND MAINTENANCE (O&M) MANUALS:

- A. Prior to the beginning of the training program for the commissioned systems, review the draft Operations and Maintenance (O&M) manuals, equipment documentation and as-installed drawings for systems that were commissioned and to verify compliance with the specifications. Communicate deficiencies in the manuals to the Owner and Contractor. When identified deficiencies have been corrected, recommend approval and acceptance of the O&M manuals to the Owner. Also, review each equipment warranty and verify that requirements needed to keep the warranty valid are clearly identified.
- B. Review the Contractor's draft O&M manuals to ensure they include single-line system diagrams on sheets matching the size required in the project specifications. These drawings shall include the chilled water system, domestic water system, heating system, supply, return and exhaust air systems, and Control systems. Drawings shall show major pieces of equipment.
- C. Ensure that the Owner's Project Requirements and the Basis of Design are included in the first section of the O&M manuals. These narrative sections shall be updated to record status by the responsible parties.
- D. Review all O&M Manuals provided from the contractor to the Owner as part of the project closeout for all components of commissioned systems.
- E. At a minimum, the O&M Manuals shall contain:
  - Itemized Equipment List: Include maintenance schedule and detailed work description of each maintenance item.
  - Each item of Equipment and each System: Include description of unit or system and component parts.
  - Operating Procedures.
  - Maintenance Requirements.
  - Servicing and Lubricant schedule and a list of lubricants required.
  - Sequence of operation from BAS controls contractor: Include post-occupancy software for all controls, BAS front end, and any software needed to operate or modify the BAS for daily operation.
  - Wiring diagrams and schematics for ALL systems, including life safety and security.
  - As-built control, speaker system, CCTV and fire alarm wiring diagrams.
  - O&M Manuals shall be provided in 3-ring binders and on CDs in PDF version.

## Appendix H – Target Finder and Portfolio Manager Set Up Worksheets

### Preparation Worksheet for Target Finder

#### Part A – Establish Target Performance

Information in this section results in energy performance parameters for a selected ENERGY STAR rating.

##### Go to the Target Finder Web site

- In the Web browser, type in: [www.energystar.gov](http://www.energystar.gov).
- Click on “Buildings and Plants.”
- Scroll down the page to the link for Target Finder.
- When at the Target Finder page, click on “Enter Target Finder.”

##### 1. Facility Information:

- Zip Code
- Facility Name
- City
- State

##### 2. Facility Characteristics:

- Select “Space Type” (K-12 School)
- Gross Floor Area
- Open Weekends?
- Number of PCs
- Number of walk-in refrigeration/freezer units
- Presence of cooking facilities (yes or no)
- Percent cooled
- Percent heated
- High School (yes or no)

##### 3. The Target:

- Click on “Select” under “Target Rating.”

##### 4. View Results:

- Scroll down to the bottom of the form and click on “View Results.”

#### Part B – Estimate Design Energy

Information in this section results in energy performance parameters based on energy source and cost information that becomes available during design development.

##### 1. Complete Part A.

##### 2. Estimate Design Energy:

- Select all energy sources used in the project and appropriate units.

- Estimate total annual use.
- Enter energy cost rates.

**3. View Results:**

- Scroll down to the bottom of the form and click on “View Results.”

## **Preparation Worksheet for Portfolio Manager**

### **Part A – Required Registration Information**

Establishing a Portfolio Manager account is easy when you have all the information available to you during user registration. This worksheet helps you research and collect the data needed so that when you go online, you will have it all together in one place. You should also file this sheet in an easily accessible place for future reference.

**Go to the Portfolio Manager Web site**

- In your Web browser, type in: [www.energystar.gov](http://www.energystar.gov).
- Click on “Buildings and Plants.”
- On the right of the Buildings and Plants page under the heading “Quick Finder,” click on “Portfolio Manager Login.”
- When you get to the login page, look to the top right of the page and click on “New User? Register.”

**1. Username:**

Select a name such as your organization, municipality or school district, for example. (The username cannot have spaces, dashes or other special characters.)

**2. Password:**

Pick a password with 8 to 32 characters (letters and numbers only, no spaces).

**3. First Name:**

(The name of the person who will be using the account the most)

**4. Last Name:**

**5. E-mail:**

**6. Title:** (Your job title)

**7. Organization:** (Organization’s name)

**8. Address:** (Organization’s address)

**9. City:**

**10. State:**

**11. ZIP Code:**

**12. Phone:**

**13. Select a Verification Question:**

This is for obtaining the password if you lose it.

Here are the options you will be given:

- What is your birth city?
- What is your favorite sports team?
- What is your favorite restaurant?
- What is the name of your pet?
- What is your favorite hobby?
- What is your favorite musical group?
- What was the make of your first car?

**14. Enter Answer:**

**15. What is the primary business or service of your organization?**

**16. Which best describes your job title?**

Choose from the following:

- Construction/Project Manager
  - Energy Manager
  - Energy/Environmental Manager
  - Facility Owner/Developer
  - Facility/Building/Property Manager
  - Leasing Manager/Broker/Agent
  - Physical Plant Manager
  - Staff Architect/Space Planner/Designer
  - Staff Engineer
  - VP/Dir. Of Construction/Design/Engineer
  - VP/Director of Facilities/Agent
  - Other: \_\_\_\_\_ (please specify)
- ("Energy Manager" or "Facility Manager" are the two categories most often selected because these are the people who usually track building energy performance.)

**17. Indicate your organization's annual activity for each category.**

You will need to know the total square footage of all facilities within your jurisdiction.

Manage/Upgrade: \_\_\_\_\_ (use total District SQFT)

Own: \_\_\_\_\_ (same as above)

Develop/Build: \_\_\_\_\_ (unless you know your capital improvement plan in terms of square footage, just use your best guess/estimate of the square footage of new facilities in design and construction)

**18. You do not need to complete about the optional "Master Account Feature."**

**Part B – Required Information for Each Facility Space**

**"Add a Property" Set Up**

Click on "Add a Property" — Enter the information for your facility.

### **“Add Space” Set Up**

Once you have added a property to your account (the project building), you are ready to add a space. The dropdown menu shows all the “ratable” spaces in Portfolio Manager. Select the one that best describes your facility or select “other.” Each space type will have its own combination of space attributes. Attributes for a K-12 space type are shown below. In the case of schools, the total gross floor area should include all supporting functions such as administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoria, laboratory classrooms, greenhouses, stairways, atria, elevator shafts, small landscaping sheds, storage areas, etc.

The following information is required for a K-12 School Space.

- Geographical area (by Zip Code)
- Total gross floor area
- Whether the school is open on weekends
- Number of PCs
- Number of walk-in refrigeration/freezer units
- Presence of cooking facilities
- Percent of space cooled
- Percent of space heated
- Whether it is a high school or not
- Number of months during the year the school is open

### **“Add Meter” Set Up**

You must now enter at least 12 months of energy consumption data from utility bills for all fuel types (electricity, natural gas, fuel oil, etc.) used by your building. There are help menus to assist you in completing this step.



# Owner's Project Requirements for Fundamental Commissioning

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1. Owner and User Requirements
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  - Broad Goals
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  - EMCS
  - Occupant Training and Orientation
  - O&M Staff Training and Orientation

Table 1A

Table 1B

# Owner's Project Requirements for Fundamental Commissioning

## 1. Owner and User Requirements

What are the primary purpose, program and use of this project? (Example: K-8 School, media center)

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Describe pertinent project history. (Example: standard design development)

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### Broad Goals

What are the broad goals relative to program needs?

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What are the broad goals relative to future expansion?

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What are the broad goals relative to flexibility?

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What are the broad goals relative to quality of materials? (Cost per square foot?)

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What are the broad goals relative to construction costs?

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What are the broad goals relative to operational costs? (Operational cost per square foot?)

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What are the broad goals relative to lifecycle of the equipment?

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Other broad goals: *(Insert as applicable)*

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**2. Environmental and Sustainability Goals**

What are the project goals relative to energy efficiency? (example: ENERGY STAR rating, BTU budget/SF)

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What are the project goals and requirements for the building site that will impact energy use?

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What are the project goals and requirements for building façade that will impact energy use?

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What are the project goals and requirements for building fenestration that will impact energy use?

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What are the project goals and requirements for building envelope that will impact energy use?

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---

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What are the project goals and requirements for building roof that will impact energy use?

---

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---

Other: *(Insert as applicable)*

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### 3. Indoor Environmental Quality Requirements

What is the intended use for all spaces? For all spaces that have an intended use that is not readily apparent from the space name, provide this information in Table 1. (Add an attachment showing space use.)

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What is the anticipated occupancy schedule (numbers of occupants and time frames) for all occupied spaces? Indicate the default occupancy schedule below, and for all spaces that have an occupancy schedule that differs from the default, provide this information in Table 1.

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What accommodations for after-hours use are required? (Example: access control, lighting controls, HVAC controls, etc.) Indicate general accommodations required below, and for all spaces that have special requirements, provide this information in Table 1.

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---

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What are the lighting, temperature, humidity, air quality, ventilation and filtration requirements for all spaces? Indicate the default requirements below, and for all spaces that have a requirement that differs from the default, provide this information in Table 1.

Lighting: \_\_\_\_\_

Temperature: \_\_\_\_\_

Humidity: \_\_\_\_\_

Air Quality: \_\_\_\_\_

Ventilation: \_\_\_\_\_

Filtration: \_\_\_\_\_

What are the acoustical requirements for all spaces? Indicate the default acoustical requirements below, and for all spaces that have a requirement that differs from the default, provide this information in Table 1.

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---

What is the desired level of occupant ability to adjust systems controls? Indicate the default desired levels below, and for all spaces that have a desired level that differs from the default, provide this information in Table 1.

Lighting: \_\_\_\_\_

Temperature: \_\_\_\_\_

Humidity: \_\_\_\_\_

Air Quality: \_\_\_\_\_

Ventilation: \_\_\_\_\_

What, if any, specific types of lighting are desired? (Example: fluorescent in 2x2 grid, accent lighting, particular lamps)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

#### 4. Equipment and System Expectations

*(Complete for each category as applicable or indicate "none identified" or "N/A." Add desired features information for other anticipated commissioned systems as applicable)*

Indicate desired features for the following commissioned system: **Space Heating**

Desired Type: \_\_\_\_\_

Quality: \_\_\_\_\_

Preferred Manufacturer: \_\_\_\_\_

Reliability: \_\_\_\_\_

Automation: \_\_\_\_\_

Flexibility: \_\_\_\_\_

Maintenance Requirements: \_\_\_\_\_

Efficiency Target: \_\_\_\_\_

Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Ventilation**

Desired Type: \_\_\_\_\_

Quality: \_\_\_\_\_

Preferred Manufacturer: \_\_\_\_\_

Reliability: \_\_\_\_\_

Automation: \_\_\_\_\_

Flexibility: \_\_\_\_\_

Maintenance Requirements: \_\_\_\_\_

Efficiency Target: \_\_\_\_\_

Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Air Conditioning**

Desired Type: \_\_\_\_\_

Quality: \_\_\_\_\_

Preferred Manufacturer: \_\_\_\_\_

Reliability: \_\_\_\_\_

Automation: \_\_\_\_\_

Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Refrigeration**

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **HVAC Controls**

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Domestic Hot Water**

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Lighting Controls**

Desired Type: \_\_\_\_\_

Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Daylighting Controls**

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Emergency Power**

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_  
Desired Technologies: \_\_\_\_\_

Indicate desired features for the following commissioned system: **Other** \_\_\_\_\_

Desired Type: \_\_\_\_\_  
Quality: \_\_\_\_\_  
Preferred Manufacturer: \_\_\_\_\_  
Reliability: \_\_\_\_\_  
Automation: \_\_\_\_\_  
Flexibility: \_\_\_\_\_  
Maintenance Requirements: \_\_\_\_\_  
Efficiency Target: \_\_\_\_\_

Desired Technologies: \_\_\_\_\_

**5. Building Occupant and O&M Personnel Requirements**

How will the facility be operated? Who will operate the facility?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Will the facility be connected to an EMCS? If so, what are the interface requirements?  
(Example: monitoring points, control points, scheduling)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

What is the desired level of training and orientation for building occupants to understand and use the building systems?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

What is the desired level of training and orientation for O&M staff to understand and maintain the building systems?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**Table 1-B**

<b>Space</b>	<b>Special Humidity Requirements</b>	<b>Special Ventilation/Filtration Requirements</b>	<b>Special Acoustic Requirements</b>	<b>Special Lighting Requirements</b>	<b>Special Occupancy Adjustability Requirements</b>

## Appendix J – Building Operating Plan Template

### Building Operation Plan

#### General Requirements for All Spaces

Description of Requirement	Classrooms	Offices	Media Center	Kitchen
1. Cooling Season Temperature				
2. Heating Season Temperature				
3. Humidity Levels				
4. Air Pressure Relationships				
5. Air Filters				
6. Outside Air Ventilation				
7. Air Changes				
8. Interior Lighting Levels				

Description of Requirement	Gymnasium	Auditorium	Cafetorium	Other
1. Cooling Season Temperature				
2. Heating Season Temperature				
3. Humidity Levels				
4. Air Pressure Relationships				
5. Air Filters				
6. Outside Air Ventilation				
7. Air Changes				
8. Interior Lighting Levels				

# Building Operation Plan

## Equipment Inventory and Run Time Schedules

Building:	
Responsible Building Operator:	
Last Update:	

Item Description	Occupied Hours Week days	After Hours Week days	Weekends and Holidays	Vacation Periods
[Examples]				
PU-1 (Room 101)				
RTU-1 (Rooms 102, 103, 104, 105)				
AHU-01 (Building 06)				
AHU-02 (Wing A, 2 <sup>nd</sup> Floor)				
DX-1				
Chiller (250 t)				
Cooling Tower				
Boiler #1 (Natural Gas)				
Parking lot lights				
Overhead walkway lights				
Tennis court lights				
Field lights				

# Building Operation Plan

## Design Set Points

Building:	
Responsible Building Operator:	
Last Update:	

Item Description	Supply Air Temperature	Supply Water Temperature	Static Pressure	
[Examples]				
PU-1 (Room 101)				
RTU-1 (Rooms 102, 103, 104, 105)				
RTU's (All RTU's serving classrooms)				
AHU-01 (Building 06)				
AHU-02 (Wing A, 2 <sup>nd</sup> Floor)				
Chiller (250 t)				
Cooling Tower				
Boiler #1 (Natural Gas)				

# **ADECA**

[www.adeca.alabama.gov/energy](http://www.adeca.alabama.gov/energy)

Alabama Department of Economic and Community Affairs  
Energy Division  
401 Adams Avenue  
P.O. Box 5690  
Montgomery, AL 36103-5690  
(334) 242-5290

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