

Establishing Commissioning Costs

Portland Energy Conservation, Inc. (PECI) 9/12/00; Revised 02/14/02

The following summarizes the latest information on commissioning costs taking into account costing studies PEGI has completed in-house reconciling our costing models and experience with Ron Wilkinson's ASHRAE Journal, February 2000 article.

Commissioning costs vary considerably with project size and building type, equipment type, commissioning scope and traveling requirements. Historically, commissioning has focused on HVAC and controls and started during construction. However, the quality control and assurance for more and more systems is being brought under the commissioning umbrella and commissioning is starting more often in the design phase. A few rules of thumb will assist the project manager in planning for commissioning. *These costing guidelines must be used with great caution.* Understanding what is and is not included in each cost number is critical. The project manager is advised, when possible, to contact a commissioning provider to discuss cost ranges for specific projects before finalizing a planning budget. As a very general rule, the total cost commissioning cost will include a design phase and construction phase component and will amount to approximately .6 to 1.8% of the overall construction cost for the project.

Design Phase Commissioning Costs

Design phase commissioning may consist of a variety of tasks. At minimum, the process entails the commissioning provider:

- Ensuring that the Owner's objectives are clearly documented.
- Ensuring that the design team develops a design description and design basis.
- Providing an independent design review with a operating perspective.
- Ensuring that design can be adequately commissioned¹.
- Ensuring that commissioning is adequately reflected in the bid documents².

Additional activities may include detailed design review in such areas as indoor environmental quality, maintainability, contractibility, structural, envelope and moisture, energy efficiency, code and policy compliance and sustainability. Rarely would a project warrant a third party taking on all the above tasks. The Owner should identify the issues they feel are critical or that require special attention from another consultant in addition to the designer, based on the expertise of the designer(s) of record and the nature of the project.

For a project that includes the minimum tasks listed above and a few of the additional activities listed, the costs for the commissioning provider combined with the additional work of the designers may range from one to three tenths of 1% of the total

¹ Ensuring that sufficient test ports, monitoring points and control points in the BAS, access panels, etc.

² By including commissioning language in the project specifications.

construction cost for a typical office building. Buildings over 100,000 square feet will typically be near the bottom of the range and buildings less than 100,000 square feet in the top end of the range. More complex building types and larger scopes may cost considerably more. As a percentage, the commissioning provider's design phase costs will be roughly 75% of the total, and the designer's 25%.

Construction Phase Commissioning Costs

The following numbers cover the commissioning agent's costs for the construction and warranty phases, including submittal review, construction checklist development, construction observation, writing, overseeing and documenting functional tests (initial and seasonal), verifying that staff training and O&M manuals are per specification and conducting a near-warranty-end review. Commissioning of the HVAC system includes all systems, including fire, life, safety and controls. Commissioning of the electrical system includes lighting controls, emergency power and limited connection and grounding checks. It does not include infrared scanning, power quality, switchgear, transformer, or low voltage system testing. Complex systems and critical applications will have higher costs.

Table 1: Construction Phase Commissioning Costs

Commissioned System	Commissioning Cost
HVAC and controls	2.0% to 3.0% of total mechanical cost
Electrical system	1.0% to 2.0% of total electrical cost
HVAC, controls and electrical	0.5% to 1.5% of total construction cost

Source for the first two line items: Ron Wilkinson, ASHRAE Journal, Feb. 2000. Third line: PECCI,

The above costs cover only the commissioning agent's fees. There are also costs to the contractor, the designers and Owner staff for their part in the commissioning process. The costs for the contractor attending meetings, documenting the construction checklists and assisting with testing will roughly equal 10% to 25% of the commissioning agent's costs. However, in the larger picture, the savings to the contractor in callback costs and holding of final payment retention may exceed the first costs, resulting in little if any net commissioning cost to the contractor. The designer's costs for construction phase commissioning is fairly insignificant when their scope is limited to review of the commissioning plan and a few meetings.

The project manager should realize that the savings to them in reduced change orders (if commissioning starts during design), smoother turnover and less troubleshooting time during the first year will often offset the cost of the commissioning agent. Increased energy efficiency also reduces the net cost of commissioning, not to mention the value of more satisfied tenants and reduced indoor air quality liability.

Estimating by floor area is another method often used for rough estimates. The costs in Figure 1 include the cost of the commissioning agent from early construction through warranty for HVAC and controls, including lighting, but do not include low voltage, electrical grounding, infrared scanning, power quality, switchgear and transformer testing. Tasks include submittal review, construction checklist development, construction observation, writing, overseeing and documenting

functional tests and reviewing staff training and O&M manuals. These costs are averages and can vary considerably, since the number of pieces of equipment and commissioning rigor vary. Note that these curves become very steep as they approach the Y axis. In pure theory, the \$ per square foot for a 0 square foot building should be infinity. Experience on some projects indicates that a small, 10,000 square foot building with complex systems and LEED requirements could have legitimate costs in the \$4 per square foot range (the specialty curve). That same building with simple systems or without LEED could run in the \$2 per square foot range (the simple curve). The reasons for this will be discussed in greater detail later in this document.

Estimates of Construction Phase Commissioning Costs
 (Costs for the commissioning authority in new construction, per square foot)

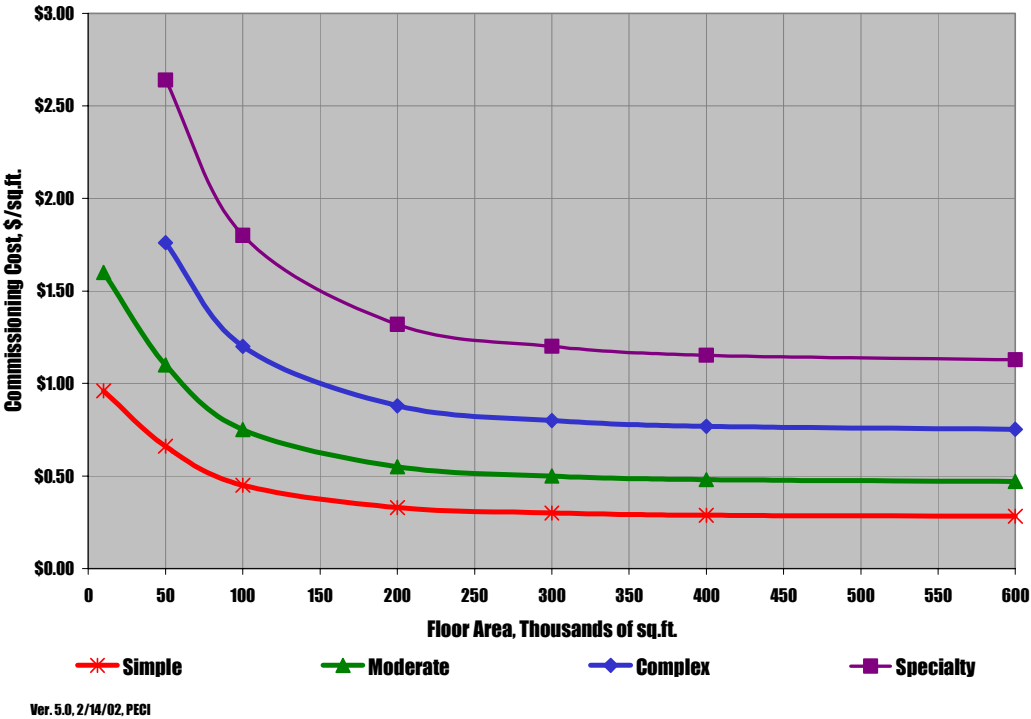


Figure 1 - Commissioning Costs in Terms of Dollars per Square Foot

Simple = office buildings, classrooms, packaged equipment and controls; common systems, fewer pieces of equipment.
 Moderate = more complex office, classroom with some labs, building automation, more control strategies, fewer packaged equipment; more systems (fire, emergency power, etc.).
 Complex = Moderate plus most of floor area in complex systems (hospitals, labs, operating rooms, clean rooms, fume hoods or other non-HVAC systems are commissioned such as electrical quality, transformers, security, communications, etc. Traveling requirements and high cost of living locations increase costs.
 Specialty = Very complex facilities like prisons. (Doesn't include security systems commissioning costs).

Things That Can Break the Rules

The preceding paragraphs provide a reasonable guideline for establishing project budgets or spot-checking commissioning costs. However, there are situations under which the preceding rules simply will not hold resulting in commissioning costs that are significantly higher than would be projected based on the preceding information. Thus, the rules should be used with caution. Some items to consider are discussed in the following paragraphs.

Duration of Construction

The duration of the project construction process can often have a significant impact on the commissioning costs for a project. Even if the current project phase does not require a significant involvement on the part of the commissioning agent, there will still be phone calls, miscellaneous consultations and other project related business to attend to. For a long construction cycle, this can really add up. One hour a week adds up to 52 man-hours in the course of a year. Many times, this cost is covered by the commissioning agent's overhead, built into their fee, or by a contingency carried in the budget. For a project with a long construction window, but fairly simple systems, the man-hours associated with this can begin to skew the commissioning costs well outside what the rules of thumb would have anticipated.

Project Meeting Requirements

The modern construction process often can involve a significant number of meetings. During the design phase, regular coordination meetings among the members of the design team are quite common. During the bidding phase of the project, there will typically be at least one pre-bid meeting and walk through; sometimes, there can be more than one for a complex project or if an addendum makes a significant change to the bidding documents. The construction process itself is often initiated with a pre-construction meeting followed by regular (often weekly) construction coordination meetings. If the project requires coordination drawings, then there will be a series of meetings dedicated to them in addition to the regular construction meetings. The requirements of the commissioning specifications or contract and the needs of the project and/or the commissioning agent may obligate the commissioning agent to attend some or all of these meetings. As a result, there will be a fixed cost associated with the project that can have much more to do with the length of the construction cycle than the systems to be commissioned.

Even if the project is located near the commissioning agent's office, the need to attend a meeting at the site or at another office can very easily require 2 to 4 hours per meeting when travel time is considered. Construction delays can aggravate the cost associated with this. Even if the commissioning agent is not bound by contract to attend these meetings, the needs of the project or even the success of the commissioning process itself can snowball into a frequent need to meet. If the project is not going well with a lot of problems and lack of cooperation from the contractors, then circumstances may force the commissioning agent to attend the regular construction meetings simply to remain in control of the process and resolve

conflicts. It is also possible for a successful commissioning process to mushroom into more meetings than anticipated as construction team members become excited and enthusiastically embrace the process and seek advice and input from the commissioning agent. Budgeting for this can often be difficult, and the commissioning agent always will be at risk to some extent in this regard. However, taking the following steps can minimize the inherent risks.

- 1** Gain a clear understanding of the anticipated duration of construction prior to finalizing the commissioning proposal. If the commissioning RFQ, specifications, or contract will mandate your attendance at regular meetings, be sure you understand how many meetings this will entail over the course of the project.
- 2** Clearly indicate in your proposal what you anticipate your involvement in meetings during the construction/commissioning process will be. You may even want to specifically state the number of meetings you will attend or which meetings you have included in your proposal and which are an added cost if your attendance is required.
- 3** Consider making meeting attendance costs a separate, reimbursable expense. (Meetings that are fundamental to the commissioning process, like the scoping meeting, should be included in the base proposal if this approach is taken.)
- 4** Coordinate and combine meeting attendance with other project commissioning requirements like site inspections or testing.

Site Inspection and Testing Requirements

The considerations listed previously for meetings can also apply to the need to perform site inspections during the construction process. Contractual obligations, duration of construction, and construction delays can all make the costs associated with this requirement disproportionate to the building size or the complexity of its systems.

Even a fairly simple building with packaged equipment can take 6 to 12 months to construct. If the commissioning agent is obligated to perform regular site inspections with follow-up reports for the duration of the construction process, then the costs for this process can match or exceed the costs associated with the actual start-up and testing of the systems in the building, skewing the commissioning costs significantly from what the rules of thumb would lead one to expect.

Quality control issues for buildings with complex and/or exotic systems in them may also require frequent site inspections by the commissioning agent if IAQ and efficiency issues are to be adequately addressed, even if the visits are not specifically called out by the contract documents. For instance, the pressure losses associated with duct and piping systems are as much a function of proper fabrication in the field as they are of design and detailing on the drawings. The identification and resolution of poor fabrications and misinterpretations of the design documents that can adversely impact performance must be accomplished early in the fabrication process to minimize delays and cost. And, they must be identified before the assembly is covered up by other building elements. Similarly, more exotic system configurations,

like under floor distribution systems, will often require nearly constant attention from a quality control focused individual to ensure that they are fabricated in an air-tight manner and kept clean to prevent IAQ problems down the road. These efforts will require frequent inspection and diligence from someone on the construction quality control team. Often this person is the commissioning agent either by contractual obligation or simply to protect his or her own interests and avoid more difficult, ripple effect commissioning problems down the road.

System Complexity

Complex systems and/or systems with a large number of zones of control will have much higher commissioning costs than less sophisticated packaged approaches. This is partially because the more complex systems will imply the need for more frequent site inspections and more coordination meetings. But it is also true because the more complex systems require more review and coordination during design to assure that they are properly implemented and more sophisticated functional testing during start-up and commissioning to assure that performance of the integrated systems with each other and the building and its environment meet the design intent. Large buildings, by their nature, tend to require that more sophisticated and customized systems be employed to achieve the desired levels of performance and efficiency. Small buildings often cannot justify complex system solutions and thus, tend to be served by more standardized, packaged arrangements. Thus, the rules of thumb when applied to commissioning large buildings tend to reflect the costs more accurately than they do when applied to small buildings that employ complex systems.

Zone counts can also increase commissioning costs, especially if the zone density is high relative to the building square footage. This is because each zone represents equipment that must be checked out and tested by the commissioning process. It also represents a higher level of risk for the commissioning agent since installation problems are often repeated in each zone via standard details, copied programs, and the repetitive nature of the process used to fabricate and install the zone equipment. An improper wiring detail for a zone thermostat on the drawings can quickly become 200-300 field problems (one per zone) if it is not caught and corrected before installation. It is not uncommon for the commissioning process to uncover this type of problem. As a result, the commissioning agent is faced with resolving and verifying every occurrence of the problem. Thus, the costs to commission a building with a high zone density may be higher than would be expected based on the rules of thumb.

LEED Requirements

As interest in sustainability and efficiency grows, many new projects are being constructed to meet the requirements of the U.S. Green Building Councils LEED program. Commissioning is a fundamental prerequisite required to achieve a LEED rating. The LEED Reference Guide outlines the specific requirements associated with this, but in general, the fundamental commissioning process must include:

- 1 Engage a commissioning agent.
- 2 Develop design intent and basis of design documentation (required even if started after design).
- 3 Incorporate clear and complete commissioning requirements ideally in the construction specifications or through explicit change order.
- 4 Develop and utilize a commissioning plan.
- 5 Verify installation, functional performance, training and documentation.
- 6 Complete a commissioning report.

Even though these steps are part of any good commissioning process, the need to document these steps for LEED purposes and coordinate with other members of the LEED team may add costs to the commissioning work that would not be anticipated based on the rules of thumb. In addition, a specific LEED requirement for item 5 is that the functional testing of the heating and cooling systems occurs during the heating and cooling seasons respectively. While this is desirable, it is not considered mandatory for a non-LEED commissioning process, and thus, this aspect of the LEED process may also represent additional commissioning costs.

Recent experience on LEED projects has revealed that many Owners and construction project managers assume that the LEED process and the commissioning process are one in the same, and thus assume that the commissioning agent is handling any and all LEED requirements and coordination. This may or may not be true depending on the commissioning agent's understanding of his contractual obligations. Just because LEED may be interpreted to require that all LEED features be commissioned doesn't mean that the person commissioning them can or will handle all LEED related design and coordination issues. A successful LEED project requires involvement and participation by all members of the project design and construction team. Having a designated LEED coordinator is certainly a desirable step in ensuring that the LEED goals are met. However, such coordination is above and beyond the scope of the prerequisite commissioning associated with a LEED project. While the commissioning agent is a likely candidate for performing this coordination, it should not be assumed that they will be providing this coordination simply because they have been engaged to perform the commissioning work for the project. Similarly, a commissioning agent who is contracting for work on a LEED project should be sure to identify exactly what his or her obligations are in light of the LEED requirements. If LEED coordination is to be included in the commissioning scope of work, then there will be added costs to the commissioning contract that will be above and beyond those that might be arrived at by using the rules of thumb.

Another interesting aspect of LEED projects is that in an effort to obtain LEED points for efficiency and innovation, the design team often employs exotic and less proven approaches and technologies for the system associated with the building. LEED buildings often employ systems that use renewable energy sources such as solar power or wind power and low energy HVAC systems and cycles like natural ventilation or evaporative cooling systems. Using rainwater recovery systems, gray water systems, and composting toilets can conserve other resources and these approaches are often included too. All of these technologies can make a significant

contribution to the sustainability of the project and the number of LEED credit points achieved, but they also add complexity to the commissioning process since the technologies are currently less proven and less understood by the people implementing them. When all of these factors are combined into the systems serving a small building, the “per square foot” commissioning costs can be significantly above what the rules of thumb would predict.

In addition to requiring commissioning as a prerequisite, a LEED credit point can be obtained for “extra commissioning”. Again, the LEED Reference Guide goes into detail regarding exactly what is necessary for achieving this credit, but in general, the following items are required.

- 1** Complete a design review by a qualified party other than the designer, and preferably by the commissioning agent.
- 2** Complete a construction documents review by a qualified party other than the designer.
- 3** Complete a focused review of submittals (shop drawings, cut sheets, etc.)
- 4** Develop a Systems and Energy Management Manual or Recommissioning Manual.
- 5** Have a contract in place for a near-warranty end or post occupancy review.

While these items are all valuable and highly desirable from a commissioning and operations standpoint, the effort required on the part of the commissioning agent to provide them can be significant, especially with regard to developing the Systems and Energy Management Manual. This effort will have more to do with the number of systems and their complexity than the size of the building. The effort required to develop a manual for a small building with complex, customized systems will be nearly identical to that required for a large building with identical system types. Thus, the actual costs to provide these features on a small building with complex systems might be significantly higher than the rules of thumb would indicate.

Handling Commissioning Costs

Many Owners and Facilities Engineers find that while they are interested in the benefits associated with the commissioning process and have a gut level understanding of the benefits, they lack the more concrete information often required to sell commissioning to management and accounting personnel involved with funding their project. A detailed discussion of this topic is beyond the scope of this paper, however, historical data and past experience can often be used to develop specific information in the following areas:

- **Improved Efficiency:** Generally, this is one of the easiest areas to substantiate. There is quite a bit of public domain information available that documents commissioning savings in both new construction and retrocommissioning. Some of the information is in the form of case studies, but some of it is more general in nature and related to building types and functions. One good source for this type of data is the PECE website located at www.peci.org. In addition, if an Owner has

gone through a commissioning process previously, then the information from that project can often be extrapolated to reflect the new project.

- **Reduced Change Orders:** One of the more commonly acknowledged benefits of commissioning (especially design phase commissioning) is that the process will reduce the number of change-orders encountered in a typical construction cycle. Many Owners and facilities managers have access to the cost records of past projects and can extract the savings potential in this category from this historical data. When using this data, it is important to base the estimate only on change orders that would have been impacted or eliminated by the commissioning process. For instance, the costs associated with an Owner initiated change order that added tenant finishes in an area shown as unfinished space on the contract documents should not be included as costs that could be avoided via a good commissioning process.
- **Improved Maintainability:** Many commissioning related improvements simply make the systems and equipment in a building easier to service and maintain. A design phase commissioning finding that makes an equipment room easily accessible for equipment replacement can easily save tens of thousands of dollars any time the machinery in the room undergoes a major repair or replacement. Typically, this will happen at least once in the building's life cycle if not two or three times. Informal discussions with a friendly contractor over lunch can often provide an Owner or Facility Manager with useful insights into these costs based on real world experiences.

Improvements that make routine and maintenance and service easier will also add up to significant savings over the life of a building. Often, the Owner's own maintenance staff is the best source of information in this regard. There are also estimating guides such as *R.S. Means Cost Planning and Estimating for Facilities Maintenance* available which can provide a more standardized perspective on this problem.

- **Improved Occupant Comfort And Productivity:** There is growing evidence to show that improved occupant comfort translated directly to improved productivity. Improved productivity translates directly to an improved bottom line for most business. Even a 1 or 2% improvement in worker productivity can significantly boost a company's bottom line. Some information on this topic can be found in *Commissioning for Better Buildings in Oregon* available at the Oregon Office of Energy website at www.cbs.state.or.us/external/ooe. Additional research in this area is ongoing and new and updated information will more than likely be found in a search of the internet.

Commissioning related savings typically extend beyond the construction budget and will show up year after year as reduced operating and maintenance costs. Thus, it is important to show the savings in these terms. Presenting annual savings in terms of present worth or future value is often a real attention getter when dealing with financial professionals.

It is also important to realize that simply documenting or improving on a process that is already in place in an Owner's facility or organization may provide some of the commissioning benefits with little if any additional direct cost. For instance:

- Many facilities groups spend time reviewing the construction documents for new projects or modifications to existing facilities. Many times, these review efforts will include the plans, specifications and shop drawings for the project. This type of review is an important component of any commissioning project. On LEED projects, documenting this process can help gain the extra commissioning credit that is offered.

By focusing their in-house effort and taking advantage of in-house expertise, and perhaps providing a little more time for the process to occur, an Owner with knowledgeable staff can gain the benefit of an independent plan review without having to hire an independent provider for as much of the work. This does not mean that an independent provider will not need to do some review; some effort in this area is required simply to become familiar with and stay on top of the project. However, it may be possible to develop a coordinated approach to the effort that will allow the independent provider to delegate some of the review responsibility to the Owner's staff, to the benefit of all involved.

- In existing facilities undergoing modification, many of the construction observation requirements can be addressed by enabling the operating staff to spend some time each day or week on the construction site. In addition to providing construction observation with a commissioning focus, the operating staff will learn a great deal about the new systems they will soon be operating, which will provide significant long-term benefits to the facility. For new facilities, consider ramping up and bringing the operating team on-board during the design and construction process. This will allow them to provide the benefit of their real world operating insight to the design and construction team as the project develops. It will also allow them to provide construction observation services and participate in the start-up of the systems they will eventually own and operate.
- Many times, the information that the Owner develops for their maintenance program is very similar to what is required for a LEED Systems and Recommissioning Manual. By starting this process earlier and providing a path that allows the staff that is involved with the maintenance program to work with the project commissioning agent during the functional testing process, it may be possible to meet the requirements for the manual with little additional cost.