Part 2: Simplifying The Commissioning Process

Tips for Applying Commissioning

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ABSTRACT

This is Part 2 of a three-part series article. The original paper was first submitted in the Proceedings of the World Energy Engineering Congress 2006. It has been reformatted into three parts and condensed for publication in Energy Engineering. The complete original paper is available from the author.

The success of commissioning depends to a very large extent on the support of the owner, which in turn depends upon the owner knowing what commissioning is. The topic of commissioning (Cx) is often viewed as complex, confusing, and expensive.

This article speaks to anyone with interest in the field of commissioning, with an emphasis on anticipating and answering questions owners may have, and will have served its purpose if it improves the owner’s comfort level with respect to commissioning.

This article is divided into three parts.

Part 1 - What is Commissioning?
Part 2 - Tips for Applying Commissioning
Part 3 - Quantifying Commissioning Benefits

Part 2, “Tips for Applying Commissioning,” includes practical suggestions and a variety of “lessons learned” items. The chance of success in a commissioned project will improve by following the suggestions and guidelines in this section.
PART 2: TIPS FOR APPLYING COMMISSIONING

This section provides some practical tips for getting the most out of commissioning.

TIP 1 - WHAT TO LOOK FOR IN A COMMISSIONING PROVIDER

The concept that people buy from people applies to commissioning, since the commissioning provider is usually in direct association with the owner. Some characteristics to look for in a commissioning provider are provided to help the owner choose a good partner. Communication skills are stressed, so that the objectives can be met with cooperation instead of dissension from the project team.

Here are some basic qualifications to get you started. But beyond these, be sure the person or team you have chosen meets your personal litmus test as well. Communication skills, cooperative nature, positive attitude, willingness to compromise, willingness to listen, and especially paying attention are things to look for.

Experience Required:

- At least five years experience in all phases of commissioning work, including pre-construction, construction, and start-up phases.
- Design of HVAC systems and energy management control systems.
- Field operation and troubleshooting of HVAC systems and energy management control systems.
- Knowledgeable in indoor air quality (IAQ) issues related to HVAC design and construction.
- Knowledgeable in air and water test and balance, including best practice procedures.
- Direct experience in monitoring and analyzing system operation using instruments.
- Excellent corporate support to the commissioning agent. History of successful projects.

Team Approach Allowed

- The commissioning agent (CxA) requirements need not be fulfilled by a single “super” individual.
- With proper leadership, the combined expertise of multiple persons is acceptable.
Credentials
• The commissioning lead individual should be a licensed professional mechanical engineer (PE) in the project state. This simple requirement establishes a quality bar of the person for character, and is a great first step in earning the respect of the owner’s team.
• Other credentials such as Certified Energy Manager (CEM) and LEED professional may be valuable, depending on the project scope and the owner’s project intent hot buttons.

Third Party Status
• The commissioning agent will act on the behalf of the owner, and must have no other business attachments that create a conflict of interest with the project. The commissioning agent should be an independent entity employed directly by the owner.
• The commissioning agent must not be the general contractor (GC), or a business affiliate of the GC, or a subcontractor of the GC.
• The commissioning agent must not be the project architect or engineer (A/E), or a business affiliate of the A/E, or a subcontractor of the A/E.
• The commissioning agent must not be the project test and balance (TAB) contractor; however, he or she may employ the TAB if requested by the owner.

Commissioning Standard/Methods
• Utilize methods based on ASHRAE Guideline 1, the HVAC Commissioning Process [3].
• Commissioning methods and commissioning plan shall include design review, and other pre-construction activities, and shall not be limited to “start-up” commissioning.
• Commissioning methods primarily focused on equipment start-up phase, such as those published by NEBB, SMACNA, or the U.S. Army Corps of Engineers, will not be acceptable unless supplemented to provide a complete service that parallels the approved methods noted above.

TIP 2 - OWNER INVOLVEMENT—THE KEY INGREDIENT

Lead for Success
The success of commissioning depends to a very large extent on the
support of the owner and the cooperation of the architects, engineers, and contractors involved. It is very easy to undermine.

**Give Owner Support**

Enthusiastic support by the owner is needed for the commissioning goals and activities. The owner needs to instruct the design team and the contractors that the commissioning agent represents the owner’s interests and his or her advice will be taken seriously, but direction will come only from the owner.

**Require Prompt Response to Comments**

Without requiring this, the value of commissioning can be reduced to a fraction of its potential. This may require the use of the phrase “just do it.”

**Require Cooperation**

Owner-required cooperation with the commissioning agent includes prompt, courteous responses to all comments. The owner needs to require this cooperation and quick response, otherwise it is very easy to ignore the commissioning agent and dilute the benefits.

**Be a Facilitator**

The owner needs to facilitate discussion of design review and site observation report issues, and get them into the “resolved” bin as quickly as possible.

**Require Coordination**

The owner needs to require that the commissioning activities be coordinated with the contractor’s schedule to avoid confusion and delay in the construction work.

**TIP 3 - WHEN TO USE COMMISSIONING? HOW MUCH IS TOO MUCH?**

It’s probably safe to say that anything and any project can be improved on. Does that mean all construction projects should be commissioned? Probably not. A prudent decision will weigh the cost of the quality benefits against the risks themselves, as well as whether quality is a project factor or not.
While the choice is entirely the owner’s, here are some considerations for whether to commission or not.

STEP 1: Mission Critical Project Importance?

If the project is or contains parts that are ultra-critical, such that project failure is unacceptable, commissioning as an overlay for added insurance may be a great investment. In other words, if the risk of failure is intolerable, then the cost to mitigate that risk is usually warranted. In extreme circumstances, it may also be warranted to forego the usual low-bid process and select project partners on qualifications alone.

If you consider your project mission critical, commissioning may be an excellent tool to help ensure success. Note that a commissioning scope can always be confined to certain areas where the concern for risk management is greatest, e.g. a computer data center in a spec office building. If you have a high-risk item with pass-fail severe consequences, go to Step 3.

STEP 2: (Non-Mission Critical Project.)

Where does quality fit in your list of priorities?

Understand that there can only be ONE #1 priority, and begin by ranking your project’s priorities.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Project Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>Price</td>
</tr>
<tr>
<td>?</td>
<td>Schedule</td>
</tr>
<tr>
<td>?</td>
<td>Quality</td>
</tr>
</tbody>
</table>

If quality is at the bottom of the list, chances are commissioning won’t serve you well. This is because quality issues, when discovered, will be pushed back from the pressures of price and schedule. Benefits will occur from commissioning, but they will likely be minimal and may not justify the commissioning cost.

If quality is either first or second in this table, then commissioning may be appropriate.

STEP 3: Project Cost vs. Commissioning Cost.

The usual answer to the question “How much does commissioning cost?” is “It depends.” However, there are some guidelines for approximate costs that will take some of the mystery out of this.
Like most services, there is a range of service levels and associated effort and cost (and benefit). Also like many things, there is economy of scale to implementing the commissioning process. The “per SF” or “percent of construction cost” rules of thumb will slide up and down with project size, but below some project size the minimum charges will dominate and the cost will become prohibitive. This phenomenon is not unique to commissioning; consider the “per SF” cost for a general contractor to construct a 1000 SF building vs. a 100,000 SF building. Also, retrofit commissioning, just like retrofit construction, will cost more than new construction; on order of 50 percent more.

That said, here are some approximate ranges of commissioning costs, expressed as a percent of construction cost. Please note that costs are “order of magnitude” with a range of +/- 30 percent, so the tables of figures must be taken with a grain of salt.

TIP 4 - WHAT DOES COMMISSIONING COST?

There are different sources that try to estimate this; none are perfect, but all are better than the standard engineering answer of “it depends.” Owners need an answer to this most basic question. While the successful commissioning project provides owner savings that quickly return the investment, it is still an investment. In addition to the direct costs of the commissioning provider, there are usually costs from contractors and designers that add to the project cost, equal to the time spent participating in commissioning activities. Approximate figures for these costs are shown in Table 2-1. Note that these are in terms of the commissioning line item fees.

<table>
<thead>
<tr>
<th>Team</th>
<th>Added Cost, Besides Direct Commissioning Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Design Team Added Costs for Commissioning</td>
<td>25% of the Commissioning Design-Phase Costs</td>
</tr>
<tr>
<td>Typical Construction Team Added Costs for Commissioning</td>
<td>10-25% of the Commissioning Construction-Phase Costs</td>
</tr>
</tbody>
</table>
PECI provides a range of typical commissioning costs for HVAC & controls, electrical (only), and HVAC + electrical + controls, and further breaks these costs down into design-phase and construction phase pieces. These methods provide reasonable budget pricing for very large projects, but are generally not suitable for use on smaller projects, where economies of scale work against the pricing of commissioning, like everything else. If a sliding scale is utilized, and a standardized scope of work is assumed, then a simplified budget cost estimating table can be formed, as shown in Table 2-2.

### Table 2-2. Approximate Commissioning Costs for Standard Buildings.

Scope Assumptions:
New Buildings = HVAC, Elec, and Controls
Retro-commissioning = HVAC and Controls only

<table>
<thead>
<tr>
<th>Project Cost</th>
<th>New, Detailed</th>
<th>New, Basic</th>
<th>Renovation, Retro-Cx, all Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ 0-50k</td>
<td>---</td>
<td>---</td>
<td>$5000 +5-7% of HVAC and controls replacement cost</td>
</tr>
<tr>
<td>$ 200k</td>
<td>---</td>
<td>---</td>
<td>12-14% of HVAC and controls replacement cost</td>
</tr>
<tr>
<td>$ 500k</td>
<td>---</td>
<td>---</td>
<td>10-12% of HVAC and controls replacement cost</td>
</tr>
<tr>
<td>$ 1M</td>
<td>---</td>
<td>2-4% of total construction cost</td>
<td>8-10% of HVAC and controls replacement cost</td>
</tr>
<tr>
<td>$ 2M</td>
<td>3-6% of total construction cost</td>
<td>1.5-3% of total construction cost</td>
<td>---</td>
</tr>
<tr>
<td>$ 5M</td>
<td>2-5% of total construction cost</td>
<td>1-2.5% of total construction cost</td>
<td>---</td>
</tr>
<tr>
<td>$ 10M</td>
<td>1-3% of total construction cost</td>
<td>0.5-1.5% of total construction cost</td>
<td>---</td>
</tr>
</tbody>
</table>
While the tolerance level for commissioning cost will vary by customer, it seems clear that projects over a certain size are typically the better candidates for commissioning, simply because it is more affordable. The following table assumes maximum commissioning costs to be 5 percent of construction cost for new construction and 10 percent of HVAC and controls costs for renovation. While not exact, this provides a quick sanity check to assist in the owner’s decision whether or not to invest in commissioning, based simply on economy of scale. Of course, the owner can choose commissioning on any size project to help insure a better quality project.

Table 2-3. Typical Minimum Project Size for Reasonable Commissioning Investment. (See Table 1-1 for “detailed” and “basic” services.)

<table>
<thead>
<tr>
<th>Type of Building Project</th>
<th>General Cx Scope</th>
<th>Minimum Project Size ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New, Detailed Cx Services</td>
<td>HVAC, electric, controls, detailed services</td>
<td>$2M (total construction cost)</td>
</tr>
<tr>
<td>New, Basic Services</td>
<td>HVAC &amp; controls only, basic services</td>
<td>$1M (total construction cost)</td>
</tr>
<tr>
<td>Renovation, Retro-Cx</td>
<td>HVAC &amp; controls only, basic services</td>
<td>$500K (HVAC and controls replacement cost)</td>
</tr>
<tr>
<td>Specialty Cx Scope</td>
<td>Mission critical/high-risk projects</td>
<td>No limit</td>
</tr>
</tbody>
</table>

TIP 5 - WHAT COMMISSIONING WILL AND WILL NOT DO FOR THE OWNER—SETTING REALISTIC EXPECTATIONS

There is no silver bullet for quality control, but commissioning will definitely help. To ensure a happy customer, aligning expectations is important.
What Commissioning WILL DO

- **Helps Protect Your Investment.**
  Increase your chances of getting what you wanted in the first place.

- **Reduces Risk.**
  Unknowns are a way of life and they can be expensive. This reduces them.

- **Another Pair of Eyes Looking Out For Your Interest.**
  Too many cooks in the kitchen are a problem, but so is blind trust.

- **Raises the Bar of Quality.**
  The project teams will sit up straighter, sharpen their pencils, and give an extra effort when the commissioning agent is around. That’s a good thing, as long as it’s done in a positive environment.

- **Early Detection of Coordination Issues and Systemic Problems.**
  Systemic problems are “built-in problems.” The sooner a problem is detected, the less it costs to correct (Figure 1-1). The ones that get missed entirely can haunt the project for its entire life. Getting it right the first time is always the goal. Design review is strongly recommended to increase the chance of discovering and correcting systemic problems. Limiting commissioning services to the start-up phase, skipping the design review phase, creates the risk of faithfully executed and nicely constructed mistakes.

![Figure 1-1. The Earlier the Better](image)
• **Improved Team Coordination.**
  A good commissioning agent will be a catalyst for a focused project.

• **Identifies and Protects the Project Intent.**
  These two words, “project intent,” are metaphorically tattooed onto the commissioning agent with pride. All tasks revolve around the project intent, which is simply to understand, never forget, and remind the team players of the purpose of the project and the owner’s instructions.

• **Avoids Pitfalls.**
  No one can think of everything. The design team’s experience is augmented with the experience of the commissioning agent. Pitfalls come in all sizes and shapes, from coordinating change orders to things that just don’t work. The commissioning process provides one more chance to weed these out.

• **Reduces Change Orders and Construction-Related Problems.**
  Since no documents are ever perfect, no construction job ever went without a change order or a construction conflict or issue. But less is more!

• **Avoids Lost Time from RFIs and Other Construction Delays.**
  Time is increasingly of the essence in our society. All too often, the owner is placed in a position to either accept a delay or accept something they really don’t want, if discovered at a late stage.

• **Reduces Warranty Items.**
  By emphasizing quality control during construction and start-up, items are discovered and corrected early... before the warranty period.

• **New Building Runs Smoother from the First Day.**
  Because of the start-up testing and correcting many issues in advance of the warranty period, the building “opens” with a minimum of issues.

**What Commissioning WILL NOT DO**

• **Commissioning benefits just happen automatically once paid for.**
  Nope—owner involvement is required to get the benefits. Commissioning will likely fail without the owner’s support.

• **Commissioning agent acts as owner’s agent, approves payment requests, directs contractors, attends all meetings, and takes minutes.**
  Nope—owner’s agent or construction manager is a different role than commissioning.
• Commissioning replaces the general contractor’s quality control activities during construction and the designer’s punch lists.
  Nope—the design team and contractor quality control responsibilities are not reduced.

• Testing and reviews include 100 percent of systems.
  Nope—random sampling technique is used to look for “red flags” that indicate quality control problems.

• My project will be free from all problems.
  Nope—the bar of quality is raised, and problems are reduced, but perfection will not be achieved.

TIP 6—OVERCOMING RESISTANCE TO COMMISSIONING

Commissioning is often about managing conflict. If there weren’t processes needing fixing, there wouldn’t be commissioning. Managing the changes in a way that preserves people’s dignity and in a constructive manner is important, and requires a careful balance between assertiveness and sensitivity. Done properly, it should always be said that discovering the issue early means the pain of the correction would have been much worse if left to its natural course. Here are some common heartaches in commissioning and some suggestions on how to work through them. There are other lessons learned from commissioning, and they should each be analyzed for opportunities to improve. The real-world feedback on what works and what doesn’t is the best indicator for change. Sometimes the lessons learned are not pleasant pills to swallow; they may point to needed change for any of the parties involved, including owners and commissioning agents. The point is to do your best to understand the messages of the lessons learned, document them, and learn from them.

Conflict is inevitable with the commissioning process, but can be managed by careful consideration of people’s feelings, and by tempering commissioning comments and limiting comments to true problems—and avoiding personal opinions or “designer choice” items. Each project will be different, and so lessons learned from each project should be viewed constructively for self-improvement.

Issue: Without owner support, it’s easy for the commissioning work to be undermined. When this happens, it’s frustrating and demoralizing to see the potential value slip away.
Discussion: The easy path is the familiar path, and commissioning is often a change in process for both the design team and the contractors. Without a firm commitment from the owner, the default outcome is to revert to non-commissioned methods. This is done by steady resistance, delays, and general non-cooperation. It begins as what appears to be a test of the owner’s will, and if unchecked by the owner clarifying their support of the process and requirements for other members to support the process, the inertia of the dissenting team will quickly take over, at which point the owner’s money is being wasted.

Suggestion: The owner should decide if he or she really wants the commissioning benefits and understand he will be instrumental in winning the cooperation of the design and construction teams. In short, the commissioning agent is easy to ignore. Asserting early, and reasserting often, with praise, is suggested. An initial “kickoff” commissioning meeting to discuss concepts and goals can go a long way in alleviating the apprehension of contractors who may view the commissioning agent as an adversary. When interventions are made by the commissioning activity, the corrective work will need the resolve of the owner to follow through, but then should be followed by praise and thanks to all for the improvement, painting the improvement as a success and not a failure.

Issue: Commissioning activities are perceived as highlighting problems, which is demoralizing.
Discussion: Each problem found is a win for the owner in the long run, but may “feel” like a slap in the face to the team entity who owned it.
Suggestion: Stressing the partnership of the project venture may help to actually celebrate the discovery of the issue, and early resolution. A reminder of how much worse it would have been to discover later may also help. And reporting the good things discovered in each design review and construction observation is good for morale.

Issue: Reactions and pushback to comments during design phase.
Discussion: It is very common that architects and engineers are not used to being questioned on their judgment and present a negative reaction, or resistance to cooperate with a reply or explanation to the comment. In some cases, exorbitant fees are presented to the owner to “deal with” the commissioning comments, in an attempt to sway the owner to eliminate commissioning.
Suggestion:
Architects and engineers may equate comments as personal attacks. Presenting the argument for change in factual terms without resorting to “designer preferences” is a good approach. Relating each comment back to an original project intent item is also constructive. One suggestion by Rebecca Ellis, is “… to get down to the basics of physics in most cases; a level at which peer engineers will not be able to argue “[5].

An up-front agreement to limit comments to true problems—and avoid personal opinions or “designer choice” items—may help avert the pushback. To this end, prefacing each comment with a one or two-word statement giving it a category, is suggested, e.g. “Project Intent Item: xxx,” or “Service Access Item: xxx.”

CONCLUSIONS AND TAKE-AWAY TOPICS

A few tips in applying commissioning can make the experience more effective, pleasant, and rewarding.

- The ability to identify approximate costs is important to customers.
- Without owner involvement and support, the results and value to the owner may be only a fraction of their potential.
- Understanding what commissioning will and won’t do sets reasonable expectations for all.
- There is a natural resistance to commissioning by many team players, but this can be reduced through partnering.

References
5. Rebecca Ellis, P.E., Personal Correspondence, December, 2005.
ABOUT THE AUTHOR

Steve Doty, PE, CEM, is an energy engineer for Colorado Springs Utilities, providing technical support and facility audits for commercial and industrial utility customers. Steve is a registered Professional Engineer in several states and has a 20+ year background that includes mechanical design, automatic controls, and commissioning. He can be reached at sdoty@csu.org.

APPENDIX FOR PART 2

(Reproduced from Part 1 of the article)

Table 1.1 Typical Deliverables: New Buildings or Major Renovations

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Basic</th>
<th>Detailed</th>
</tr>
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<tbody>
<tr>
<td>Document Design Intent and Narrative</td>
<td></td>
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<tr>
<td>Project Intent Workshop for Owner</td>
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<td></td>
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<tr>
<td>Write Specifications</td>
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<tr>
<td>Develop Commissioning Plan</td>
<td></td>
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<tr>
<td>Building Modeling</td>
<td></td>
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<tr>
<td>Design Review – Schematic</td>
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<tr>
<td>Design Review – Design Development</td>
<td></td>
<td></td>
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<tr>
<td>Design Review – Final Documents, Before Construction Begins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review / Edit Control Sequences of Operation</td>
<td></td>
<td></td>
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<tr>
<td>Submittal Review</td>
<td></td>
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<tr>
<td>Construction Observation</td>
<td></td>
<td></td>
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<tr>
<td>Regular Meeting with Contractors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify Indoor Air Quality Construction Practices</td>
<td></td>
<td></td>
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<tr>
<td>Test and Balance Verification</td>
<td></td>
<td></td>
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<tr>
<td>Construction Checklists</td>
<td></td>
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<tr>
<td>Functional testing</td>
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<tr>
<td>Issue Resolution Participation</td>
<td></td>
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<tr>
<td>As-Built Drawing Verification</td>
<td></td>
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<tr>
<td>Control Sequence Verification</td>
<td></td>
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<tr>
<td>Training Plan Review</td>
<td></td>
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<tr>
<td>Oversee / Conduct Training</td>
<td></td>
<td></td>
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<tr>
<td>Operations and Maintenance Manual Review</td>
<td></td>
<td></td>
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<tr>
<td>Near-End Warranty Review</td>
<td></td>
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<tr>
<td>Evaluate Cost Savings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Systems Manual</td>
<td></td>
<td></td>
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<tr>
<td>Re-Commissioning Manual</td>
<td></td>
<td></td>
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<tr>
<td>Final Report and Lessons Learned</td>
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</tbody>
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