

EDR's Cx Assistant: Helping Commissioning Teams Choose the Appropriate Level

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Synopsis

Cx Assistant is a free web-based assistance tool developed under Savings By Design, California's public goods funded state-wide new-construction energy efficiency program. The tool is part of the program's educational component, Energy Design Resources. The tool is intended to help new-construction commissioning teams initiate the commissioning process for projects in California. To date the tool contains the following modules:

- Scope Generator (RFP/RFQ)
- Commissioning Cost Estimator
- Design Intent Generator
- Basis of Design Generator
- Commissioning Specifications Generator
- Sequences of Operation Generator

The paper explains Cx Assistant's approach to recommending a commissioning process. It also discusses how these recommendations affect the tool's output.

About the Author(s)

Treasa Sweek provides commissioning, energy audits, and energy simulation for commercial and municipal buildings. Treasa also has experience in the evaluation of building projects for cost effectiveness and performance verification. She has provided energy analysis for many commercial, institutional, and military facilities and has conducted electrical and mechanical energy audits for over 75 buildings totaling more than six million square feet. Treasa is a professionally registered Mechanical Engineer in California and Washington, a member of the California Commissioning Collaborative advisory board, the chair of the BCA's Administration Committee, and a corresponding member of ASHRAE's technical committee on commissioning.

Ken Gillespie is a Technologist with the Performance Test and Analysis unit of PG&E's Technical & Ecological Services department in San Ramon, California. He has 25 years of performance test and monitoring experience in utility and building applications, with the past 15 years primarily focused on monitoring and commissioning of energy using systems in existing buildings. He is an Associate Member of ASHRAE. He is past vice chair of both Guideline Project Committee (GPC) 14P: "The Measurement of Energy and Demand Savings", published in 2002 and GPC 1-1989R: "The HVAC Commissioning Process", published in 1996. He is

currently a member of ASHRAE's TC7.6: Systems Energy Utilization; GPC-20P: XML Definitions for HVAC&R; and GPC-1-1996R. Ken is a founding member of the California Commissioning Collaborative and currently is a member of its advisory board.

Introduction

Savings By Design's Energy Design Resources (EDR) Program is a growing source of information on commissioning for design teams and building owners. In the past EDR has supported development of commissioning resources such as a Design Brief, a reference manual, and an interactive tool to guide users through various aspects of the commissioning process. As of February 2004, a new web-based reference tool enhances those EDR materials and provides updated information that reflects current trends in the commissioning world. The goal of this tool, dubbed "Cx Assistant," is to increase the adoption of high quality commissioning practices by helping owners and providers choose an appropriate range of commissioning services. The tool also is intended to provide example documents to get commissioning started in the right direction. It provides information to assist with a variety of commissioning related activities, from development of a request for proposal document (RFP) to creating better construction documents and tracking the building's overarching goals.

Commissioning Costs Module

[Cx+ Introduction](#) You have selected a 125,000 square-foot office building with the "LEED Commissioning Prerequisite" process of commissioning.

[Cx+ Tool](#) Commissioning costs for this type of building range from **\$0.30** to **\$0.90** per square foot. The range of commissioning costs for this type of building have been between \$37,500 and \$112,500.

[Cx+ Resources](#)

Figure A. This excerpt of the cost-estimating tool in Cx Assistant shows a range of probable commissioning costs for a medium-sized office building.

What is Cx Assistant?

Energy Design Resources' Cx Assistant is a web-based reference designed to provide project specific commissioning information to the design team. The tool enables users to accomplish the following:

1. Evaluate probable commissioning cost.
2. Identify the appropriate commissioning scope for each project, and develop sample scope documents.
3. Develop a sample "design intent document" summarizing the owner's requirements with specific project inputs.
4. Develop a sample "basis of design" document with specific project inputs.
5. Access sample commissioning specifications related to specific project inputs.
6. View sample sequence of operations for their HVAC equipment.

In addition, Cx Assistant incorporates the most current trends in the commissioning industry by providing multiple paths graded into levels of commissioning services according to a project's size and the needs of the owner.

LEVEL 1. The first level focuses on large or complex building projects that may include detailed sustainable design characteristics or cutting edge energy saving design elements. This level is called "comprehensive" commissioning and can also be used as a basis for whole-building commissioning or advanced LEEDⁱ Green Building commissioning.

LEVEL 2. The second level focuses on standard commercial buildings that may include projects aiming to achieve a basic LEED Green Building Certification. This level is also appropriate for incorporating a commissioning quality assurance process into building projects as a matter of course and is called "standard" commissioning.

LEVEL 3. The third level focuses on small, uncomplicated buildings and is referred to as "abbreviated" commissioning. Abbreviated commissioning is applicable to buildings without much complex energy-using equipment, but for which an owner desires to implement a commissioning quality assurance process.

The levels of commissioning are used by Cx Assistant to tailor the tool's outputs to an appropriate level. Cx Assistant is focused on mass market building types as well as more complex building types in order to reach a broad audience throughout California's new construction sector. Occupancy types include: office, school, university, laboratory, library, auditorium/theatre, convention, grocery, retail/wholesale, restaurant, medical, high-bay industrial use, low-bay industrial use, and non-residential mixed use.

How are Commissioning Levels determined?

When a user enters Cx Assistant, the tool requests general information regarding a building project. This information includes the building's occupancy type, approximate square footage, location, and delivery method (i.e. plans & specs or design-build). The user can also choose a specific level of commissioning or let the tool recommend a level. The difference between commissioning levels is described below.

"Abbreviated" Commissioning

Abbreviated commissioning recognizes the need for an abbreviated, non-third party commissioning process. Since general contractors use the term "commissioning" as well as mechanical and electrical contractors, air balance specialists, turnkey contractors and a host of engineers and consultants, this term captures a multitude of activities and processes.ⁱⁱ Engineering research groups and professional societies around the country tend to discount the commissioning processes employed by contractors. However, denying the contractors' commissioning activities creates a rift in the community, which only furthers an owner's confusion and a commissioning team's frustration when initiating a commissioning process.

Instead, it is important to bridge the division by contemplating cases where the non-third party model works. Abbreviated commissioning can be successful in retail, office, warehouse, and mixed-use building types. Speculatively developed buildings may be good candidates for abbreviated commissioning. This thinking is the foundation of Cx Assistant's abbreviated commissioning level, which is defined as follows:

The abbreviated commissioning process generally applies to small and medium-sized buildings without centralized control schemes or highly integrated mechanical and electrical systems. Within these building projects, the more complex mechanical and electrical systems are commissioned. The abbreviated commissioning process combines key checks and test procedures into one on-site testing procedure performed by the Commissioning Provider. The process is managed by a Commissioning Provider who may be part of the contractor or ownership organization. Construction team members are present at and assist in some testing. Although the process should be started during design, abbreviated commissioning can begin after construction has started.

“Standard” Commissioning

While hundreds of projects suited for abbreviated commissioning are constructed each year, it is believed that buildings of a moderate size and complexity dominate the new construction market. Standard commissioning is based on the traditional HVAC commissioning process that mimics ASHRAE Guideline 1 – 1996 and the LEED Fundamental Building Systems Commissioning Process. Standard commissioning is applicable to owner-occupied buildings such as offices, schools, libraries, auditoriums, restaurants, industrial buildings and the like. As such, this level of commissioning also applies to many of the California High Performance Schools (CHPS) projects. This thinking is the foundation of Cx Assistant's standard commissioning level, which is defined as follows:

The standard commissioning process generally applies to small and medium-sized buildings with centralized control schemes or complex zone-level HVAC or lighting systems. Within these building projects, the more complex mechanical and electrical systems are commissioned. The standard commissioning process begins during the design phase and continues through the end of the acceptance period. The standard commissioning process is managed by a Commissioning Provider who may be part of the contractor or ownership organization. During construction, the Commissioning Provider conducts site inspections and works with the construction team to complete on-site testing.

“Comprehensive” Commissioning

The foundation of comprehensive commissioning is a whole building commissioning process. Comprehensive commissioning is relevant to the most complicated building and campus projects constructed today such as medical facilities, laboratories, grocery stores, convention centers, and high-rise buildings. This level is based on the newest research conducted by ASHRAE and

NIBS as well as on the Additional Commissioning requirements included in LEED and CHPS.ⁱⁱⁱ Cx Assistant’s comprehensive commissioning level is defined as follows:

The comprehensive commissioning process generally applies to medium and large-sized buildings with centralized control systems and complex zone-level HVAC and lighting systems. The comprehensive commissioning process begins during the schematic design phase and continues through the first year of the building's occupancy. In most cases, this process will be managed by an independent third party who specializes in building commissioning. During construction, the Commissioning Provider conducts regular site inspections. Members of the construction team complete the majority of the on-site testing while the Commissioning Provider directs and documents the tests.

What activities are included in each Commissioning Level?

Cx Assistant recommends different commissioning activities for each level of commissioning, as shown in Figure B. To some degree, the user can customize these activities. For example, if Cx Assistant recommends a Standard level of commissioning, the user has the option of removing the **Systems Manual** activity as well as the **Design Review (CD)** activity. The user may also add commissioning activities line **Design Review (DD)** or **Submittal Review** to further customize their commissioning documents. Cx Assistant recommends that if a user adds more than 2 activities to the recommended list, they consider changing the selected Commissioning Level.

	DID and BoD	Cx Plan	Design Review (DD)	Design Review (CD)	Commissioning Specs	Submittal Review	Prefunctional Testing	Functional Testing	Cx Report	Meeting Attendance	O&M Document Review	Operator Training	Systems Manual	Post-Occupancy Review
Abbreviated	X	X			X			X	X			X*		
Standard	X	X		X*	X		X	X	X		X	X	X*	
Comprehensive	X	X	X	X	X	X	X	X	X	X	X	X	X	X

* Optional Activity for this level of commissioning

Figure B. Cx Assistant recommends some commissioning activities for all levels of commissioning. Other commissioning activities are only recommended for more complicated commissioning levels.

How does the level of commissioning affect Cx Assistant output?

Each level of commissioning has unique output files. For example, if a designer had one large office building (comprehensive commissioning), one small office building (standard commissioning), and one medium-sized elementary school (standard commissioning), the request for proposal (RFP) for the small office and the school would be more similar to each other than the large office building's RFP. Some tools within Cx Assistant are based almost solely on the level of commissioning for example; the cost estimating tool is built this way. On the other hand, the sequences of operations recommended by Cx Assistant are based on the types of equipment designed for the project rather than the level of commissioning chosen for it. The following sections of this article provide more detail on Cx Assistant's output for three of its modules: the Design Intent Generator, the Basis of Design Generator, and the Sequences of Operations Generator.

What's in the DID?

Table 1. The section headings of the Design Intent Document include a broad range of information.

DID Section Headings
Location & Directions
General Project Information
General Building Standards
Training, Operations, & Maintenance
Building Space Summary
Building Performance Criteria

The Design Intent Document (DID) is written in order to communicate to the building's stakeholders about what the facility is. Because the level of commissioning chosen for the project may be an integral part of the project's design, construction, and operation, Cx Assistant provides different sample documents for different levels of commissioning. The samples are structured using a description of the Design Intent and Basis of Design developed by Karl Stum for the 2002 ASHRAE Annual Meeting.^{iv} The content of the documents varies by level of commissioning and is based on a combination of products including ASHRAE Guideline 1-1996, work completed by PG&E on "Current Facilities Requirements," and a public review draft of

ASHRAE's Guideline 0P.^v The contents of the comprehensive document mimic ASHRAE's draft "Owner's Project Requirements" document but, because the term Owner's Project Requirements has not yet been officially recognized by ASHRAE, Cx Assistant uses "Design Intent Document".^{vi}

What's in the BoD?

Table 2. The section headings of the Basis of Design follow those of the Design Intent Document.

DID Section Headings
General Project Information
Training, Operations, & Maintenance
Building Design Assumptions
System Summary
Building Performance Criteria
Sequences of Operation

The Basis of Design (BoD) is the technical architectural and engineering response to the owner's Design Intent. As such, Cx Assistant's BoD follows the formatting of the DID while providing space for an accounting of the technical assumptions used to design the building. As with the Design Intent, the BoD documents differ based on the project's level of commissioning. For example, the abbreviated level Basis of Design is focused on listing the basic engineering assumptions. Since buildings that use abbreviated commissioning contain few complicated systems, this approach captures the essential information without too much effort. On the other

hand, the comprehensive BoD leaves space for very detailed engineering assumptions as well as a narrative description of the advantages and trade-offs of the chosen system design. Projects that employ a comprehensive commissioning process often contain complex, highly interactive systems that require careful design and need to be documented for the building owner.

What are the Sequences based on?

Sequences of operation are included in Cx Assistant in order to help "raise the bar" for standard practice contract documents. One great challenge in commissioning complicated control systems is the consistent lack of clearly defined, well-written sequences of operation. Cx Assistant provides sample sequences in plain English, as opposed to using programming terms or "legalese." The samples show the level of detail and rigor required for commissioning common mechanical systems.^{vii} The systems are intended to meet California's 2005 Title 24 energy efficiency standards.^{viii} They are based on commercial building mechanical designs as follows:

- Split system air conditioner: single room, not continuously occupied, cooling only
- Packaged rooftop unit: single zone, 100% outdoor air, cooling and heating
- Evaporative cooler packaged unit: single zone, 100% outdoor air, cooling and heating
- Standard packaged: single zone, airside economizer, cooling and heating
- Packaged unit with variable volume, variable temperature (VVT) control: multiple zones, airside economizer, cooling and heating
- 4-pipe fan coil unit: constant volume fan coil units with chilled water cooling coils & hot water heating coils, constant volume outdoor air. Central plant for hot/chilled water.
- Condenser Water Loop Heat Pump System: constant volume heat pump units with condenser water loop, constant volume outdoor air. Central plant for maintenance of condenser water loop temperature.
- Constant air volume: air handling units with chilled water cooling coils & variable speed supply and return fans. Central plant for hot/chilled water, hot water constant volume re-heat terminal units.

- Air cooled variable air volume: air handling units with chilled water cooling coils and variable speed supply and return fans. Central plant for hot/chilled water (air cooled), hot water variable volume re-heat terminal units.
- Water cooled variable air volume: air handling units with chilled water cooling coils and variable speed supply and return fans. Central plant for hot/chilled water (water cooled), hot water variable volume re-heat terminal units.

Looking Towards the Future

Cx Assistant may be accessed from <http://www.energydesignresources.com> (click on “Cx Asst.” under Online Tools). During the next phase of the project, the tool will gain three new modules:

- Commissioning Plan Generator
- Systems Manual Generator
- Training Plan Generator

The current product was released for beta testing in February 2004. Prior to its public release, the Design Intent tool was demonstrated in a class at PG&E’s Pacific Energy Center. Also, Cx Assistant’s Scope Generator was used during a commissioning charrette for the California High Performance Schools (CHPS) program in April. The tool was also presented to a LEED subcommittee on commissioning as a potential resource for upcoming LEED reference materials. The authors hope to continue demonstrating the tool in the coming months and are open to feedback and comments.

Cx Assistant has been designed to be applicable to a very wide range of new construction commercial building projects. The products generated by the tool are “template” documents and require further editing by the user before a commissioning team uses them. While this structure makes the tool useful to a wide audience, it detracts from the ability for the tool to home in on key parameters that are unique to different building types. Customizing Cx Assistant for more focused audiences such as educational facilities or grocery stores would allow the tool to delve into issues that are specific to different building types.

The tool also may continue to grow by adding new components such as a design review wizard, a library of Title 24 acceptance tests, or a commissioning report template.

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ⁱ The LEED Green Building Rating System™ is a trademark of the US Green Building Council. The authors of Cx Assistant referenced the rating system and reference guide for version 2.1 of the New Construction rating system (i.e. LEED-NC v2.1).

ⁱⁱ Several contractors' associations have published commissioning guidelines including the Air Conditioning Contractor's of America (ACCA Good Practices Manual), the National Environmental Balancing Bureau (NEBB Procedural Standards for Building Systems Commissioning), and the Associated Air Balance Council (AABC Commissioning Guideline). These documents vary in scope and recommendations, just as commissioning guidelines published by engineering associations vary.

ⁱⁱⁱ ASHRAE Guideline 0, The Commissioning Process, provides a framework for a rigorous quality assurance whole building commissioning process. This Guideline is an integral part of the National Institute of Building Sciences total building commissioning guideline series. For more information, visit <http://sustainable.state.fl.us/fdi/edesign/resource/totalbcx/index.html>.

^{iv} Stum, Karl. "Design Intent and Basis of Design: Clarification of Terms, Structure, and Use". 2002 ASHRAE Annual Meeting HI-02-20-1.

^v Pacific Gas & Electric Company. "Current Facility Requirements". San Francisco, 2002.

^{vi} ASHRAE's Guideline 0 describes an Owner's Project Requirements document that has previously been referred to as a Design Intent Document. The term Design Intent Document is used in ASHRAE's Guideline 1-1996, "The HVAC Commissioning Process" and has gained wide acceptance in the commissioning community.

^{vii} To ensure their technical accuracy, Taylor Engineering LLC, an independent mechanical design firm, reviewed the sequences.

^{viii} Cx Assistant is based on the portion of Title 24, California's energy efficiency code, which is specific to non-residential new construction. Title 24 is updated every 4 years and is one of the more rigorous energy efficiency codes in the county. For more information, go to <http://www.energy.ca.gov/title24/>.