Developing a Design Review Tool for Use in the Commissioning Process

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Synopsis

The Design Review Tool is the newest addition to Energy Design Resources' Cx Assistant (http://www.energydesignresources.com/resource/176/), a web-based checklist and reference guide designed to provide project specific commissioning information to design teams. The Design Review Tool module generates customized design review checklists that can be used to facilitate design reviews or to communicate to designers the issues that their designs should address. The checklists can be used during the design development, construction document, and submittal phases of the design. Checklists covering eighteen design review areas include key topics such as:

- maintainability
- constructability
- control software and hardware
- common energy efficiency issues
- underfloor air distribution

The paper describes the Design Review Tool's objectives, content, and use by commissioning providers and designers. This tool is intended to provide a great benefit to the commissioning industry in facilitating and streamlining the design review phase of the commissioning process.

About the Authors

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Project Committee (GPC) 30P: "The Commissioning Process for Existing HVAC Systems". He is a founding member of the California Commissioning Collaborative and currently is a member of its advisory board. He has been PG&E's technical project manager throughout the development of the Cx Assistant.

Karl Stum is a principal of Summit Building Engineering, a firm focused on commissioning, building forensics and energy efficiency in buildings. Mr. Stum has been actively commissioning since 1993 and has been in the energy efficiency and building industry since 1980. He performs project management and field work, including project planning and management, design review, specification development, in-field commissioning, testing and troubleshooting. Mr. Stum is active in ASHRAE and LEED commissioning guideline development and was the recipient of the NCBC 2001 Benner Award for Commissioning Excellence.

Kristin Heinemeier is a Senior Engineer with PECI, where she manages and contributes to research and development projects in the area of building commissioning, energy management, and measurement and verification. She is the chair of ASHRAE's Building Commissioning Technical Committee, and the Technical Manager for the California Commissioning Collaborative..

Gail Stranske is the Director of Energy Services for CTG Energetics, a company providing energy and sustainability consulting and commissioning for buildings. Gail provides energy design assistance, performs building energy simulations, and has developed LEED energy credit documentation for numerous projects.

Introduction

Energy Design Resources' Commissioning Assistant (also called Cx Assistant) (http://www.energydesignresources.com/resource/176/) is a web-based reference tool designed to provide project specific commissioning information to design teams. The tool enables users to accomplish the following nine functions:

- Evaluate probable commissioning cost
- Identify the appropriate commissioning scope for each project, and develop sample scope documents
- Develop a sample design intent document with specific inputs from their projects
- Develop a sample basis of design document with specific inputs from their projects
- Access sample commissioning specifications related to specific inputs for his/her construction project
- View sample sequence of operations for their HVAC equipment
- Develop a sample Commissioning Plan with specific inputs from their projects
- Develop a sample Training Plan with specific inputs from their projects
- Develop a sample Systems Manual with specific inputs from their projects.

One area that to date has not been included in the Cx Assistant is a tool to facilitate the design review process. Design review is a process undertaken in most effective commissioning projects, to review design decisions made during different stages of the design process. The objectives of a design review are typically to ensure that the designer has considered the range of consequences of design decisions, and to ensure that the Owner's Project Requirements are likely to be met. While it is clearly the designer's job to develop an effective design, the commissioning provider (CxP) serves as a second set of eyes to find things the designer may have overlooked, and to ensure that key commissioning-related elements have been considered.

Previous to this module, there were online tools available to assist in a number of different areas of the commissioning process, but none for the design review process. There is a need for a tool to ensure that the design review process is methodical and complete as is practical.

Design Review Tool

Pacific Gas and Electric Company engaged Portland Energy Conservation, Inc, along with Summit Building Engineering and CTG Energetics to develop a tool to be incorporated in the Cx Assistant suite of tools to aid in the design review process. During development, peer reviewers evaluated and commented on the structure and content of the tool. These reviewers included Kent Barber (Keithly Barber Associates), Eric Utterson (McClure Engineering Associates) and Norm Nelson (Hilton Hotels Corporation). This tool is currently available as a test version and is expected to "go live" in mid-2007.

Objectives of Design Review Tool

There were multiple objectives for developing the Design Review Tool. The primary objective was to develop a flexible checklist that can be used or adapted by a somewhat experienced commissioning provider or designer to organize and track a design review, including enough information to "remind" them of the issues that need to be checked. A secondary objective was to provide additional information and resources for a less experienced commissioning provider or designer to help clarify these design issues. The tool should be useable for a range of design review applications (e.g., sampling, thorough peer review, or quality control) and able to be applied by commissioning providers, design professionals and owner groups.

The tool was built to integrate with the existing Cx Assistant tool. It was developed using scalable technology and architecture, so that additional checks can be added in the future.

The tool was designed to enable users to generate either a customized Checklist or a Reference Guide. Both of these documents consist of a number of "checks," which include information that a designer or a design reviewer can use to ensure that the design does not overlook important issues. The Checklist or Reference Guide generated can be either all-inclusive "master" documents, or customized documents for specific projects, filtered according to the user's wishes, including only the issues that the user finds appropriate. The customized Checklist will be available for export into either Microsoft Word or Excel format once the tool is fully developed, to allow further customization by the user.

Design Review Areas, Issues, and Checks

At the heart of the tool are nearly 800 checks that designers or commissioning providers can use in reviewing a design. One example of a "check" is:

> *The mixed air low limit control is clearly specified and is not higher than it needs to be, recognizing that in cold climates, with high minimum outdoor air fractions (and preheat coils) a mixed air low limit may not be appropriate. Higher mixed air low limit values reduce economizer hours.*

The list of checks is not considered to be a comprehensive list. Design review areas and individual checks were selected based on the experience of the tool developers and peer reviewers and from information gathered from other review guides as covering issues that are more common or important. The checks are organized according to high level "Design Review Areas". Table 1 lists the 18 Design Review Areas currently included in the tool. This list was developed over several months with input obtained at a 2006 National Conference on Building Commissioning session dedicated to soliciting ideas, and after consulting with multiple peer reviewers. There are other areas that could have been included, and the flexibility of the tool structure will allow this in future releases of the tool.

Table 1: Design Review Areas

1	Sequence of Operation and Control Drawing Issues
2	Sensor Issues
3	Control Software and Hardware Issues
4	Maintainability Issues
5	Constructability Issues
6	Clarity and Detail of Contract Documents
7	Specification of Requirements, Roles and Responsibilities Issues
8	Test Port and Gauge Issues
9	Energy Efficiency Issues
10	Air and Water Balancing Issues
11	Underfloor Air Distribution Issues
12	Moisture Issues – Envelope and HVAC Related
13	Staging and Low-Flow Operation Issues
14	Outdoor Air Control Issues
15	Duct Design Issues
16	Pump, Piping and Plant Design Issues
17	Building and Space Pressurization Issues
18	Daylight Dimming Issues

Within each of these Design Review Areas, the checks are categorized into a number of "issues" sections. For example, the check cited above is one of four checks that comprise the issue: "Economizer sequence of operation is clear and adequately describes proper operation," which is found in the *Outdoor Air Control Issues* Design Review Area.

An outline of the structure is:

--Design Review Areas
--Review Issues
--Review Checks

Selection of Scope

Users can include all of the checks in their Checklist or Reference Guide, or can choose to manually eliminate checks, or automatically filter the checks according to the following criteria:

- System: When using other tools in Cx Assistant, the user identifies what systems are included in the building, and this information is available to the Design Review Checklist module. The user can select whether to show all checks, or only those relevant to the collection of systems.
- Phase: The user can identify which review phase requires checks: Design Documents, Construction Documents, or Submittals (or all phases).

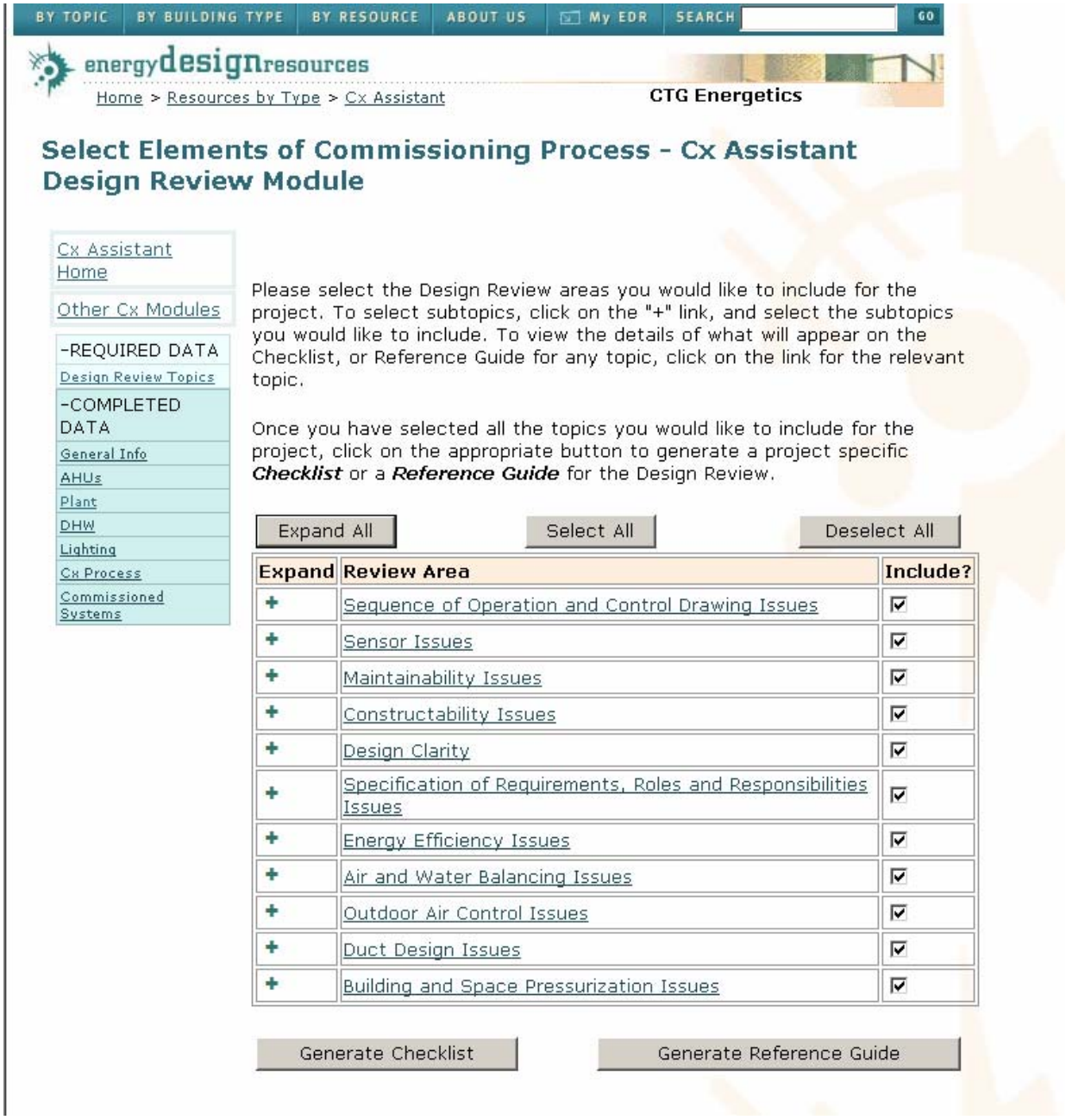
- Energy: The user can select whether to include only checks that have direct impacts on energy performance, or to include non-energy checks as well. (Note that many issues have an *indirect* impact on energy performance, and this filter reflects only issues that directly influence energy consumption.)

These selections will determine the information the tool provides. Figure 1 illustrates how the user makes these selections.

Figure 1: Design Review Tool - Scope Selection

As a result of the selections shown in Figure 1, the user is automatically shown a table that includes only the Design Review Areas that meet the criteria defined in the filter. Since flexibility of the tool is important, the user can select which of the relevant Design Review Areas to exclude in the exportable Checklist or Reference Guide by deselecting the checkbox, as shown in Figure 2. If the user requires more discussion of what checks each Design Review Area includes, they can click on the name, and a window will appear with a description, the issues and checks, and a list of resources.

Figure 2: Design Review Tool - Topic Selection



The user can view the specific issues that are included in the Design Review Area by clicking on the expansion box (+) in the left hand column (See Figure 2). Again, these specific checks can all be included, or can be individually deselected as desired by the user. Once all these selections have been made, the user can decide to generate a Checklist or a Reference Guide that will include only the Design Review Areas and Issues that are relevant and that the user has selected.

Checklists and Reference Guide

If the user decides to generate a Checklist, they will get the option to Open or Save a Word document with a Checklist Table. As can be seen in Appendix Figure A1, the Checklist Table shows the Design Review Areas, Issues, and all the checks that were selected. For each of the checks, there are a number of fields that can be used to track the progress of the design review and the current status of each check. Some checks should be made during different phases of the design: design development, construction documents, or submittals. In some cases, a check should be made in an early review, but if there is insufficient information during that review, it should be checked at a later phase. There are separate rows to track the status of that check during the different phases.

If the user decides to generate a Reference Guide, a Microsoft Word document will be generated, including all the Design Review Areas, Issues, and Checks that were determined with the filters and selections (see Appendix Figure A2). This document includes an introductory section describing the intent of the tool, and an entry for each of the selected Design Review Areas. These entries include name, introductory paragraph, tables for each Issue with check text and relevant phases, and references.

Summary

The Design Review Tool has been developed for Pacific Gas and Electric Company, and will soon be available as a part of the Cx Assistant suite of tools. This tool will help both commissioning providers and designers to ensure that the design review process is complete and methodical, and the tool helps to ensure that important issues are addressed throughout the design process. There are a range of ways in which the tool can be used:

- A CxP who is using the Cx Assistant suite of tools to produce other commissioning documents will generate a customized Design Review Tool document early in the design process, in order to communicate to the designer what types of issues will be checked during the various phases of the design review.
- A designer or CxP will use the tool to generate a complete Reference Guide, for educational purposes, to learn or to train others how to develop an effective design or to conduct an effective design review.
- A CxP and a Design Team will use the tool to develop a checklist to use in the design process. This might serve as a document that the team uses to step through, one issue at a time, to discuss whether or not or how the issue has been addressed in the design. If the

tool was also used earlier in the process to identify what issues will be addressed in the review, most issues will have already been addressed, and the exchange of information can help everyone in the process to understand the design decisions more fully.

- A CxP can use the generated checklist directly, add to it any other issues that are relevant for their project, or paste the checks into their own checklist format.

The tool has been developed using scalable technology and architecture, so that additional design review areas or checks can be added. This tool is intended to provide a great benefit to the commissioning industry in facilitating and streamlining the design review phase of the commissioning process.

Appendix: Design Review Tool Output Examples

Figure A1: Example of Checklist Generated by Design Review Tool

Phase (Doc ID; Date):
DD: 100% DD, 6/7/07
CD: 90% CD, 10/23/07
Sub: 06/15/08

ID	Check	Phase to Ck	Review in Phase? (Note 1)	Ck'd: Plans, Specs, Cut-sheets, Shop Drawings	Method: Sampled (%), Revu'd All	Chk in Next Submis-sion?	Results: OK or Comments Added to Report
	AIR AND WATER BALANCING ISSUES						
	Drawings and specifications are coordinated and contain sufficient technical data.						
1	Specific requirements that appear in the Owner's Project Requirements and Basis of Design are clearly stated. For example: • Construction-quality leakage (leakage from everything but the actual raised floor plate) is less than 8% of total design flow at 0.05 in. WC pressure. • Floor plate leakage (with diffusers sealed) is less than 17% of design flow at 0.05 in. WC pressure.	DD	○	S	**A**	**N**	**A**
		CD	●				
		Sub	N/A				
2	The diversity factor for air and hydronic flows is determined from review of the equipment schedules (see next check) and matches the design intent obtained from the designer.	DD	○	P; S	**S**	**Y**	**IN**
		CD	●	P; S	**S**	**--**	**OK**
		Sub	●				
3	The sequences of operation will work with the piping and valve layout (e.g., bypass leg in primary / secondary systems, proper isolation in common header systems and overflow of primary chiller loops). This can be verified from review of the flow schematic and flow rates.	DD	○	P; S	**A**	**Y**	**IN**
		CD	●	P; S	**A**	**--**	**A**
		Sub	N/A				

Check items in Phase to Ck column during Design Development (DD), Construction Documents (CD) or contractor Submittals of cut sheets and shop drawings (Sub).

○: An open circle indicates that a preliminary review may be conducted if there is sufficient detail, otherwise it may be deferred till a later phase.

●: A filled circle indicates that a complete review should be completed during this phase.

N/A: N/A indicates that the review is not relevant for that phase. IN = Insufficient progress in this design submission to make a substantive review of this Check.

Figure A2: Example Section of Design Review Tool Reference Guide

Air and Water Balancing Issues

Proper air and water balancing are essential for proper functioning of HVAC systems, ensuring that they maintain comfort and air quality in the most energy efficient manner possible. Technically sound and transparent design, combined with clear instructions to the air balancing contractor are needed, but they are not always found in design documents. Too often the contractor, because of insufficient information, makes improper decisions in the field or unneeded requests for information, and change orders are needed to properly balance the system.

Below are four categories of balancing issues, each with a number of checks.

1. Drawings and specifications are coordinated and contain sufficient technical data
2. Flow and riser diagrams for major systems (chilled water, heating water, and air) are included
3. Sufficient and appropriate balancing dampers or valves are shown in drawings and in the specifications
4. Balancing requirements are complete and clear

1. Drawings and specifications are coordinated and contain sufficient technical data

Checks:

		DD	***CD***	***S***
A.	*Specific minimum outside air quantities and set up parameters are shown on drawings (e.g., set air quantity with 75% of air terminal boxes in heating). See Design Area 14 Outdoor Air Issues.*	*X*	*XX*	
B.	*The diversity factor for air and hydronic flows is determined from review of the equipment schedules and matches the design intent obtained from the designer.*	*XX*	*XX*	
C.	*Air flow quantities on the mechanical floor plans correlate with the totals in the equipment schedules. For example, if the floor diffusers totaled 30,000 cfm and assuming 5% duct leakage, 5% reasonable safety factor, and 85% as a reasonable diversity factor, then the equipment schedule should show the fan to be 28,100 cfm (30,000 x 1.05 x 1.05 x 0.85).*	*X*	*XX*	
D.	*The sequences of operation will work with the piping and valve layout (e.g., bypass leg in primary / secondary systems, proper isolation in common header systems and overflow of primary chiller loops). This can be verified from review of the flow schematic and flow rates.*	*X*	*XX*	