Tune in to High Performance Buildings

Reducing Energy & Costs through Proper Commissioning

Natascha Castro, National Institute of Standards and Technology, USA

Daniel Choinière, CANMET Energy Technology Centre -Varennes, Canada

Building commissioning is a quality assurance process that, if applied more widely and at earlier stages in the building life cycle, has the potential to dramatically reduce building energy use and improve performance. In practice, significant inefficiencies in the building delivery process and information loss throughout the building lifecycle increase the potential for error, as seen in Figure 1. During the design, construction and occupancy phases of buildings, the players and experts, who hold the knowledge of the building and its systems, change frequently. Tasks are completed by different people and even different companies; with the change of players within a project, knowledge that would be helpful or even important for future tasks is often lost. In particular, the commissioning authority and later on the operation personnel need to have a clear understanding of the details of and intentions for the design. While for standard systems missing information can at times be compensated by experience, it is hardly possible to do so for advanced and innovative systems.

There is an internationally recognized need for improved quality assurance and it is even more critical that low energy buildings be commissioned to optimize operation based on actual occupancy and use. In several countries, the buildings industry has responded to encourage and improve commissioning practices but the process is generally carried out manually, the quality varies widely, and the perceived cost and time investment is often deemed prohibitive.

Since 2004, ECBCS has brought together experts from 12 countries in Asia, Europe, and North America to study the methodologies and tools needed to enable the cost-effective commissioning of existing and low

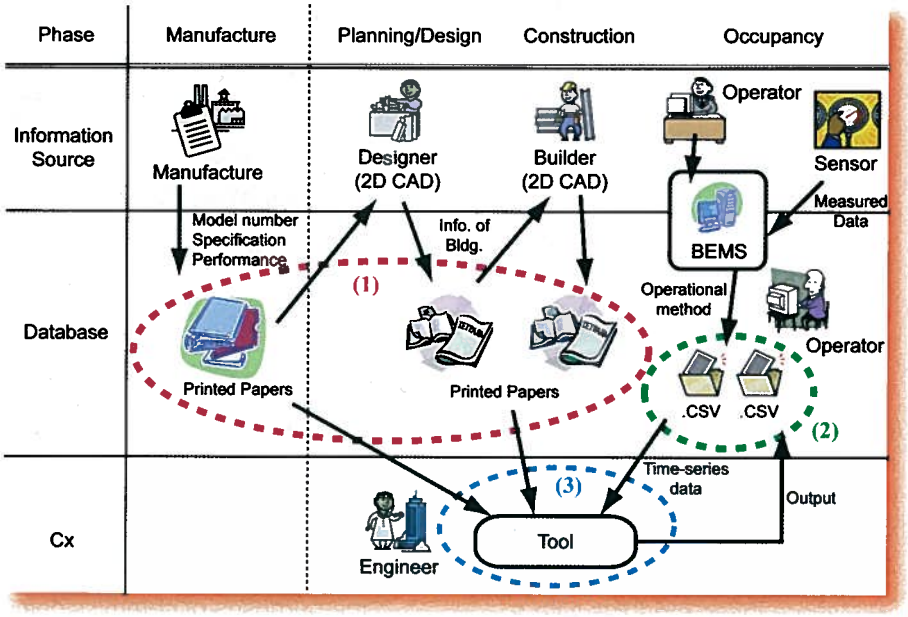

Figure 1. Present information flow.

energy buildings. The collaborative project has addressed three important research areas:

- **Information Flow.** Documentation processes must be improved to retain the information obtained and created during the design process to leverage proper and cost-effective commissioning of advanced and low-energy building systems.
- **Commissioning Methods and Tools.** Documented commissioning methods are currently available on a limited basis for conventional HVAC systems and must be extended to address the systems and system combinations that are critical to the proper performance of **low energy buildings (LEBs)**, such as demand control ventilation, radiant floor heating, and underfloor air distribution.
- **Cost-Benefit and Persistence Data.** There is a need to address technological and process barriers to achieve greater market penetration. Although the environmental and energy saving benefits for commissioning are significant, demonstrating cost-effectiveness, including the persistence of commissioning measures will remove a major barrier to the wider market acceptance of commissioning.

Using Flowcharts & Data Models for Initial Commissioning

The fragmented building delivery process, combined with the range of disciplines participating in the process, ensures multi-dimensional demands for the data models and flow diagrams used in commissioning. Variations in international building delivery processes add another layer of complexity. This is an area of practice with complex data and process management needs. Without digital tools to assist in this management task, there are significant losses of information, time and money. Figure 2 shows how information and data accumulate in each phase of building delivery. Due to the difficulty of

maintaining consistent information representation when transitioning to each successive phase, not all of the data available in the previous phase is made available to subsequent phases. As a result, key information is lost during these transition points and has to be subsequently recovered, exposing the project to an additional risk of errors. This 'saw tooth' effect means that significant time and effort are wasted.

Figure 2 illustrates a vision of the future where the commissioning agent is able to:

- access a very large portion of the data needed through data-mining and sensor-control feeds;
- produce reports, recommendations, and persistent data stores, digitally and with interoperability; and
- share these products with a variety of building professionals including architects, design engineers, facility managers, building operators, owners and equipment manufacturers.

To enable this vision, commissioning data and processes must be formally represented in databases and associated algorithms in a format compatible with tools used by different practitioners and over long periods of time. This requires that interoperable, persistent and accurate data as well as process models are made available to the commissioning agent.

Therefore, the project team has recommended use of the following to improve the building commissioning process:

- Integrated DEFinition methods (IDEF0 and IDEF3) as a shared representation by all constituents involved.
- Functional Performance Tests (FPT) and similar commissioning protocol data as a testbed for commissioning Flow Charts and process models.

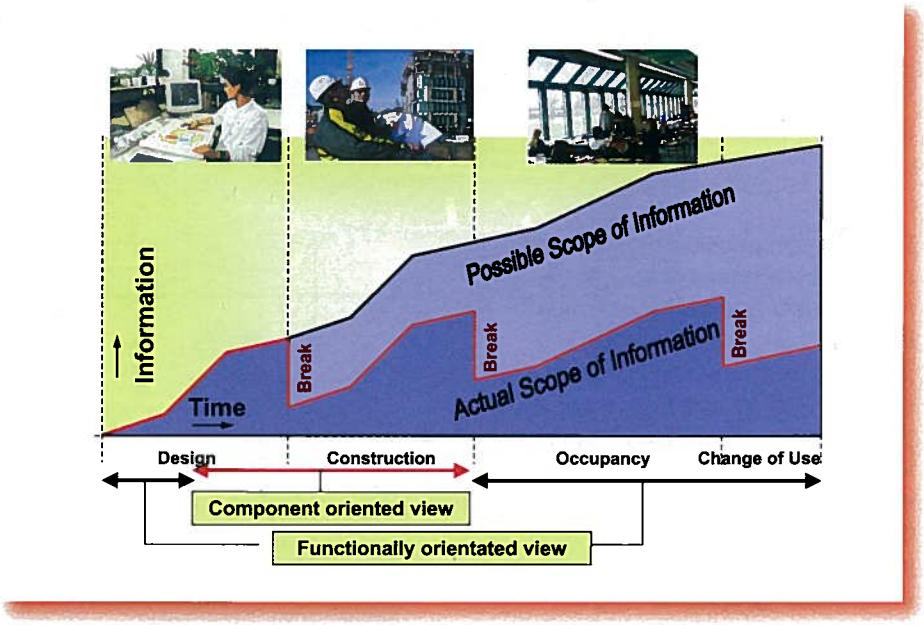

Figure 2. The vision of the future.

- existing energy auditing, the "green movement," and building occupancy certification procedures as leverage to implement the purposes of commissioning.
- available product modelling software such as Express Language of the Industry Foundation Classes (IFC), Seadec data eXchange Format (SXF), and Green Building XML (gbXML) to represent building performance data and FPT protocols for the commissioning.
- conventional database representations such as ACCESS, RDBMS, and HDF5 to formalize data representations and Flow Charts.

Participants in the commissioning process must strive towards standardizing parameters of commissioning data, users, and practices. It is critical to find representations that can carry data from one phase of building delivery to the next one seamlessly minimizing the loss of data. Current efforts in the area of building information modeling (BIM) can provide good opportunities for the development of parallel models and software applications for commissioning of advanced and low-energy buildings. As these approaches advance, researchers can use pre-specified data and flow chart categories to develop historic data records for commissioning of advanced and low-energy buildings to leverage the research challenges of cost, function, and payback in digital commissioning tools.

Re-Commissioning & Optimization of Existing Buildings

As with any type of commissioning effort, re-commissioning, retro-commissioning, and optimization can be labor and cost-intensive efforts that demand highly trained experts.

The development of tools has been identified as a key element to remove these barriers and facilitate the market penetration of the commissioning process.

One of the challenges in developing commissioning tools is to address the different needs of existing buildings and new low energy buildings. Low-energy buildings emphasize an integrated systems approach throughout their life cycle; some buildings may comprise novel and / or advanced technologies and system operation strategies, while others take full advantage of existing technologies.

For conventional buildings, the interest to improve methodologies and develop automated and semi-

automated tools is based on the sheer number of buildings, their high-energy use, and the fact that very few have been commissioned. Therefore significant energy savings will be attained at the national level by applying cost effective processes for commissioning and optimization of building envelopes, HVAC systems, and the building energy management systems (BEMS) in conventional buildings.

The goal for re-commissioning is usually to get the best performance with existing systems (e.g, run fault detection and diagnostic, FDD algorithms and, if problems are identified, run specific FPTs). However, conventional buildings often lack design data and have limited monitored data, while the addition of new sensors and minor refinement of present systems must be shown to be cost-effective. In contrast, new low energy buildings do have design data and the goal for commissioning is performance verification. Here, FPTs can be used to clarify or diagnose any abnormal operation. In all buildings, thorough documentation is important to build the benchmark for persistence of energy savings and system performance.

The tools developed are classified as those intended for:

1. **active testing**, where setpoint changes or control overrides are used to force equipment and system responses;
2. **passive monitoring**, where performance is assessed under normal and optimal operating conditions;
3. **data management**, which help facilitate testing and data analysis; and
4. **system operator training**.

The following are examples of the range of tools developed in the research area of "Recommissioning and Optimizing Existing Buildings":

1. **Commissioning (Cx) Tool for the Whole Building Level**: a tool that continuously monitors the overall heating, cooling, electricity use and indoor temperatures. These serve as inputs to the overall energy performance analysis and optimization of commercial office buildings. (see Figure 3).
2. **Cx Tool for HVAC Systems**: an automated tool to help users verify and optimize the performance of building HVAC systems using the capabilities of a building energy management system. A reasoning algorithm performs an intelligent analysis of all building control data and also performs additional automated commissioning of HVAC components and systems.

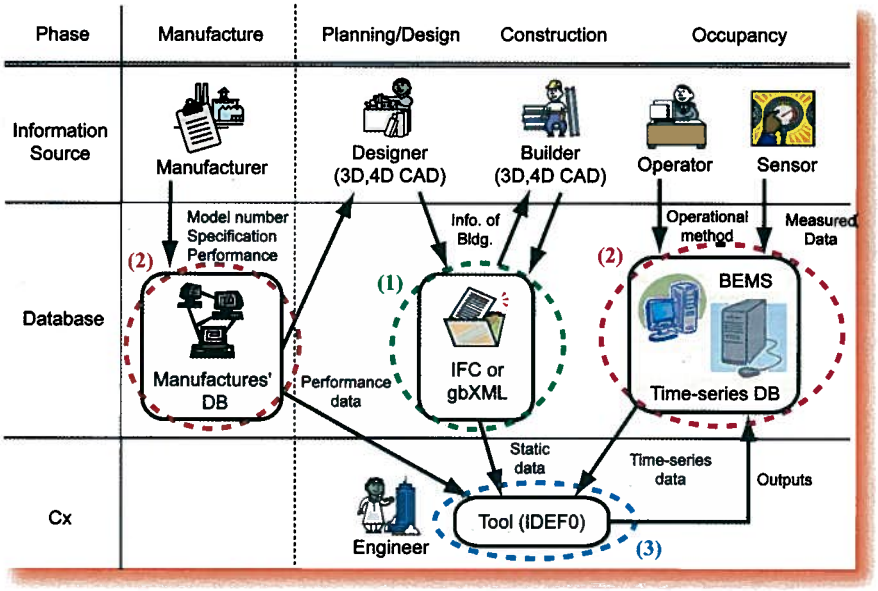

Figure 3. Proposed information flow mechanism.

Making the Case: Quantifying the Benefits, Costs, & Persistence of Commissioning

Internationally, much of the cost-benefit data available today is piecemeal or anecdotal in nature. The lack of systematically documented and quantified data on the costs and benefits of commissioning is due in part to the varying degree to which commissioning is established in countries as well as the cost and or difficulty in measuring both energy and non-energy benefits. A literature review, which focused on countries involved in the research project, found 13 relevant cost benefit case studies that ranged from single building to a 175 project meta-analysis. However, there were numerous unresolved questions about how the costs, benefits and persistence of benefits should be defined and determined. An added difficulty in the review of persistence studies is that the number of existing persistence studies in the literature was so small that each used its own evaluation approach.

The project has developed a comprehensive and systematic cost-benefit methodology that addresses the treatment of cost-benefit issues. This methodology was based on lessons learned from the literature review and issues encountered by participants. The team considered the definition of costs and benefits, level of verification, role of stakeholder interests, data collection approaches, and the influence of project organization and contractual clauses on the cost-benefit of the commissioning process. The cost benefit methodology is implemented in an Excel spreadsheet that contains fields designating the key pieces of information that are deemed essential in performing the most basic cost-benefit analysis. A more complete version of the tool is also available that is use-

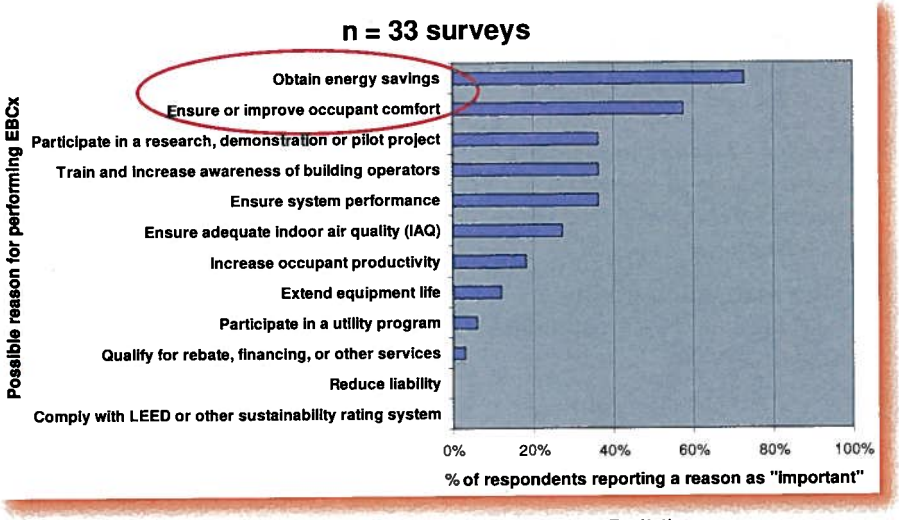

Figure 4. Reported reasons for performing Existing Building Commissioning.

ful in informing project personnel on the information that should be gathered to make a more complete assessment. The recommendations include fields for including non-energy benefits that are inherently difficult to quantify.

A standard methodology will ensure future assessments can be carried out in a systematic manner and added to a searchable database of projects. By enabling decision makers to access relevant cost-benefit data from similar projects, they can learn from the experience of their peers and move towards adopting best practices with a long-term outlook.

The research team used the cost benefit methodology and applied it to data available from 10 new construction and 54 existing building commissioning projects across a range of countries. From the data, it was found that while most projects had complete data for the project information section, very few had the data required to determine the cost effectiveness. This deficiency highlights the need to establish a standard set of data that is documented throughout the commissioning process. The data collected identified some of the market drivers and current practice. For example, Figure 4 shows a bar graph of the motivation for existing building commissioning in 33 international commissioning projects while Figure 5 shows the percentage of measures implemented by type.

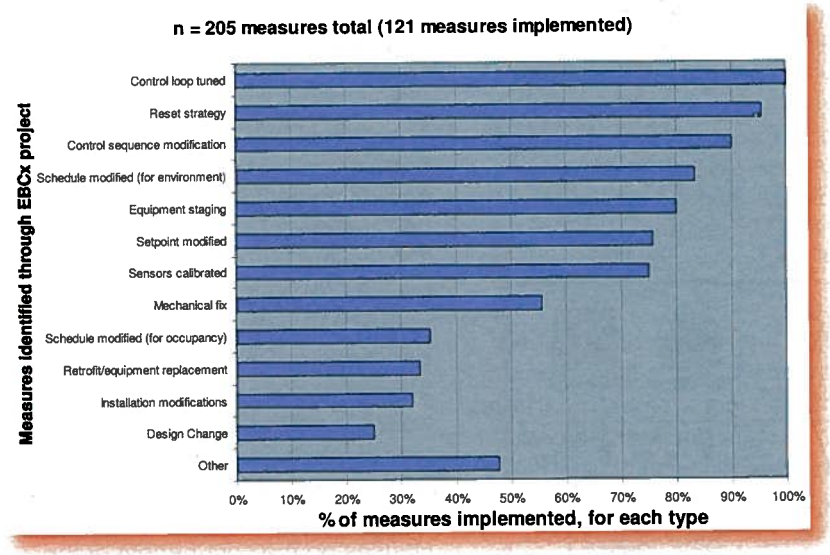

Figure 5. Percent of measures implemented, by type.

Dissemination of Results

The new procedures and tools that have been developed and applied to low energy buildings have shown significant benefits. The aim of this research project is to scale up the impact by incorporating the validated procedures and tools into standard commissioning practice in order to achieve even greater energy savings and green house gas reduction in the building stock. The final reports of the research project on "Cost Effective Commissioning in Existing and Low-Energy Buildings" are now available.

Additional Information

www.ecbcs.org
/annexes/annex47.htm

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