

3 Ways Commissioning Increases Building Management System Efficiency

by Eashvarya Sharma

Executive summary

A building in operation experiences natural wear and tear of its systems and an overall decline in performance with time. While it is possible to limit performance decline through maintenance, it remains difficult to eliminate it all together. Building management is made further difficult by the strains of budget limitations, energy expenses, and changes to operating conditions. Commissioning, a process of recalibrating building systems to optimal performance requirements, is a low-cost, high return on investment solution estimated to deliver energy savings between 5 and 25%.

Introduction

“20% of the energy consumed in a commercial building can be attributed to poorly operated systems.”

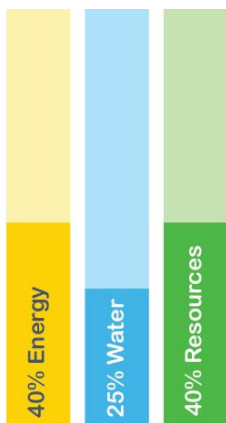
In today’s energy-conscious world, considerable focus is given to reducing energy consumption in buildings; this comes as no surprise when an estimated 40% of the world’s energy is dedicated to them. Facility managers are constantly on the hook to realize energy savings under the strict confines of limited budgets, increasing energy expenses and fluctuating operating conditions. To make matters worse, facility managers are also responsible for ensuring occupant comfort and safety amidst all these other constraints.

With time, buildings have evolved and are now frequently outfitted with [state-of-the-art electric, Heating Ventilation Air-Conditioning \(HVAC\)](#) and lighting systems which consume a lot of energy. To control these various components, building management and automation systems are installed. Ironically, these best-in-class systems can turn into energy guzzlers capable of throwing off building operation, maintenance and budget if not properly installed and regularly tested and tuned. According to research conducted by Texas A&M, as much as 20%¹ of the energy consumed in a commercial building can be attributed to poorly operated systems. Without maintenance, these systems tend to cause comfort-related issues for building occupants.

Properly installed and tested systems that adhere to original intentions for design and performance are essential. The solution to meet this need is referred to as “Commissioning” (Cx), whereby a system review determines proper installation and start-up per design requirements and operating conditions.

Commissioning also ensures that training and proper documentation for operating and maintaining the system are provided. Continuous commissioning practices cover continual functional performance testing, operation and maintenance and improved operator training and documentation. Globally, commissioning has been identified as the low-cost, sustainable, energy-saving measure for all types of buildings and systems.

Energy consumption in buildings



Research by the United Nations Environment Programme (UNEP) indicates that buildings consume 40% of global energy, 25% of global water and 40% of global resources. Not surprisingly though, the research further states that globally, 30 to 80% of energy consumption can be reduced by adopting proven and commercially available technologies, specifically, aiming to do so in buildings.

Among several available measures, commissioning is a strategy that can help building owners manage and reduce energy consumption and related costs. Research indicates that energy savings achieved through commissioning tend to persist well over a three- to five-year time frame; data over longer time periods is not yet available.² However, the energy savings realized in a building after a commissioning project has concluded are governed by several factors:

- Building size and type
- Use of the building, (e.g. segment)
- System type and complexity

¹ <http://esl.tamu.edu/continuous-commissioning>

² <http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf>

- Investment pledged by the owners
- Type of measures implemented
- Expertise of the commissioning authority and agent
- Comprehensiveness of the commissioning study

Evolution of commissioning

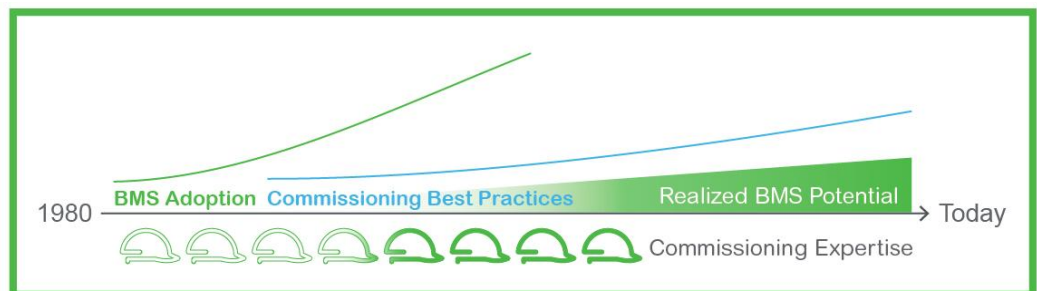
Considering the history of commissioning, it has not always been acknowledged as best practice or even integrated on an as-needed basis to address building performance needs.³ Starting in the 1980s, the building industry witnessed an upsurge in the adoption of Building Management Systems (BMS). However, the industry had yet to understand the full potential of BMS to more fully leverage their features. Commissioning was considered suitable for new construction as a way to get the system to operate rather than as an effective process for maintaining and operating systems in both new and existing buildings.

At the same time, a shortage of trained commissioning engineers was tasked with managing a process many thought to be labor-intensive with minimal return on investment (ROI). A methodology or code of best practices had yet to be developed to guide the process of commissioning. The result was a significant difference in the expectations of building owners, contractors and commissioning authorities and agents.

Gradually, the advantages of commissioning were realized and manufacturers and integrators alike shifted their attention to more intensive BMS commissioning. Manufacturing companies, academia and research organizations began owning up to the arduous task of developing a process for commissioning. Today, while guidelines governing commissioning are in place, the process has yet to gain massive popularity as an effective way to reduce energy consumption and increase occupant comfort and safety (see **Figure 1**).

Figure 1

Timeline showing gradual adoption of commissioning as a best practice for both new and existing buildings



Different types of commissioning

“Energy savings achieved through commissioning may persist well over a 3-5 year time frame, estimated to range between 5 and 25%.”

Commissioning is a quality assurance process carried out on equipment and systems to assign and/or restore them to optimal performance levels. This process, when executed for a new building under construction, is referred to as “New Building Commissioning” (NBCx). In an ideal scenario, planning for commissioning new construction would begin during the design stage itself.

Even in new buildings, system components, for example controllers, lighting, etc. tend to gradually fall out of alignment with their original performance states. This is

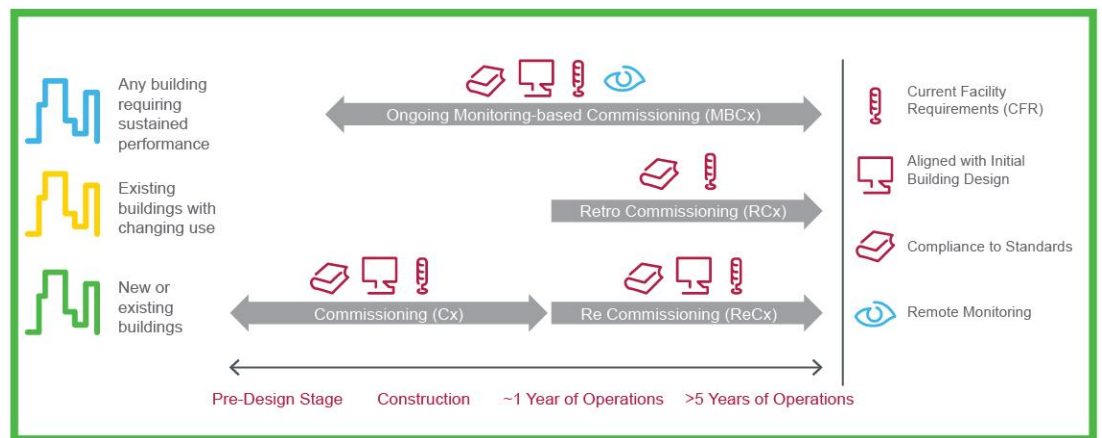
³ http://www.bcxa.org/ncbc/2012/_documents/presentations/77-ncbc-2012-ncbc-twentieth-anniversary-lunch.pdf

a part of the normal wear and tear of any system or equipment over its life cycle. Also, many other factors such as usage, occupancy or environment tend to change with time, requiring adjustments to the systems and equipment to suit changed operating conditions. Any number of these factors can affect the output equipment is capable of delivering over time.

In these scenarios, systems can be brought back to their original design intent to enhance overall performance. This process of revisiting the systems in a building that has previously been commissioned to recalibrate to original design criteria and owner requirements is referred to as “Recommissioning” (ReCx). In some situations, the building is commissioned later for current usage, occupancy and environmental conditions. This process of testing, validating and fine-tuning systems according to Current Facility Requirements (CFR) is referred to as “Retrocommissioning” (RCx). Both ReCx and RCx are known as “Existing Building Commissioning” (EBCx) (see Figure 2).

Figure 2

Ongoing commissioning process



In a unique process involving the collection of system performance trend data and analysis to determine deviations over time, changing building conditions and system performance can be addressed in a timely manner. This process of [continuously monitoring the building for any changes](#) is referred to as “Ongoing Commissioning” or “Monitoring-Based Commissioning” (MBCx). MBCx, as defined by the Lawrence-Berkeley National Laboratory, is a process that “combines ongoing building energy system monitoring with standard retro-commissioning practices with the aim of providing substantial, persistent, energy-savings.”⁴

Since this is an ongoing process, it requires a continuous stream of building performance insights to establish which equipment requires fine-tuning and which measures will lead to energy savings and optimized performance. These building performance insights can be generated by analyzing [building performance data](#), often gathered from the controllers or through the database hosted on the BMS workstation. This data is generally subjected to an analytics engine in order to automate and speed up the process. The analytics engine can be hosted in the building automation network or in the Cloud to facilitate the storage of large amount of data and faster processing. Read the research paper, [“The rise of ‘big data’ on cloud computing”](#) to learn more about how the two intersect.⁵

⁴ Mills, Evan, and Paul Mathew. Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects. Rep. Berkeley, California: Lawrence Berkeley National Laboratory, 2009

⁵ http://sameekhan.org/pub/H_K_2015_IS.pdf

Ultimately, engineering expertise and firsthand experience cannot be entirely replaced by automated analytics. Therefore, it becomes crucial to have experts review and make sense of the findings by superimposing actual site conditions on the analyzed results. MBCx, enabled by data mining, can help identify faults such as simultaneous heating and cooling or leaking valves, which are difficult to identify during the regular course of maintenance, and/or during retro or re-commissioning. Ongoing commissioning solutions are scalable, efficient, and unite automation with human expertise.

Benefits of commissioning

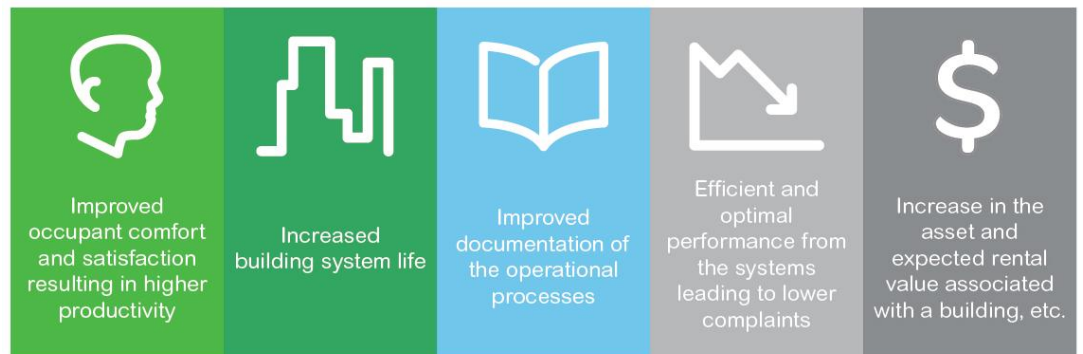
“Experience indicates that the overall cost of comprehensive HVAC commissioning is usually between 2% and 5% of the HVAC construction cost.”

According to a U.S.-based commissioning study,⁶ the median normalized cost to deliver commissioning is \$0.30/sq. ft. for existing buildings and \$1.16/sq. ft. for new buildings. The study included 643 non-residential buildings, 99 million sq. ft. of floor space, \$43 million in commissioning expenses and the work of 37 separate commissioning providers. Commissioning was found to result in 16% median whole building energy savings in existing buildings and 13% in new construction. The payback times were estimated to be 1.1 years and 4.2 years for existing buildings and new buildings, respectively. Based on an in-depth analysis of savings across benchmarking projects by the University of California and California State University systems, average source energy savings of 10% were achieved, with a range of 2-25%, when applying MBCx strategies.⁷

On top of these energy savings, commissioning delivers several other benefits as shown in **Figure 3**:

Figure 3

Commissioning delivers benefits to both building occupants and owners



Discounting for differences in the savings potential due to the factors outlined above, **Table 1** summarizes the range of savings that can be realized in a building post-commissioning.⁸

Table 1

Range of savings in a building as a result of commissioning

Description	Range of Values
Value of Energy Savings	\$ 0.11 - \$ 0.72 /sq. ft.
Value of Non-Energy Savings	\$ 0.10 - \$ 0.45/sq. ft.

⁶ Mill, E., 'Building Commissioning: a golden opportunity for reducing energy costs and greenhouse gas emissions in the United States, 2010.

⁷ <http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf>

⁸ Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory.

For a more detailed understanding of the benefits of commissioning and how the payback period differs by segment and building stage, read the Schneider Electric white paper, "[How Recommissioning Saves Energy in Buildings.](#)"

Overview of the commissioning process

Commissioning is a process, inclusive of construction and operations, which should therefore be considered long before the first brick of a building is ever laid. Building design, type and number are developed in keeping with owner and occupant requirements. This considered, it is essential to include commissioning experts during all building stages. After the construction of the building is in its advanced stage, systems required in the building are procured and installed, paving the way for on-site commissioning. Any system, even a best-in-class one, cannot perform at its optimal level in the absence of commissioning.

Commissioning involves many steps, including:

Main Commissioning Steps:

1. Collect design criterion, system documentations and performance guidelines, etc.
2. Develop a plan of action with clearly identified objectives and timelines
3. Conduct systems testing, taking control sequences into account
 - a. Pre-Functional Performance Testing (Pre-FPT)
 - b. Functional Performance Testing (FPT)
4. Prepare and submit findings report to the customer to identify necessary CapEx measures
5. Carry out post-occupancy seasonal testing as-needed

1. If the commissioning agent/party is not involved in the designing process, then it is imperative for the agent to understand the design criterion by collecting and referring to the designs, system documentations, performance guidelines, etc.
2. After this step, the commissioning agent/party needs to develop a plan of action with clearly identified objectives and timelines. The objectives play an important role in ascertaining the success of the commissioning exercise. Further, if the commissioning agent/party is not directly conducting systems testing, control sequences for testing purposes also need to be identified. A few test sequences can be developed to help validate that the systems have been commissioned and confirm that objectives have been met.
3. The testing of the equipment is carried out in two stages: pre-functional performance testing and functional performance testing. In the case of initial commissioning for a new building, point-to-point validation of each piece of equipment or system is essential. In existing building commissioning, the focus shifts to ensuring that all the systems and equipment are fine-tuned and calibrated. The commissioning agent should work to ensure that the controls are performing optimally, control sequences are appropriate and the scheduling allows for optimal functioning of the systems.

- **Pre-Functional Performance Testing (Pre-FPT)**

In this stage, all the equipments are tested stand-alone. Controls hardware and software, sensors, and the controlled devices are considered in this step. This step helps ascertain that the right equipment is installed at the right place, as per the design and that the naming, tagging and location of the equipment is correct and as per the design, which must be available while conducting stand-alone testing. From the equipments and cabling perspective, continuity testing and voltage checks are also carried out.

- **Functional Performance Testing (FPT)**

After all the systems and equipments are tested for stand-alone performance, they are tested for their performance in the integrated setup. Programming may be altered to check whether the response is aligned. Exemplary sequences of operations are run to check the response. Trends, critical alarms call outs, remote dial up, access and passwords are checked for the response. Successfully demonstrating that the BMS and HVAC are operating correctly is the key success measure at this stage.

4. After equipment testing, a report on the findings is prepared and submitted to the customer for final sign-off. The report must include checks run, results obtained, issues identified, possible solutions and an implementation overview, etc. This report is also used to determine which CapEx measures will need to be implemented as a follow-up to the commissioning exercise.
5. An integral part of commissioning is to carry out post-occupancy seasonal testing. This is done by monitoring the building operation, analyzing short-term trend data captured in the BMS, and developing an understanding of all issues faced by the occupants and/or operator over different seasonal conditions.

Commissioning and global compliance

Among the many benefits of commissioning, compliance to energy certifications and ratings avails a variety of opportunities to building owners. A wide range of global certifications recognizing commissioning are listed below:

BREEAM

Building Research Establishment Environmental Assessment Methodology⁹ is the world's longest established and most widely used method of assessing, rating and certifying the sustainability of buildings. More than 250,000 buildings are BREEAM-certified and over a million are registered for certification in more than 50 countries worldwide.

EU.BAC

The European Building Automation and Control Association represents European manufacturers for home and building automation and energy service companies.

EU.BAC provides a methodology that supports building owners during the life cycle of a building from an energy efficiency perspective. It provides a set of guidelines for designing, commissioning and operating of an energy-efficient building automation and control system. These guidelines, when implemented in the form of an audit by a certified auditor, award buildings with a certificate/rating that correlates to how well-managed the building systems are and their level of energy efficiency.

The association has 28 members including Sauter, Honeywell, Siemens, Schneider Electric, Sonder, Trend, Tridium, Wago, Aramak, Belimo, Broen, Comap and others who operate in the product manufacturing domain or provide energy efficiency consultations.

ASHRAE

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers¹⁰ focuses on sustainable technology for the built environment. ASHRAE Guideline 0-2013, The Commissioning Process,¹¹ is a set of guidelines that presents best practices for commissioning newly constructed buildings.

LEED

Leadership in Energy & Environmental Design¹² recognizes best-in-class building strategies and practices in the United States.



⁹ <http://www.breeam.org/>

¹⁰ <https://www.ashrae.org/>

¹¹ [ASHRAE Guideline 0-2013, The Commissioning Process](#)

¹² <http://in.usgbc.org/leed>

Energy STAR

Energy STAR¹³ is a U.S. Environmental Protection Agency voluntary program that focuses on energy strategies for buildings and plants.

NABERS

The National Australian Built Environment Rating System¹⁴ is a government initiative to measure and compare the environmental performance of Australian buildings.

NABERS allows building owners to self-rate by following a specific process; however, self-rating can be used only for internal consumption purposes and cannot be published or used for promotions. Therefore, while self-rating is a more cost-efficient option, it does not allow building owners to leverage the energy efficiency status of a building to attract tenants or increase asset value. The other rating mechanism is through an accreditation process where the association rates the building on the basis of its environmental performance, energy efficiency, water usage, waste management and indoor environment quality. This rating can be published and used to increase asset value.

Green Mark

The Building and Construction Authority's Green Mark¹⁵ Scheme in Singapore is focused on driving Singapore's construction industry toward more environmentally friendly buildings.

¹³ <http://www.energystar.gov/>

¹⁴ <http://www.nabers.gov.au/public/WebPages/Home.aspx>

¹⁵ http://www.bca.gov.sg/greenmark/green_mark_buildings.html

Conclusion

Global research continues to name commissioning among the top energy conservation approaches available today.^{16 17} Reflected in building certification criterion worldwide, it has been established as one of the most useful approaches for solving energy and controls performance deterioration while ensuring a high return on investment. Additionally, a properly executed commissioning process enhances occupant comfort and reduces safety concerns.

Building owners and facility managers seeking an approach that reduces energy consumption and avoids other cost-prohibitive approaches should employ commissioning in their facilities. It is commonly known that commissioning can be conducted on an as-needed basis, repeated to address whenever substantial changes to operating conditions are made or when performance levels decrease beyond optimal levels. Lesser known however, is that approaches like ongoing monitoring-based commissioning can also be used at the time of initial commissioning all the way through maintaining daily performance requirements. This entire gamut of commissioning services, deployable at any stage in the life cycle of a building, is not dependent on the training or skill levels of personnel in the organizations; it can now be delivered by established industry leaders in partnership with expert agents.

Requiring an integrated approach to building operations, commissioning aligns systems with system providers for faster issue resolution and peak performance. An industry expert, such as Schneider Electric, can guide building owners through the process of selecting the commissioning methodology most aligned with their building needs for optimized performance and measurable results throughout a building's life cycle.

About the author

Eaishvarya Sharma is a Global Field Services Offer Manager within the EcoBuilding Division of Schneider Electric. Responsible for the development and launch of service offers worldwide, she brings 9+ years of experience in BMS strategy development and deployment within the APAC region to her current roll. Eaishvarya has additional expertise in market research, strategy, project management, multifunctional stakeholder management and intellectual property research and asset management. She holds a Masters in Business Administration (MBA) with dual concentrations in Marketing and Strategy and Leadership from the Indian School of Business, Hyderabad.

¹⁶ https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH5_RetroComm.pdf

¹⁷ <http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf>