



COMMISSIONING YOUR WAY TO HIGH PERFORMANCE BUILDINGS

"The Value of Independent Commissioning"

April 16th 2017

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Version 20170714.4

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INTRODUCTION

In many fields, the benefit of involving independent specialists is universal, and despite the initial investment involved, the positive factors typically far outweigh the financial costs. This white paper analyses and highlights the real value and importance of independent commissioning; beyond simply saving you time and money, it ultimately helps shape a more superior built asset that stands up to the test of time and the demands of the ever evolving built-asset market.

While the overall cost and aesthetics of a building are important, it is vital that an asset performs well in the long-term, with as little maintenance as possible. Take the example of buying a car. Despite taking the time to consider a variety of options, you may still end up having to replace the vehicle after only a short time due to poor design or manufacturing issues. These hidden design or operational flaws may be issues that only an expert or specialist could detect.

Therefore, to help you make a fully informed decision regarding quality (especially if it is a pre-owned vehicle), it would be better to seek the assurance of an objective external reviewer or certifier. The word of a member of the car's production or sales team may be biased towards his or her own personal offerings, potentially leaving you open to problems in the future.

Building commissioning is not unlike this vehicle analogy, but of course it is much more complex. While building systems becoming increasingly more complex (especially given the ongoing integration of information technology with MEPF), some lower tier developers are still biased against the important process of building commissioning (Cx), viewing it simply as a "box-ticking" exercise rather than a vital, value-add on service that serves both their immediate and long-term interests.

Some developers might also opt for the lowest cost option regardless of quality, independence or expertise, simply to fulfil a statutory requirement. The commissioning process is even sometimes passed on to the contractor or designer, which creates a conflict of interest and completely

contradicts the intent of the commissioning process. We will highlight this below, and demonstrate that commissioning must be independent in order to fully maximize its benefits.

In this paper, we will discuss and explain in detail the value of independent commissioning for developers, FM teams, project designers, and end users. We believe its inherent value lies in having an optimal, independent advisor with extensive expertise and specialist knowledge who can ultimately help fulfil an owner's exact vision for a project. To get the full benefits of commissioning and to ensure Cx is properly implemented, it is important to first understand this meticulous process. We will cover this in detail, along with the various types of commissioning, before analysing its cost and benefits. We will also outline the intrinsic values it can add, and how the initial costs may be gradually covered through independent, certified and early-implemented Whole Building Commissioning.

Furthermore, we would like to thank the persons, companies and research institutions referred to throughout this report for their strong input on vital data and analysis.

WHAT IS BUILDING COMMISSIONING?

ASHRAE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, defines commissioning as:

“A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the Owner’s Project Requirements (OPR).”¹

- Some of the most important benefits of property commissioning are outlined below:
- Averted premature equipment failures
- Avoided construction-defects litigation
- Improved end user comfort
- Mitigated indoor air quality problems
- Increased competence of in-house staff
- Reduced change orders

Cx is a quality assurance process whereby the desired quality is achieved through extensive attention to detail in each stage of the process.

‘Desired quality’ refers to the functional requirements of a project and the expectations of how it will be used and operated. This includes project and design goals, measurable performance criteria, budgets, schedules, success criteria, and supporting information.²

As part of Cx, all these details are put down in a written document called Owner’s Project Requirements’ (OPR). The project is only considered complete once the OPR has been achieved to the satisfaction of the owner. Thus, Cx refers to the means of verifying the identified functional needs of the owner throughout all phases of the project.

From building design to construction to hand-over and to occupancy, numerous complex systems are installed as part of today’s Smart Building. Additionally, municipal codes and various standards (e.g. ASHRAE, NFPA, CISBE, LEED and other regional and local green building standards) have to be met. This makes commissioning a necessary process to implement. On nearly every type of project, a successful commissioning program contributes to the performance and lifespan of a building project and helps to guarantee that all standards are fulfilled.

Commissioning is dependent upon teamwork, because all partners have to work closely together and ensure that they are all aligned on the project and its goals. Integrated development is an objective of the Cx process, and is achieved through proper coordination between various trades. The greatest benefit is derived through early design stage involvement; hence it is a process that begins in the **Pre-Design Stage** and continues throughout Design, **Construction** and **Post Construction (warranty)** and throughout operations.

This process reduces energy related design issues to a great extent, and mitigates potential risks by addressing building commissioning expectations early on in the project.

Training of facility operators on the operation and maintenance of the building systems, as well as record keeping in terms of Operations and Maintenance (O&M) manuals, is part of the Cx process that helps to ensure that the needs of the building owner and occupants are met and the facility continues to operate as intended.³

The whole Cx process is governed by a Third-Party Independent Commissioning Authority (CxA or ICA). CxA is an entity identified by the Owner who plans, schedules, and coordinates the commissioning team to implement the commissioning process throughout all phases of the project. It is imperative that the CxA works

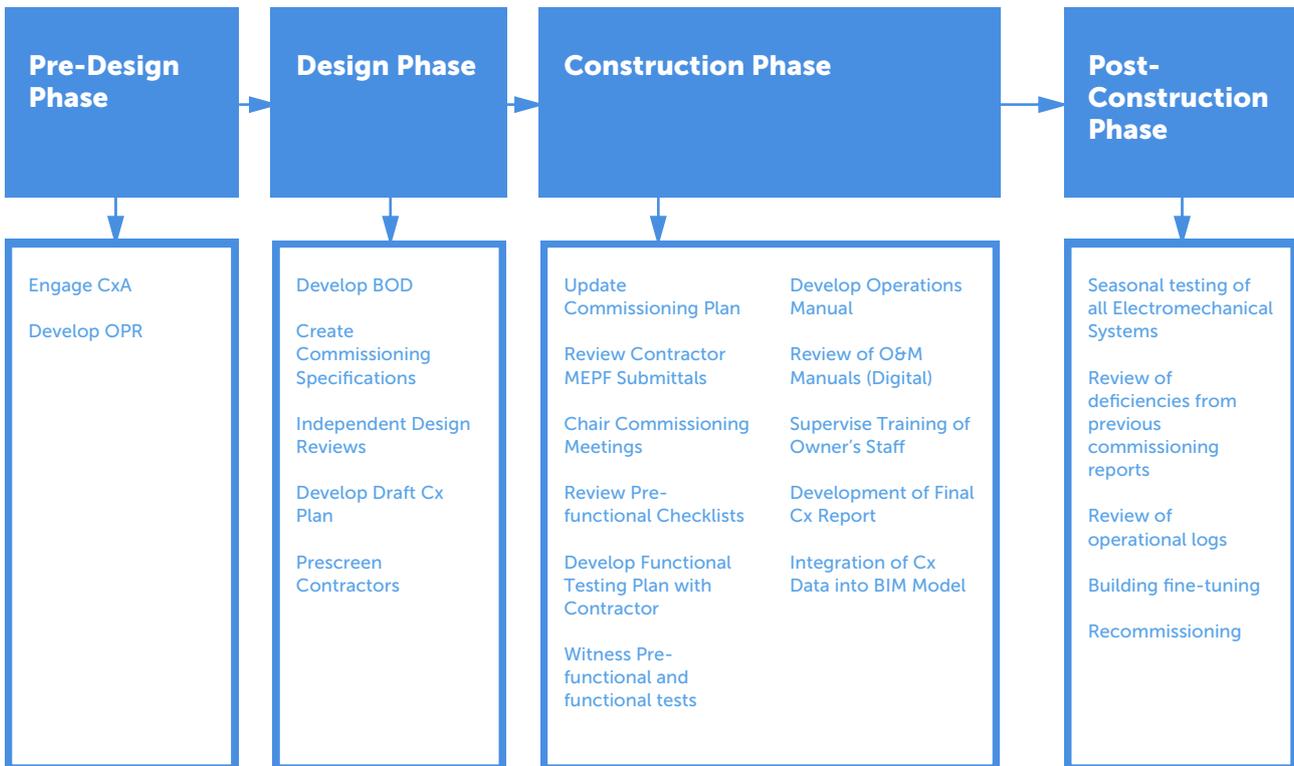
independently and reports directly to the Project Owner / Project Management Consultant (PMC) without undue influence from either the design or construction teams.⁶

“Commissioning can be looked at as Risk Management and Interface Management”²¹

The scope of Cx covers the following systems, which may have the highest impact on energy and water consumption of built environments:

- Space Heating and Cooling
- Refrigeration
- Ventilation systems and controls
- Lighting and daylight controls
- Domestic hot water systems
- Renewable energy systems
- Building Envelope, Fire life-safety systems, Security systems, and Electrical power distribution
- Any additional systems requested by the client or as required by green building standards

THE COMMISSIONING PROCESS



Core Phases Of [The Commissioning Process](#)

PRE-DESIGN STAGE

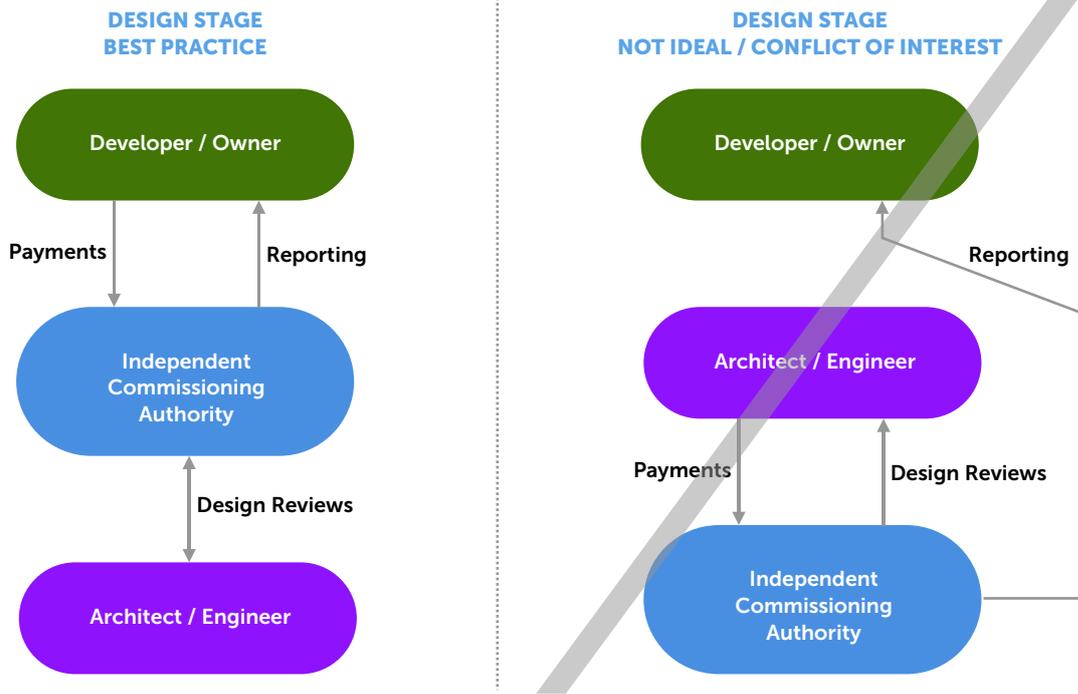
The owner selects the design team, which includes the commissioning authority (CxA). Commissioning authority consists of the initial Cx team and team leader, and they are involved from project initiation up until approximately one year of occupancy. Together they will work with the Owner to develop the OPR (Owners Project Requirements) to ensure that the project will meet the owner's expectations. The aim of Cx is to achieve the OPR by verifying a building's systems and subsystems such as HVAC, plumbing, electrical installations, building envelope, among others.

DESIGN STAGE

As the design develops from concept to documentation, the CxA must work closely with the

design team to create the Commissioning Requirements, Specifications, and Draft Commissioning Plan. They must also perform an independent review of the design documents.

"The Commissioning Authority must focus on the interface of systems and disciplines, an area where designers do not devote enough time"²¹



Basis of Design

The Basis of Design (BOD) is a technical document developed by the architect and/or engineer based on the OPR. The document describes the technical and design parameters to be used in the design of building systems such as HVAC, building envelope, building lighting, BMS, among others.

Design Document Review

Specifications and drawings are reviewed at critical junctures as the design progresses.

Commissioning Plan

The Commissioning Plan is a document that outlines the responsibilities of each member of the construction and commissioning teams. It also details the organization, schedule, allocation of resources, and documentation requirements of the commissioning process. It identifies the requirements for static and dynamic testing, air & water balancing, training and demonstration, O&M manuals and as-built documentation and outlines what is expected of the Contractors. The initial Cx Plan is created during the design phase and serves

as the road map for executing the process during the design and construction phases. The plan is continuously updated and enhanced until the end of the project, when it then becomes part of the Project Commissioning Record.

CONSTRUCTION STAGE

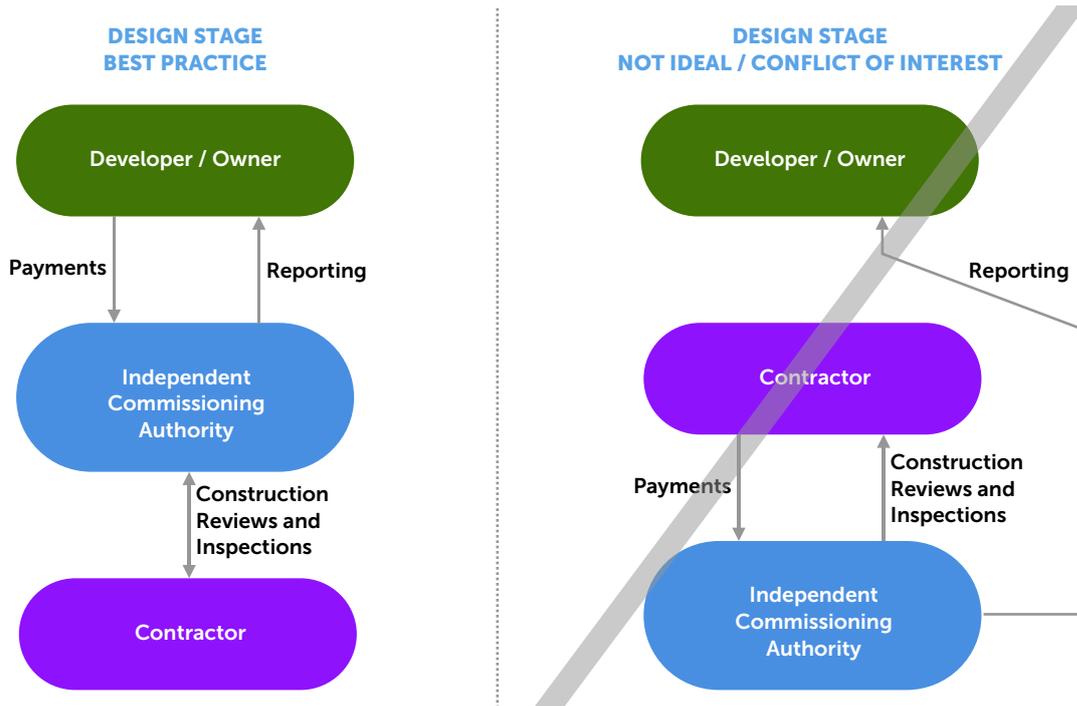
The CxA provides the following services, some of which include:

Update of the Commissioning Plan

The Commissioning Plan is updated with project specific information and with specific input from the contractor, commissioning contractor and testing and balancing team. This is a living document that is updated as required throughout the project.

Review of Contractor MEPF Submittals

The independent CxA reviews related submittals for compliance with the OPR, BOD and design documents, and confirms the ability to commission both system components and integrated systems. FAT inspections can also be undertaken at this point.



Pre-Functional Checklists

These ensure that every piece of equipment associated with each system is installed correctly, statically tested and ready to be started up and prepared for functional testing.

Functional Testing Plan

The Functional Testing Plan makes sure that each sequence of operation has been verified. This includes making sure that all machines (be it a chiller plant or an air handling unit) start correctly and follow the right sequence of events. For each system, a file is generated to track that all necessary test items (such as pre-functional testing, water and air testing and balancing) have been accomplished.

The above documentation assigns the responsibility to each of the team members: owner, architect, consultants, CxA and contractors. This sets the foundation for the commissioning process. Clear, detailed documentation is imperative in order to ensure a successful process.

- Inspection of system installations

- Inspect proper performance of equipment and systems
- Chair Commissioning Meetings
- Review of Contractor Submittals
- Review of Test Procedures
- Witnessing of Pre-functional and Functional Tests
- Development of Systems Operations Manual
- Review of the Operation and Maintenance Manuals
- Supervision of the Training of the Owner’s Staff

POST CONSTRUCTION STAGE (OPERATIONS/ ACCEPTANCE, BUILDING TUNING & WARRANTY PHASE)

The following services are provided by the CxA during the final stage of a project or the post construction stage:

- Recommissioning

- Building fine-tuning
- Seasonal testing on all mechanical and electrical systems
- Review of deficiencies from previous commissioning reports
- Review of operation logs
- Review of concerns as noted by the building operators

INTEGRATION WITH BIM (BUILDING INFORMATION MODELING) VIA COBIE FOR ASSET MANAGEMENT

All performance testing data as well as all findings and recommendations by the commissioning team are detailed in the final commissioning report at project completion.

To ensure all systems run efficiently, an operations manual is prepared detailing how to optimally run each system during all modes of operation (fire, power outage, shutdown, etc.).

TYPES OF COMMISSIONING

Commissioning is so much more than the box-ticking exercise that is often followed simply for compliance and sustainability certification. It can, and does, deliver high returns to the savvy client who embraces the commissioning process in its entirety.²¹ Commissioning can be applied to new building projects (as outlined above) as well as to existing buildings, whether or not they have been previously commissioned. Commonly used terms include:

WHOLE BUILDING COMMISSIONING

A term used to emphasize that the focus is not only on the building's functional systems but also includes Building Enclosure Commissioning where a more holistic approach is employed (see below).

RETRO-COMMISSIONING

This applies to existing buildings that have not been previously commissioned. These buildings would likely be experiencing complaints regarding occupant comfort, O&M and high-energy costs. Low cost O&M improvements for the existing building are identified in order to meet initial design intent and the current needs of the owners and occupants. This could include testing the HVAC systems' performance and recommending solutions accordingly.⁴

Re-commissioning applies to existing buildings that have been previously commissioned.

MONITORING BASED CONTINUOUS COMMISSIONING (MBCX)

It is a review of building operation within the first year of a building's operation phase. The process involves continuous monitoring of real-time performance and comparing it to energy simulation data in an effort to identify faults or performance deficiencies in the systems immediately after occurrence.



Process Cycle Of Monitoring Based Continuous Commissioning

BUILDING ENCLOSURE COMMISSIONING

Building Enclosure Commissioning (BECx) and testing is an inherent part of Whole Building Commissioning, and focuses on much more than just technical system installations. It deserves distinct attention as it continues to increase in importance as a result of the demand for high energy efficiency, longer building life cycles, increased performance expectations, and new construction products.⁹ The building envelope design is crucial for indoor comfort and air quality, energy efficiency and sustainability, and thus can no longer be regarded separately from the building's energy systems.

The most crucial part of BECx is the mock-up phase. Unfortunately, despite its importance, it is often not implemented effectively on new construction projects because initial cost savings are prioritized.¹⁰ Building enclosure commissioning (BECx) and testing can prevent many unwanted consequences. Some include the identification and rectification of air leakage and moisture issues, which result in increasing the effectiveness of the technical MEP systems. The process commences at the basis of design (BOD) and can continue through all stages of the project.

Mock-Up Testing

The Building Design + Construction magazine defines Mock-ups as "full-sized structural models made with the exact construction techniques,

materials, and technicians that will be used on a project, providing the project team [owner, designer, contractors, consultants] with the opportunity to assess a three-dimensional representation of a design and serving as a means to evaluate functionality, determine compliance with project documents, assess aesthetics, establish quality standards, and enhance workmanship.”¹⁰

Mock-ups are set up for review and testing by the specialist building enclosure commissioning authority prior to installation on site. Each mock-up must be representative of the OPR and the quality standard of the future construction. Ideally, the mock-up will be constructed with the same materials and by the same personnel employed for actual construction.

A congruent implementation requires that the Building Enclosure Commissioning Agent/ Authority (BECxA) be involved in all stages of the mock-up process (design, testing and post-test evaluation, troubleshooting).

Typical testing includes air infiltration, static and dynamic water penetration, thermal cycling, condensation resistance, inter-story drift, and design load and structural overload tests. Additional tests may be added, for example, airtightness testing of membrane seams and penetrations.

The intent of mock-up testing is to locate potential issues prior to the actual construction and then to transfer lessons learned and results of the evaluation to the actual building site to lead to a well-streamlined and flawless installation process by exact replication of the final mock-ups.

The advantages are obvious: Mock-ups helps to learn which materials to use and how to install them properly, to detect incompatibilities, to locate potential leakage points, etc. Consequences include reduced energy cost, better indoor air quality and thermal comfort, and prevention of costly repairs due to water infiltration, condensation, and potential mold issues. Furthermore, it enables the constructor to determine applicator skill level, site conditions and scheduling or sequencing conflicts.⁹

SMART COMMISSIONING FOR SMART BUILDINGS

Nowadays buildings are more complex than ever: While once subsystems (like light, air conditioning, or heating) were independent and operated individually by a couple of wires and switches, systems are now highly interactive and their subsystems and components require meticulous maintenance and precise operations.¹¹ Thermostats, for example, can adjust temperature and humidity based on an occupant’s preferences and climatic conditions. They may be connected to occupancy sensors and active shading devices in order to work in harmony with environmental factors and occupancy comfort.

The installation of direct digital control (DDC) systems, automatic valves, dampers, actuators, and sensors are now common practice. According to a recent Deloitte Center for Financial Services study sensor deployment in the commercial building sector “is likely to grow at a compound annual growth rate of 78.8 percent between 2015 and 2020”.¹³ New technologies for life safety and security systems add to this. Optimal energy-efficiency and indoor air environments are required for occupant health, comfort, productivity, and sustainability.¹¹

To connect all of these complex systems, Building Management Systems (BMS) are utilized and function as the building’s “brain.” Like our nerves which sense circumstances and inform the brain via transmitters to cause the corresponding action by the body’s subsystems, the sensors installed in buildings feed the BMS with information which then initiates the appropriate responses of the heating, ventilation, air conditioning systems (HVAC), as well as other building systems.

While this is already complex enough, recent development, particularly the ongoing integration with the Internet of Things (IoT), is taking the role of BMS to a new level. Information-based applications add new ways to create value and to grow margins through the use of sensor-generated data and their analysis. In fact, information and analytics are becoming an integral part of buildings.¹³ A recent forecast suggests that “Smart commercial buildings will be the highest user of Internet of Things (IoT) until 2017, after which smart homes will take the lead with just over 1 billion connected things in 2018.”¹⁵

These developments are reflected in the flood of new products available: They no longer only consist of mechanical and electrical parts, but are complex systems that combine hardware and software, include sensors, store data, and are connected in multiple way.

While such products offer great opportunities for sustainability, reliability and effective product utilization (and thus enhanced user experience and safety as well as cost savings on energy and O&M), they also alter industry structure, require expert choices from a growing pool of options, and demand for the highest levels of expertise when it comes to their installation, operation, and maintenance. It is crucial “to understand how various types of sensors can track features such as motion, air pressure, light, temperature, and water flow”, and also how to adapt BMS accordingly. Unfortunately, companies often try to keep initial costs low, especially in the design-phase, and thus system integration is given a low priority.¹²

This is where independent commissioning comes into play. A competent Cx Authority helps to handle all these complex tasks related to the building and installation process, and works to ensure proper functioning and integrity of all subsystems. Cx authorities are chosen based on their technical competence to evaluate the OPR, design, installation and performance – right from the beginning of the project. The need for a qualified Cx team increases as the complexity of the project increases. Since clients and users will also be increasingly informed about building features thanks to the same information technological developments that are influencing the building sector, this increase in complexity is unavoidable.¹² Commissioning Authorities, since they are not bound to any one construction company’s structure keep an overview of the market and competitors, and quickly adapt to recent developments. The focus of Cx is no longer reduced to the functionality of a building's inherent mechanical systems. Much more, it is and must be considered as a whole building process, also called Whole Building Commissioning. Components, systems and assemblies all have a symbiotic relationship with one another.

Whole Building Commissioning. Components, systems and assemblies all have a symbiotic relationship with one another.

THE IMPORTANCE OF INDEPENDENT THIRD-PARTY COMMISSIONING

The CxA should be regarded the Client's Trusted Adviser and a second set of eyes on the project. Why is it so imperative that the CxA be independent? Why can the task of Cx not be undertaken by one of the other contractors, as that may reduce up-front expenses?

Simply said, because two heads are better than one. When work is supervised, reviewed, and tested by independent advisers, they will most certainly find deficiencies that can be rectified and opportunities to be executed.

Why is that? Because often, it happens that one does not see one's own mistakes. Additionally, there might be a bias in the way in work methods of a person that even he or she is not aware of. This can inhibit the person's ability to find better solutions or to realize improvements, to spot weaknesses or to adapt more efficient ways of practice. It simply does not make sense to have work double checked by the same party, yet it happens in almost every field, not just in construction.

When you pay for commissioning, the smartest choice is to put this money towards independent experts whom you can trust to assist you with their in-depth knowledge of the process. What happens if you don't? You will still finish your project, but most likely not in the best way possible.

Unfortunately the following scenario is all too common on construction projects:

A Cx team is hired by the project owner, but in an attempt to reduce costs, the Cx process is gradually undertaken by contractors. The operating staff oversee the procedure post construction, and originally this is a successful procedure. However, the cost savings of "throwing-in" commissioning as part of a one-point-of-contact construction contract are soon eliminated as problems are encountered, and contractor callbacks are difficult. The ability of an independent advisor to act on your behalf at this

point is severely hampered as MEP equipment may already have been procured and installed, and the fixing of deficiencies is more costly in retrospect.

However, if the Owner starts early, the CxA, as your professional and independent trusted adviser, provides the Owner with an unbiased, objective view of the systems installation, documentation, operation, and performance, and witnesses and verifies systems and assemblies testing. Ultimately, acceptance of design or construction work that does not pass verification tests may be rejected by the owner. The Cx authority is there to explain the implications of such decisions on the owner's objectives set out initially in the Pre-Design Stage OPR.⁷ Commissioning procedures and results are observed by the CxA, who communicates findings directly back to the developer/owner.

Experienced, specialty CxAs know what to look out for, because they have performed these task in several contexts over the years. They have already learned from previous mistakes and have an overview of all factors involved. They have seen a multitude of people work on various projects and can assess different kinds work flows and structures. They have valuable knowledge of available materials, international best practices and the processes involved, as well as the legal provisions. And, last but not least, they are not in a conflict of interest. They do not need to disguise any flaws, because as your trusted advisor, preventing issues is their primary goal.

An ideal project organizational chart would place the commissioning authority as hired by the owner directly and given equal priority to the design and construction team. This allows the CxA to deal with issues directly as they arise by communicating effectively with the owner and staff.

An independent third party CxA hired directly by the owner is the most reliable mechanism to obtain the value of the mechanical, electrical, plumbing and other systems they paid for. The independence of the CxA is crucial to ensure the client's building

components are installed to function according to the design intent. The CxA must be able to strike a balance between protecting the owner's interest as well as working effectively with the construction and design team.

A Cx Agent's role is critical to a project's success as they ensure that from the initial owner's concept through the design all the way to the finished building, every related operational requirement has been met. Among various skills they use their hands on experience with controls and HVAC systems as well as troubleshooting, problem solving skills and extensive coordination with the project team in order to advise the client accordingly.⁸

Certification of your Commissioning Authority Ensures Quality

After identifying the importance of independent Cx, it is necessary to be able to spot a certified commissioning authority. A qualified Cx Authority would have the necessary technical knowledge and experience with similar building systems from previous projects as well as effective communication and organization skills. Requesting contact references and reviewing sample work products can verify this. Also, when evaluating a firm, commissioning should be one of the core services offered.

Several international bodies accredit individuals in Commissioning including, but not limited to: ASHRAE, NEBB, The Building Commissioning Association, and The Commissioning Specialist Association. In addition to years of experience on specialized types of buildings, a Cx accreditation such as ASHRAE's CPMP/BCxP is often a reliable indicator of a CxA's ability to deliver.

COST AND BENEFITS

When buildings are commissioned correctly in accordance with ASHRAE standards, the specific benefits of the commissioning process can include

- Reduction of change of orders and contractor claims
- Fewer deficiencies at substantial completion
- Fewer project delays
- Managed startup procedures
- A shorter building turnover transition period
- Less post-occupancy corrective work
- Minimized impact from late stage design changes
- Improved air quality and occupant productivity
- Better operations, maintenance and reliability
- Lower energy and operational costs
- Added-value construction quality
- Complete and useful documentation for operations
- More knowledgeable O&M staff
- Improved future designs
- Owner advocacy for design and construction decisions

Generally, the highest cash-on-cash returns are achieved through retro-commissioning, as this often applies to buildings which were built in times with much lower standards than today (as well as much lower attention to commissioning), so that there is often a good amount of opportunities for improvements. With new building commissioning, the greatest benefits are achieved thanks to significant cost savings when beginning Cx at the design phase, and as a result of early detection of problems that arise may during the construction phase. This tends to eliminate the cost of change orders and contractor call backs, and ensures a smooth turnover process. It can also result in less troubleshooting during the first year. This alone often offsets the cost of the commissioning agent.

Reduced costs even after the first year due to proper installation and personnel training also add to these savings. Moreover, energy savings are often the long-term outcome of a thorough Whole Building Cx process. Studies which measured Cx benefits have come to convincing results in favor of early-implemented, thorough Whole Building Cx processes, and these proven quantifiable savings do not even include more complex to measure, but often more important, benefits like comfort, safety and environmental improvements.

The Lawrence Berkeley National Laboratory has compiled a decades worth of commissioning data from 643 commercial buildings, commissioned by 37 different Cx providers. The results of their extensive study illustrate the energy savings and payback achieved in projects which have embraced the commissioning process.

In this study, **new** construction (Commissioning), Cx cost amounted to \$1.16/ft² or \$12.49/m² (or 0.4% of the overall construction cost) and resulted in 13% median whole building energy savings. Cost amortized on average after 4.2 years due to lower energy usage, reduced operation problems and fewer change orders. [3] A median benefit-cost ratio of 1.1 and cash-on-cash returns of **23%** were calculated.

For **existing** buildings (Retro/Re-Commissioning), the median normalized cost to deliver commissioning was found to be \$0.30/ft² or \$3.23/m², with a result of 16% median whole building energy savings and a payback time of only 1.1 years. This translates to a median benefit-cost ratio of 4.5 and cash-on-cash returns of **91%**.

Table 1 below summarizes the Cx cost and savings expected for new and existing buildings. Actual savings may vary based on the building type, location and scope of Cx process.

	Existing Buildings	New Construction
Median normalized Cx Cost	\$0.30/ft ² \$3.23/m ²	\$1.16/ft ² \$12.49/m ²
Whole Building Median Energy Savings	16%	13%
Payback Period	1.1 years	4.2 years
Cash-on-cash Returns	91%	23%

Table 1: Cost And Benefits In New Building And Retro-Commissioning According To The Lawrence Berkeley National Laboratory Study ⁴.

While this study focuses primarily on energy savings, the authors stress that Cx also comes with multiple other, non-energy benefits such as improved worker comfort, a higher level of engagement of in-house FM staff, and improved indoor air quality.

Furthermore, significant non-energy first-cost savings of Cx, like right-sizing of heating and cooling equipment, were found to reduce the net median commissioning project cost by 49% on average, and to offset it completely in some cases.³

The projects that gained the most benefit and attained almost twice the overall median savings were those that took a comprehensive approach to commissioning, as opposed to a less thorough approach. In comparison with the least-thoroughly commissioned projects, up to five times the savings could be achieved by diligent commissioning. The measured energy savings persisted to at least a 3-5 year time frame (no longer-term data was available at the time of the study). Therefore, and for other benefits that are more difficult to measure, the results of the study may be underestimating the actual potential cost-savings through Cx.⁴

The previous finding are also in line with those of the U.S. Department for Energy. In their practical guide to building commissioning and retro-commissioning for federal buildings, they report major energy savings and short payback times. For existing buildings, energy savings average about

15% at a cost of about \$0.27/ft² or \$2.91/m², with a payback of about 8.5 months. Commissioning for new construction is reported to cost about \$1.00/ft² or \$10.76/m² and to pay back within about 4.8 years. These numbers do not include non-energy related savings, thus the total savings will most likely be even higher.¹¹ Table 2 below summarizes these findings.

	Existing Buildings	New Construction
Cx Cost	\$0.27/ft ² \$2.91/m ²	\$1.00/ft ² \$10.76/m ²
Whole Building Median Energy Savings	15%	N/A
Payback Period	8.5 years	4.8 years

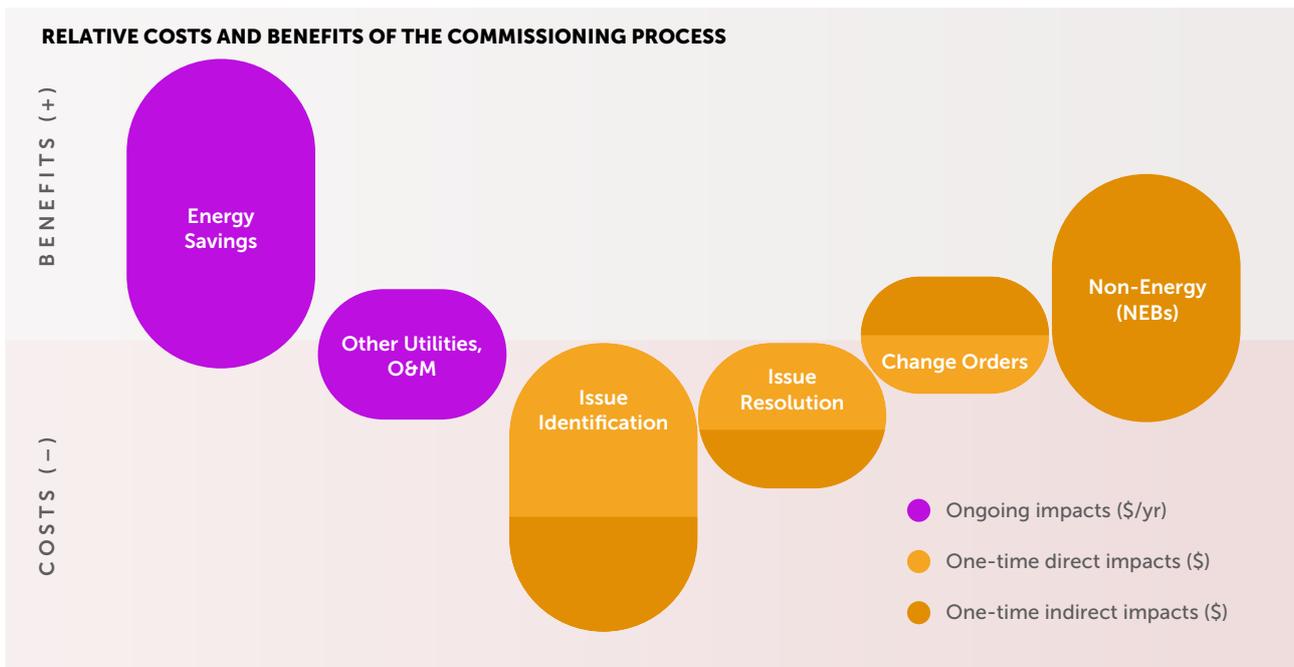
Table 2: Cost And Benefits In New Building And Retro-Commissioning For Federal Buildings According To The Us Department For Energy ⁴.

The study also names potential risks or problems that may arise without building commissioning that would typically result in higher energy costs, O&M expenses, and occupant discomfort:

- Outside air dampers stuck in the always open or always closed position
- Adjustable speed drives that no longer adjust properly
- Unconnected flexible duct work
- Not properly responding control systems components
- Incorrect operation sequences [...] ¹¹

Additionally the improved equipment performance, increased staff expertise, resulting lower O&M costs, improved comfort for occupants and the previously mentioned long-term energy savings tend to lead to an increase in asset value. High-performing buildings are easier to sell and to lease out (due to lower vacancy rates and higher lease rates per sqm), and increase occupant productivity due to a lower prevalence of sick days from respiratory related illness such as SBS and asthma.

The benefits of commissioning translate into increased profitability for tenants, building owners, and finally, to an increased net operating income and quicker returns on investment. Higher



appraised building values of the property are a likely outcome if the high-performing qualities of the building are advertised effectively.¹⁶

ENERGY SAVINGS THROUGH WHOLE BUILDING COMMISSIONING

How does Whole Building Commissioning help to achieve energy savings?

Energy-bills (non-process related) are mainly influenced by a combination of two main factors: the building enclosure, and the HVAC system, which is controlled by the BMS.

A properly functioning HVAC system, networked via an advanced BMS, determines a building's energy consumption. Through sensor (daylight, occupancy, CO₂, etc.) feedback, the BMS “knows” how much energy to employ for heating, cooling, ventilation, lighting, etc. With the ever increasing complexity of Smart Buildings, the potential for errors increases exponentially. As an example, over 10,000 energy-related problems were revealed in the commissioning projects studied by the Lawrence Berkeley Laboratory.⁴ How would an operator know if the sensors work properly and are well-integrated with the BMS, and how would he set it right? An experienced CxA ensures that all parts of the system function as required by the owner, and possibly even exceed the owner's expectations.

In addition to the HVAC system, the building envelope plays a pivotal role for energy consumption by potentially reducing costs for heating and cooling.

This is ever more important as delivered energy consumption in buildings worldwide (residential and commercial) will increase by an average of 1.5%/year from 2012 to 2040 (2.1%/year for non-OECD nations). Energy consumption for cooling is expected to increase by almost 150% globally by 2050, and by 300% to 600% in developing countries.¹⁷

When a building in the desert during summer has a facade that leaks, the building owner is essentially paying large annual energy tariffs to try and cool the desert. This is a losing proposition at best.

Energy savings in envelope design are achieved by using energy-efficient materials (like reflective roofs and walls, shades, and coatings) and by means of passive heating and cooling designs. (These include integrated facade systems with proper orientation, dynamic solar control and optimized window-to-wall ratios). According to the IEA, energy savings of up to 60% for lighting, 20% for cooling and 26% for peak electricity have been shown to be possible for such passive designs.¹⁷

Buildings can in fact lose energy through their enclosure (up to 35% according to the NISTIR7238 Report 2005¹⁹). One way that this

can happen is due to uncontrolled air movements between the conditioned interior space and the exterior.

In addition to creating energy losses, a poorly constructed building enclosure can lower the life expectancy of the entire building. Air leakage and water intrusion, for instance, can lead to mould, bad indoor air quality and other negative effects, which can in turn lead to major repair costs¹⁷ and litigation.

CONCLUSION

Studies and experience reveal that the long and short-term savings generated by an optimally performing building far outweigh the initial cost of hiring an independent commissioning professional.

Through detailed data and analysis, this report concludes that commissioning is most effective when implemented at the pre-design stage, with a highly qualified, independent team at the helm of the process. This ensures that savings which might otherwise get overlooked, are quickly identified and acted upon, with complete impartiality. The result is a more superior building that operates efficiently as the owners intends, and one that continues to perform in the long-term, with minimum maintenance required.

Moreover, this paper has highlighted that commissioning should not be just seen as a mandatory.

“box-ticking” exercise, but as vital support to help realize an owner’s vision and requirements for a project. We have significantly demonstrated that including the role of the Independent Commissioning Authority in with the contract of the contractor and/or designer is not recommended.

If we refer back to the initial analogy of buying a vehicle, you will remember that the independent nature of commissioning is vital when it comes to guaranteeing an unbiased result. As with the example of purchasing a car; it makes much more sense to seek the advice and impartial review of someone who is not directly involved in the vehicle’s manufacturing or sale. By involving a party from the vehicle’s own manufacturing or design team, you leave yourself open to potential bias.

When we apply this simple analogy to the complex process of commissioning, it is clear that choosing to pass on such a vital specialist role to someone within the project’s team who is already employed by the client, can result in a clear conflict of interest. This can potentially inhibit the actual intent of the process, which is to objectively verify and ensure the quality and performance of the

systems installed, the process of installation and building system integration.

While keeping commissioning under a contractor or designer may appear to lead to small savings in the short term, the long-term impact of maintaining or even having to re-install failed systems can negatively impact the project and increase its operational risks. This could lead to higher future energy and O&M costs, repair/equipment failure expenses, a decrease in occupant (tenant) comfort, and lower asset values.

With their expertise, objectivity and independence, qualified Commissioning Authorities can also aid in streamlining installation and maintenance processes. While commissioning does require an up-front investment, the savings gained in the long-term through reduced energy bills and lower maintenance have been significantly shown to cover these costs within a reasonable time frame, especially when implemented early and applied to the whole building. Moreover, almost half of commissioning costs – and sometimes all the costs – may be eliminated immediately through significant non-energy related, first-cost MEP equipment savings that are highlighted and quickly acted upon during the design review and construction stages.

This analysis highly recommends that owners implement forward thinking strategies early on in their projects. The first step often involves investing in a suitably qualified, independent CxA to carry out impartial design reviews relating to high-performance building operations, occupant satisfaction, reduced maintenance costs, and all the other benefits that come with qualified, independent commissioning.

Finally, the author of the most extensive study to-date on Cx benefits by the Lawrence Berkeley National Laboratory³ states that, due to various reasons, commissioning is underutilized. It concludes that results prove Cx to be “the single-most cost-effective strategy for reducing energy, costs, and greenhouse gas emissions in buildings today.”

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