

# PRIME

For the future

## PRIME Discussion Paper

### Regulating Building Commissioning

Developed for

Australian Building Code Board, Building Code Committee members by:

**PRIME**

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**AIRAH-led PRIME priority project**



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## Executive summary

This discussion paper has been prepared by the PRIME Working Group on Building Commissioning.

It has long been recognised by industry and government that building commissioning is often not carried out well in Australia and one of the impediments to improved building performance is a lack of consistency and rigor in the approach to the commissioning of new and refurbished buildings.

This discussion paper explores the benefits and options for introducing specific mandatory requirements for building commissioning into Australian Building Regulations and offers two alternatives for how this could be achieved.

The paper outlines what comprises building commissioning by defining five 'levels' of commissioning activity and explaining how these relate to the current requirements of NCC 2016. The paper also provides an overview of what a mandatory outcomes-focused commissioning process could comprise of, in terms of both process and documentation.

The potential benefits of adopting a mandatory performance-focused commissioning process for all buildings are explored, including the primary cost savings and energy productivity benefits that would arise and also the related co-benefits.

The paper concludes with an outline of two options for introducing mandatory harmonised clearly-defined building commissioning requirements into Australian Building Regulations.

**Option 1** is to introduce requirements directly into the NCC Volume One 2019; or

**Option 2** is to produce a stand-alone Commissioning Technical Specification that could be referenced directly within State and Territory Building Regulations.

Following extensive consultation with industry stakeholders PRIME recommend that governments agree to either Option 1 or Option 2 as outlined in the attached discussion paper, to progress building commissioning.

It is recommended that BCC members collaborate with ABCB, PRIME and other industry stakeholders to develop the final requirements so that building commissioning (as outlined in this discussion paper) can be referred to, in mandatory terms, by Australian building regulations.

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## About PRIME

PRIME is an initiative developed by a coalition of stakeholders from within the Australian heating, ventilation, air conditioning, and refrigeration (HVAC&R) industry. PRIME stands for the five pathways to transition: Professionalism, Regulation, Information, Measurement, and Emission abatement. PRIME is working to provide whole-of-industry pathways to a low-emissions future with a vision to have an Australian HVAC&R industry that is highly skilled and professional, safe, cost-effective and environmentally effective.

The PRIME project ***Whole-building Commissioning for NCC Volume One 2019*** aims to develop technical materials to facilitate the inclusion, within the National Construction Code Volume One 2019, of a formalised building commissioning process to ensure that a building and its building services have been delivered in accordance with the regulatory requirements and the design intent.

This project aims to formalise existing requirements for commissioning within the National Construction Code complimented by a minimum level specification defining a deemed-to-satisfy process that can be followed.

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## Discussing Building Commissioning

### Background

The climate control industry backed “Commissioning4NCC2019” PRIME project aims to develop technical materials to facilitate the inclusion, within the National Construction Code Volume One 2019, of a formalised building commissioning process to ensure that a building and its building services have been delivered in accordance with the regulatory requirements and the design intent.

The project aims to formalise existing requirements for commissioning within the National Construction Code complimented by a minimum level specification defining a deemed-to-satisfy process that can be followed to demonstrate compliance with the requirement.

Discussions with building regulators, and the state and territory agencies responsible for the administration of those regulations, have highlighted potential administrative issues that may come with including requirements for building commissioning directly into the NCC. These issues include:

- Potential clashes with existing State and Territory regulations that currently require inspection and testing of some services (typically essential safety measures from NCC);
- Elements of commissioning being outside the scope of the intergovernmental agreement that governs the scope of the NCC and the remit of the ABCB; and
- Elements of the building commissioning process that are outside the typical areas of responsibility of building certifiers and building certification regulations/systems, because they occur either prior to the installation stage or after the certification stage (i.e. after occupancy).

While building commissioning is a highly technical activity there are also non-technical administrative processes involved within it, and it is not clear to regulators if these non-technical requirements can be included in the NCC.

PRIME has agreed to provide building regulators and the state and territory building administrators with two documented options for introducing a harmonised regulatory building commissioning requirement. These options comprise a simple deemed-to-satisfy specification of building commissioning, for inclusion into the body of the NCC, or a standalone Technical Specification or Standard on building commissioning that can be referred to by individual state and territory building regulations. This discussion paper outlines these two options.

## Introduction

This discussion paper introduces two options for specifying and harmonising the regulatory requirements for building and system commissioning in Australia.

The paper provides a high-level overview of what building commissioning actually means, what the process entails and outlines 5 distinct levels of commissioning intervention. The paper also outlines what the current requirements for commissioning within NCC Volume One 2016 are, and relates these to the levels proposed. The paper addresses the costs and benefits of commissioning and quantifies the potential energy savings that could be achieved from improved commissioning practices in Australia.

The paper introduces two alternative mechanisms that could be used to document a harmonised regulatory minimum approach to the delivery of building commissioning:

1. A commissioning *performance requirement* and a *deemed-to-satisfy Commissioning Specification* for inclusion directly into the NCC Volume One 2019; or
2. A *Commissioning Technical Specification* that could be developed as a stand-alone document or standard and be suitable for direct reference within State and Territory building regulations.

It should be noted that neither of these alternative proposals represents a stringency increase in the performance requirements of the NCC per se. Systems and buildings would not be required to be designed to meet a higher performance standard as a result of this proposal. Rather, the proposals represent an increase in the detail required of industry practitioners and the guidance available to them. The proposal does represent change however - a change to the way commissioning activities are managed and recorded. This change will need to be managed by the building supply chain.

Note: The technical proposals in each alternative option are provided for illustrative and explanatory purposes and would need to be reviewed by industry and government prior to finalisation. PRIME is keen to work with all stakeholders to achieve a consensus on the technical content and format.

## The Focus of Building Commissioning

Building commissioning focuses on the entire building and takes into consideration the interrelated nature and impact of building systems and services on each other. As such, building commissioning ensures that the entire building as an entity (i.e. the building envelope, HVAC, lighting, electrical, controls, plumbing, fire systems and any related systems) functions safely, reliably, as required by regulation and most importantly functions optimally, as designed or as operated.

Building commissioning removes many of the uncertainties from the delivery of construction projects, typically at a low cost. It enables analytical and statistical tools to be applied to systems during inspection and testing, it helps to transfer knowledge from the design and construction phase to those tasked with the operational building and it enables a platform for continuous improvement and building tuning.

## Commissioning Process

Building commissioning refers to a number of activities that occur at different points in a building's life cycle (i.e. from construction to operation). It can be a defined scope of work within a building contract, but commonly is often not. The commissioning process incorporates design and construction reviews, static pre-commissioning activities, setting to work, balancing and adjustment, performance testing, demonstration and issuing of a detailed report upon completion. The following are the fundamental steps in the process:

- The building owners' requirements are documented;
- The designer's system performance intent is documented;
- The commissioning process is planned and specified;
- The commissioning process is implemented as planned;
- The building installations are verified;
- Adjustments are made where system performance issues are identified;
- The related building systems and the overall building performance is verified;
- The entire process is documented and reported.

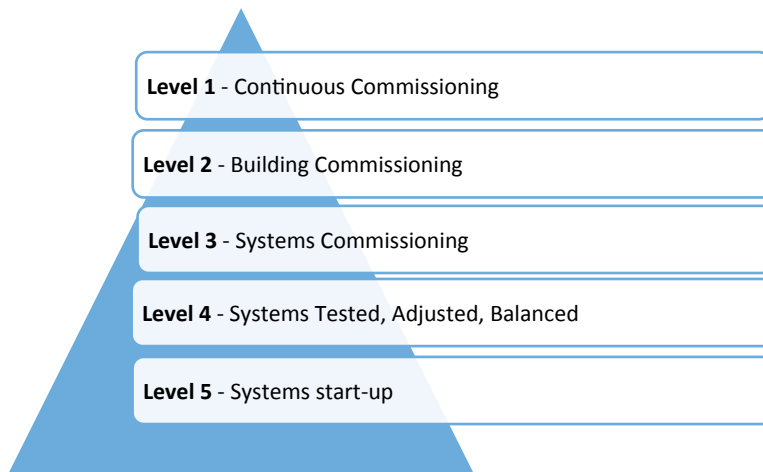
There are differences in the definition of commissioning for new construction and for refurbished existing buildings, but essentially the process remains the same. Define the *required performance*, plan and implement commissioning throughout the design and installation process, verify and document the results and actual outcomes.

Note: AIRAH Application Manual DA27 *Building Commissioning* and the CIBSE Australian/New Zealand version of *Soft Landings* have documented Australian industry-endorsed building commissioning and tuning guidelines. Green Star tools and NABERS commitment agreements also encourage and recognise commissioning, handover and tuning initiatives that ensure all building services operate to their full potential and as designed. Australian Standards often include testing and validation requirements for particular systems. International Industry Guidelines from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Chartered Institute of Building Services engineers (CIBSE), National Environmental Balancing Bureau (NEBB), Building Commissioning Association (BCA) and the like provide a range of Standards and Guides that detail technical approaches to system and building commissioning.

All of these commissioning guidelines and standards follow these fundamental steps and any commissioning process that complies with them would exceed the minimum requirements of this regulatory proposal.

## Commissioning Levels

The practice of commissioning can be considered at five (5) different Levels depending on the depth and integration of commissioning activity or interventions, see Figure 1. The depth of commissioning activities undertaken in a project can vary from the simple to the complex depending on the outcome required.



- Level 1**      **Continuous commissioning** – Building ongoing performance is optimised through measuring and monitoring, building tuning, diagnostics and maintenance.
- Level 2:**    **Building commissioning** – Building is safety verified, systems are integrated and performance is optimised.
- Level 3:**    **Systems commissioning** - Systems are optimised for performance but not integrated.
- Level 4:**    **Systems tested, adjusted and balanced (TAB)** – Systems are operational and controlled to meet a defined performance, but not optimised or integrated.
- Level 5:**    **Systems start up** – Systems are functional and safe but not performance tested.

**Figure 1 Levels of Commissioning**

## Current and Proposed Commissioning Levels

Currently compliance with the **NCC Volume One 2016** requires a Level 3 commissioning (Systems Commissioning) process for many building systems. These systems must be tested and verified to ensure that they meet the minimum performance requirements (or deemed to satisfy requirements) of the NCC. The NCC also *implies* a Level 2 commissioning process (Building Commissioning) in terms of testing, integration and verification, at least for essential safety systems, building services air and water handling systems, and other energy consuming systems which are addressed by NCC Section J, e.g. lighting, controls.

The proposed Option 1 - **NCC Specification for Building Commissioning** requires Level 2 commissioning, i.e. the building is safety-verified, systems are integrated and performance is verified to meet the designer’s intention, which includes meeting the relevant regulated requirements of the NCC.



This proposed Option 2 - **Building Commissioning Technical Specification** defines a Level 2 grade of commissioning and also provides a pathway for the application of Level 1 continuous commissioning. The building is safety-verified, systems are integrated and performance verified, documentation and training has been delivered and the operational performance of the building has been benchmarked and can be monitored. This option also includes some guidelines on the minimum competencies of commissioning personnel.

Building commissioning requires activities to be scheduled across design, construction and up to and past building certification and handover stages, and will likely require expertise beyond any single individual. The overall commissioning process should however be managed by a single entity referred to as the Commissioning Manager.

## Core Elements of Commissioning Management

It is important that the commissioning process is managed by a person or entity with authority, referred to as the Commissioning Manager.

The role of the Commissioning Manager is generally to review designer and contractor reports and witness samples from TAB (Testing, Adjusting, and Balancing) results for all systems, and verify completion of the building and its systems in a documented and planned commissioning process.

The Commissioning Manager is involved with the following commissioning activities:

- Planning, specifying and documenting building commissioning;
- Design stage review;
- Installation stage review;
- Test, adjust, and balance systems;
- Optimise systems;
- Verify documented requirements and design intent are achieved;
- Report and document final results;
- Training and tuning;
- Ongoing optimisation and management, where applicable.

To help discover and correct poor or inappropriate design choices early in the building construction process it is essential to conduct 'commissionability' reviews at the design stage.

Commissioning in isolation can be counterproductive and an important element of managing the commissioning process is the need for good communication and collaboration between all disciplines, agents, supervisor and manager level personnel who contribute to design, construction and operational phase of new buildings and major refurbishments.

## Costs and Benefits of Commissioning

Refer to Appendix A for a full discussion on the benefits, costs, drivers, risks and barriers for Building Commissioning.

### Commissioning Imperatives

Recognition of the benefits and importance of a whole-building commissioning process and focus has been increasing in the construction sector and is standard practice for many contemporary high-value building projects.

- Australian industry guides like the AIRAH Application Manual DA27 *Building Commissioning* and the CIBSE Australian/New Zealand version of *Soft Landings* have documented Australian industry-endorsed building commissioning and tuning guidelines.
- Green Star tools generally have a commissioning and tuning credit to encourage and recognise commissioning, handover and tuning initiatives that ensure all building services operate to their full potential and as designed.
- Australian Standards often include testing and validation requirements for particular systems.
- International Industry Guidelines such as ASHRAE, CIBSE, NEBB, BCA and the like, provide a range of Standards and Guides that detail technical approaches to system and building commissioning.

### Regulatory Imperative

All of the commissioning guidelines and standards referred above follow the required commissioning core elements and any commissioning process that complies with them would exceed the minimum requirements of this regulatory proposal.

The missing link is a regulatory imperative to integrate commissioning into the building delivery process for all buildings. *Commissioning is not an optional quality assurance step but rather an essential integration verification step, to ensure compliance with the regulated requirements and to help the building and its systems perform as best as they are able to.*

Building regulations are an important policy instrument available to governments wishing to improve building energy efficiency and performance and there are several examples of (international) jurisdictions that have implemented mandatory commissioning, including the United Kingdom and California (Lord et al, 2016). The crucial elements to support better commissioned buildings were identified as: outputs-focused regulation (not input based); regulation and process clarity; commissioning agents and building official training; as well as acknowledging the financial burden of upholding more complex building regulations.

Without a clear and well defined regulatory imperative for building commissioning building designers, installers and certifiers tend to accept that the commissioning process has been completed without verifying the validation protocols used or any further interrogation of building

or system performance. Currently building certifiers across all jurisdictions accept very lightweight and at times almost informal documentation as evidence of compliance.

Refer to Appendix A for additional details on the market failures that occur in building commissioning.

## Benefits of a Regulatory Approach

Including a specific commissioning requirement and defined minimum process within Australian Building Regulations should help to improve NCC compliance and simplify NCC compliance verification. The benefits of having a formal protocol to define and help certify commissioning processes within the building regulatory system include:

- An improved building verification framework that would be available to meet industry and individual building administration jurisdictions' compliance requirements;
- Verified baseline data for essential safety systems as well as mechanical, hydraulic, electrical and control systems;
- Improved performance of buildings and their services, as more buildings begin to fully meet their design intent;
- Reduced energy and water use from the building sector, with benefits increasing over time as building stock modernises;
- Cost savings that flow through the construction process as commissioning practices become standardised, including less re-work, compliance rectification and fault correction due to increased integration of design and construction.
- Reduced ongoing costs for the lifecycle of the building systems including reduced utility costs, reduced maintenance needs and increased equipment life.

Refer to Appendix A for a discussion of the co-benefits of building commissioning.

## Evidence of the Benefit

There is a vast amount of evidence in Australia and worldwide that shows a positive nett benefit for building commissioning.

There are a range of papers and reports that cite inadequate or incomplete commissioning as a major reason why buildings fail to meet their anticipated energy-use targets in practice.

In the Mills North American building commissioning meta-analysis report, the commissioning projects for which data are available revealed over 10,000 energy-related problems. Correcting these problems resulted in, on average, 13 per cent whole-building energy savings in new construction and 16 per cent savings in existing buildings. Projects with a comprehensive approach to commissioning (Level 1 or 2 commissioning standard) attained nearly twice the overall average level of savings and five-times the savings of the least-thorough projects (with a lower Level 4 or 5 commissioning standard), (Mills, 2009).

A commissioning requirement and minimum deemed-to-satisfy (DtS) process will provide a more level playing field in the construction industry and help to create an environment and culture

where commissioning is seen as an essential part of the building construction and regulatory compliance regime.

### Compliance benefits

Commissioning provides a whole-of-building verification pathway and as such the formalisation of a commissioning framework should also facilitate improvements in the overall building regulatory compliance framework, for both Performance Solutions and Deemed-to-Satisfy Solutions.

Standardised whole building commissioning approaches can improve compliance and verification for regulatory aspects such as:

- The essential safety systems of the building;
- Building performance requirements (project design requirements);
- Building energy and water use; and
- Specific verification requirements of system/product standards referenced in regulation.

This process will tie all of the various regulatory inspection and test requirements into an integrated whole building commissioning approach.

Once a commissioning process has been followed and verified for a building project, the failures that tend to occur with current existing self-certification of systems are likely to be significantly reduced. Testing and verification are documented and are available for compliance certification.

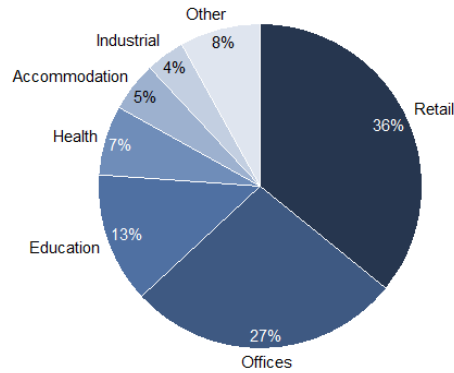
Providing a national industry-agreed harmonised building commissioning framework within Australian building regulations would potentially allow individual state and territory administrations to remove existing state-based regulations that detail required verification tests, reducing red tape.

### Magnitude of Potential Benefits from Building Commissioning

It has been shown that the correct application of a building commissioning process can improve the performance of a newly constructed building by as much as 25 per cent, with an across-the-board average of 13 per cent improvement, i.e. an average 13 per cent reduction in energy use, (Mills, 2009).

In 2013, total emissions from the commercial and residential building sub-sectors accounted for 127 MtCO<sub>2e</sub>, or nearly one quarter of Australia's national Greenhouse Gas emissions, (DSEWPaC, 2013). Grid-supplied electricity consumption by buildings was responsible for 86 per cent of the sector's emissions, (ASBEC, 2016).

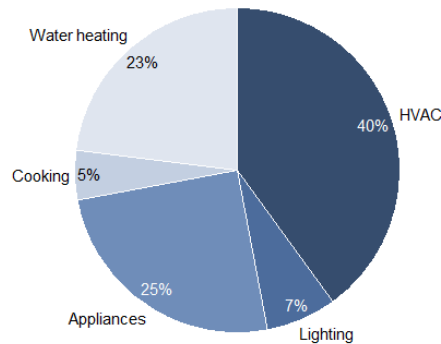
Within the existing commercial building stock, the retail sub-sector accounted for approximately 36 per cent of energy consumed in 2012. Stand-alone office buildings were the next highest energy user, consuming approximately 26 per cent of commercial energy use, with education contributing 13 per cent and health facilities consuming 7 per cent, see Figure 2, (ASBEC, 2016).



**Figure 2 Breakdown of commercial building energy use by building type, 2012 (percentage of total energy consumption, PJ)**

Commercial and residential buildings have different energy use profiles. Most energy in commercial buildings is consumed by HVAC and lighting systems (see Figure 3) although energy use is highly variable across the sector depending on the specific building classification and use.

On average 70 per cent of the energy used within a typical commercial building is consumed by HVAC, lighting and water heating systems (i.e. the building services). Often the HVAC energy consumed contributes to the peak demand energy – which is more expensive, presents more of an issue in meeting demand and tends to require higher infrastructure investment.



**Figure 3: Breakdown of energy by end use in a typical commercial building (percentage of total energy consumption) (Source ASBEC 2016)**

In 2013 the energy consumed by commercial buildings reached around 270 PJ of grid-supplied electricity.

If the application of whole building commissioning can drive energy efficiency savings of 13 per cent on average (of the energy consumed by building services), as evidenced by the Mills study, then total savings could be in the order of magnitude of 25 PJ of electricity per year as the Australian building stock modernises, just from improved operation of buildings due to the correction of design and construction errors and the integration and optimisation of systems during the delivery phase.

While market leaders in the property sector such as Green Star and NABERS rated buildings and premium grade office blocks have achieved substantial improvements in energy performance, the main challenge for policy makers is to extend this progress across the property sector as a whole. Over the past decade the energy intensity of Australian buildings has improved by only 2 per cent across the commercial sector and by 5 per cent across the residential sector. Accelerating actions to address energy intensity across the entire property sector will require strong government policy support to overcome the persistent barriers and impediments to energy efficiency.

Commissioning failures (including compliance failures) is one of these persistent barriers to buildings reaching their full energy productivity potential. Following an appropriate commissioning methodology will highlight the failures that would otherwise become legacy issues for the full building lifecycle. Prevention, discovery and correction of these issues is the core of the commissioning process.

## Existing buildings

This proposal relates to the introduction of a mandatory and explicit commissioning process requirement into building regulations to address new buildings. If such a requirement could be developed and applied to existing buildings the savings could be an order of magnitude greater and building related energy/emissions reductions achieved significantly faster.

Existing building tuning and recommissioning programs are becoming more common, and some jurisdictions in the USA have mandated existing building tuning of large commercial buildings through government regulation, (City of Seattle, 2016).

The application of the NCC to existing buildings varies across jurisdictions but the technical specification outlined in Option 2 could be developed to also address existing buildings and refurbishments. Sustainability Victoria found an average saving of 29% energy reductions in their Energy Efficiency Office Buildings study through building tuning.

## Option 1 - Commissioning Performance requirement and DtS specification within the NCC

The following text would be introduced into NCC Volume One 2019 -

### Commissioning Requirement (new clause NCC Part A2 - A2.6)

#### A2.6 Building Commissioning

The building and its systems and equipment must be commissioned to ensure that the installation meets the design intent of the systems and to validate their *required performance*.

#### New Definition (insert into NCC A1.1)

Building Commissioning - is a comprehensive process for the planning, delivery, and verification of buildings and their systems, that ensures a building and its systems meet their design intent and their *required performance*.

Required performance – is the *performance* level that the element, component, system or building has to meet (as *required* by the NCC) as specified by the building designers and documented in the commissioning plan.

### Commissioning Specification (new specification NCC Part A2 -Specification A2.6)

#### Specification A2.6 COMMISSIONING A BUILDING AND ITS SYSTEMS

##### 1. Scope

This Specification describes a process for the commissioning of a building and its systems.

##### 2. Application

Commissioning of a building and its systems must be applied to the following classes of buildings:

- (a) Class 2 and 3 buildings and Class 4 parts of a building: and
- (b) Class 5, 6, 7, 8 and 9 buildings

##### 3. The commissioning process

- (a) The building and its systems must be commissioned to validate the *required performance*.
- (b) A commissioning manager must oversee the commissioning process.
- (c) The commissioning process must be documented in a formal building-specific commissioning plan.

*The commissioning plan documents the scope of the commissioning work and –*

- i. Specifies the components of the building fabric and the building systems that must be commissioned*
- ii. Specifies the standard to which the building component or system must be commissioned;*
- iii. Specifies the system design performance and quantify the minimum required performance capabilities that the system is designed to achieve;*
- iv. Specifies the testing and inspection protocols that must be used to demonstrate achievement of the required performance;*
- v. Specifies the systems integration testing that is required;*
- vi. Provides for a design and installation review process to ensure that the maintainability of the system meet the access requirements of A2.1.*
- vii. Provides for the recording and acceptance of commissioning test results;*
- viii. Provides a system to note any faults, defects, non-compliances picked up in the commissioning process and record evidence of their correction/compliance; and*
- ix. Provides for the development and submission of a final building commissioning report.*

The commissioning data provided in the plan should enable a performance assessment of the element, component, system or building to be made without the need for additional clarification.

(d) The following systems and building components list typical systems which, where installed, must be included in the commissioning plan –

- i. Passive fire protection systems – including fire dampers and fire stopping at penetrations;
- ii. Building glazing – required and specified thermal and sealing properties;
- iii. Building envelope – required and specified thermal and sealing properties (including air permeability rate and verification method);
- iv. Adjustable or motorised shading devices;
- v. Control systems – building controls, system controls and component controls;
- vi. Ventilation systems – supply and exhaust; natural and mechanical;
- vii. Mechanical systems – cooling towers, chillers, boilers, air conditioners, heat pumps, heaters, pumps; heat exchangers, pipework distribution networks and refrigeration systems;
- viii. Hydraulic systems – water storage, domestic hot water, plumbing, stormwater and drainage dual reticulation systems, recycled water/re-use systems;
- ix. Fire detection systems - fire and smoke detection and alarm;
- x. Emergency warning and evacuation;
- xi. Fire protection systems – sprinklers, hydrants and fire pumps, fire lifts;
- xii. Lighting systems – general lighting, emergency lighting and lighting controls;
- xiii. Electrical systems - Supply and distribution systems, electrical power generation, electrical storage systems;
- xiv. Metering systems – electrical, thermal, hydraulic (water and gas);



- xv. Building transport systems – lifts, escalators and moving walkways;
- xvi. Emergency power generation;
- xvii. Miscellaneous systems including:
  - Building security systems – CCTV;
  - Lightning protection;
  - Telecommunications;
  - Antenna and aerial systems;
  - Communication systems.

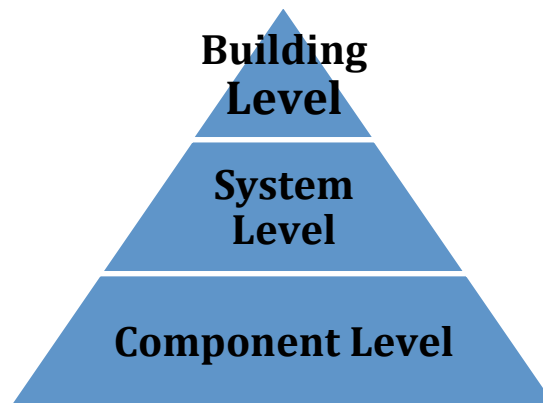
(f) The building component or systems must be commissioned in accordance with the requirements of the relevant standard, refer to Table 1.

**Table 1 Relevant DtS standards with commissioning or mandatory performance requirements**

System	Relevant Standard
<b>Air and Water handling systems</b>	AS/NZS 3666.1
<b>Mechanical ventilation systems HVAC</b>	AS 1668.2 AS 4254.1/.2
<b>Refrigerants</b>	AS/NZS ISO 817
<b>Refrigerant handling facilities</b>	A/NZ RHCop
<b>Refrigeration systems</b>	AS/NZS 5149.1/.2
<b>Fire Detection and Alarm</b>	AS 1670.1
<b>Fire and Smoke control systems HVAC</b>	AS/NZS 1668.1
<b>Fire and smoke dampers</b>	AS 1862
<b>Fire stopping penetrations</b>	AS 4072.1
<b>Automatic sprinkler systems</b>	AS 2118.1
<b>Fire hydrant installations</b>	AS 2419.1
<b>Electrical installations</b>	AS/NZS 3017
<b>Gas installations</b>	AS/NZS 5601
<b>Plumbing and drainage</b>	AS/NZS 3500
<b>Building Transport</b>	AS 1735
<b>Lighting systems</b>	AS 1680.1
<b>Emergency lighting</b>	AS 2293.1
<b>Emergency evacuation</b>	AS 1670.4

(e) The results of the commissioning tests must be recorded in the commissioning plan.

Commissioning tests include the component tests, system tests and whole building tests that are used to validate the *required performance*, see Figure 4. System and whole building tests may only be carried out after the building fabric/envelope is substantially constructed and sealed.



**Figure 4 Hierarchy of commissioning activities**

(f) The Commissioning Plan must also document:

- The As-installed drawings and design schematics for the final installation.
- The operation and maintenance manuals for the building systems and controls and any building user guides.
- The building information provided, including the recommended operator safety training, emergency start-up and shut-down procedures, and building tuning protocols for energy optimisation.
- A Final Building Commissioning Report.

(g) The Final Building Commissioning Report must include:

- The final results of the commissioning testing, recorded as baseline data for each system.
- Any outcomes from the commissioning testing or witnessing of testing that require further intervention to ensure the *required performance* is achieved.
- The extent of witnessing of the commissioning testing.
- An evaluation of the entire building performance including system design performance and minimum *required performance*.
- An issues and performance log, highlighting the issues discovered during the commissioning process and their resolution.

(j) Documented Information and Training manuals

The following information manuals must be documented and supplied:

- The As-installed drawings and design schematics for the final installation.
- Operating and Maintenance Manuals for the building addressing all systems.
- A building tuning manual or a building tuning plan.
- Training material for system operators.

## Option 2 – Commissioning Technical Specification

The following specification details the minimum building commissioning requirements that must be complied with.

This Standard was created to enable State or Territory authorities responsible for building regulation and administration to use it as the primary document of reference for building commissioning to be applied nationally.

This Standard is intended for use in the design, construction and use of all new buildings excluding Class 1 or Class 10 buildings.

### Commissioning Process

The building and its systems must be commissioned to validate the *required performance*.

An appropriately qualified or experienced Commissioning Manager must be engaged to oversee the commissioning process.

The specified commissioning process must be documented in a commissioning plan.

Commissioning must be implemented in accordance with the plan.

The commissioning implementation and results must be documented and reported.

### Commissioning Specification

The contractual documentation detailing commissioning must clearly indicate divisions of responsibilities, pre-commissioning procedures, commissioning requirements, witnessing requirements, phased completion requirements (if needed), post occupancy checks, and any training requirements for the operator.

The contractual tender or construction documentation must list the commissioning requirements for each system in the building including:

- The building elements, equipment and systems to be tested;
- The performance parameters for each system or element;
- The commissioning process and required documentation;
- The required commissioning activities - plan, review, test, verify, report;
- How each system performance parameter is intended to be verified; and
- The test methods, acceptance criteria and acceptable tolerances.

### Commissioning Plan

A commissioning plan shall be developed by the Commissioning Manager, and must include at least the following:

- The objectives, or basis, of the design;
- Scope of the commissioning including a list of building elements, equipment and systems performance characteristics to be verified;
- The commissioning process including design and installation reviews and integrated systems testing;
- A commissioning team list and the individual commissioning responsibilities matrix;
- The general sequence of commissioning;
- Proposed commissioning procedures;
- Witnessing requirements;
- Commissioning program schedule;
- The requirements for developing Operation and Maintenance information manuals; and
- The requirements for delivering Operation and Maintenance training.

*The commissioning scope of works sets out the systems to be commissioned and the commissioning tasks to be carried out. This includes tasks undertaken during the design phase, during the construction and installation phase, after the construction but prior to occupancy, and after occupancy. The commissioning scope of works allows the commissioning activities to be quantified, scheduled and programmed.*

*A commissioning responsibilities matrix is a matrix listing the commissioning activities and the commissioning team members and their roles in undertaking those activities.*

*The commissioning schedule is a detailed list of all major commissioning activities. The commissioning schedule program is created by providing start and end dates for each commissioning activity.*

## Systems to be Included within the Commissioning Plan

Examples of systems, and building elements, that must be commissioned include:

- Essential Safety Measures such as fire and smoke detection and alarm, emergency warning, fire and smoke protection or control systems, and fire fighting systems and provisions.
- Mechanical building services systems such as HVAC and refrigeration systems (including mechanically operable systems such as blinds and actuated shading devices);
- Building Management and Control Systems (BMCS); System controllers; Plant controllers;
- Electrical systems (such as electrical generation, electrical supply, distribution systems, sensors, timers, security and alarm systems);
- Metering systems, including electrical, thermal and hydraulic (water and gas);
- Hydraulic systems (such as gas, mains and domestic hot water supply distribution systems, rainwater, greywater, blackwater, stormwater, recycling and re-use systems);
- Lighting controls;
- Building transport systems – Lifts, escalators and moving walks;

- Specialised systems (such as isolation rooms, fume cupboards, clean rooms, server rooms, data centres) and
- Any other system that will impact occupant safety or the energy or water consumption of the building. This can include the building fabric or elements of it such as glazing and shading, doors and lobbies and the like.

Note: Lifts and fire services may be subject to additional separate legislated requirements.

## System Information to be Documented

The following information must be documented in the Commissioning Plan for each system:

- A narrative description of the original design and control intent outlining the owner's performance requirements and the designer's specified performance parameters – such as system performance targets for energy consumption/efficiency, water consumption/efficiency, indoor air quality characteristics, thermal comfort indices, plant operational profiles, as well as building component and building fabric performance requirements;
- A description of the basic operations and maintenance requirements;
- A list of the main components (including controls), outlining their function, their operation and the importance of their efficient use;
- The target energy and water consumption for each system, and related to energy and water operational performance targets for the building;
- A description of how energy, water, and other system/building performance indicators are metered and monitored, including a meter diagram to illustrate how energy and water consumption targets are confirmed in operation.

## Implementation of Commissioning

The commissioning must be carried out in accordance with the requirements laid out in the commissioning specification and as detailed in the Commissioning Plan.

The person responsible for the commissioning of the nominated services must have specific and demonstrable knowledge of the types of systems to be commissioned.

Equipment used for measurement and testing must be suitable for the application and correctly calibrated.

Those engaged in witnessing of the various systems must have specific and demonstrable knowledge of the types of systems which have to be commissioned.

All commissioning activities and the results thereof must be documented and reported in a commissioning report.

## Design Review

A comprehensive services and maintainability review must be conducted during the design stage and prior to construction.

This review must be led by the head contractor or Commissioning Manager and include all parties involved in the building construction, i.e. subcontractors, owner representatives, management representatives, designers.

The review must assess the following aspects for all building systems:

- Commissionability;
- Controllability;
- Maintainability;
- Operability, including 'Fitness for Purpose'; and
- Safety.

Accessibility is a key issue that must be considered in the review. The services and maintainability review and its outcomes must be summarised in a 'Service and Maintainability Report'. This report must be provided and managed by the Commissioning Manager and must also be agreed by all parties and signed off by the Commissioning Manager.

## Installation Review

An installation review must be completed by the design reviewers, to ensure the agreed recommendations from the design review have been implemented and that changes during the installation have not changed the design intent or affected system *required performance*.

## Testing and witnessing

Commissioning testing and the witnessing of such test must be carried out as specified in the commissioning plan.

## Commissioning Report

The commissioning report must certify that the commissioning has been implemented as planned and specified. The report must be signed by the designer, the head or main contractor, the commissioning manager, and the project manager (or owner representative).

The final building commissioning report that must include:

- The final results of the commissioning testing, recorded as baseline data for each system.
- Any outcomes or recommendations from the commissioning and testing that require further intervention to ensure the *required performance* is achieved;
- The extent of witnessing of the commissioning and testing;

- Any outcomes from the witnessing of testing that require further intervention to ensure the *required performance* is achieved;
- An evaluation of the entire building performance including system design performance and minimum *required performance*;
- The baseline data for the building and its systems.

The commissioning report must be completed at the time of building certification and practical completion but may be updated to record ongoing building tuning activities.

## Operational Information and Training

Operating and maintenance manuals must be developed and supplied in accordance with the specified standards and guidelines (refer to Guidance).

A building tuning manual, or a building tuning plan, must be developed and supplied in accordance with the specified standards and guidelines (refer to Guidance).

Training must be delivered in accordance with the specified standards and guidelines (refer to Guidance).

## Competencies

A Commissioning Manager is a qualified independent commissioning professional (typically separate from the design team) who is often engaged directly by the client or building owner and reports directly to the owner (or the owner's representative). An independent commissioning agent (ICA), a commissioning expert, a building services engineer or a facilities manager qualified in commissioning could fulfil this role.

The company or person undertaking the role of Commissioning Manager on a project should meet at least one of the following minimum requirements:

- NEBB qualified Building Commissioning professional;
- CSA Grade 6 Commissioning Manager;
- Relevant engineering degree and a documented minimum of 5 years' experience with the testing and commissioning of similar type projects;
- A minimum of 10 years of documented experience with the installation and commissioning of similar building systems and projects;

The company or person undertaking any TAB works on a project should meet at least one of the following minimum requirements:

- NEBB qualified technician;
- CSA Grade 4 Commissioning Engineer;
- A minimum of 5 years documented experience of undertaking TAB or commissioning of similar systems.

## Referenced documents

City of Seattle, Office of Sustainability and Environment, Director's Rule 2016-01, Implementation of Building Tune-Up Requirement (City of Seattle, 2016)

Cold Hard Facts 2: *A study of the refrigeration and air conditioning industry in Australia*, Prepared for the Department of Sustainability, Environment, Water, Population and Communities, Peter Brodribb and Michael McCann, 2013 (DSEWPaC 2013)

Sue-Fay Lord, Sarah Noye, Jim Ure, Mike G. Tennant & David J. Fisk *Comparative review of building commissioning regulation: a quality perspective*, Building Research & Information, (Lord et al 2016)

LOW CARBON, HIGH PERFORMANCE: *How buildings can make a major contribution to Australia's emissions and productivity goals*, Prepared for the Australian Sustainable Built Environment Council, ClimateWorks, 2016 (ASBEC 2016)

*Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Prepared for California Energy Commission - Public Interest Energy Research (PIER) (Mills 2009)

## Industry commissioning guidelines

AIRAH DA 27 Building Commissioning (2010)

AIRAH DA 24 Water system balancing (2003)

AIRAH DA28 Building Management and Control systems (2010)

ASHRAE Standard 202 - Commissioning Process for Buildings and Systems (2013)

ASHRAE Guideline 0 - The Commissioning Process (2013)

ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process (2007)

ASHRAE Guideline 1.5 - The Commissioning Process for Smoke Control Systems (2012)

ASHRAE Standard 111 - Measurement, Testing, Adjusting and Balancing of Building HVAC Systems (2008)

CIBSE ANZ (2014) The Soft Landings Framework Australia and New Zealand - For better briefing, handover and building performance in-use

CIBSE (2003) Commissioning Code M: Commissioning management

CIBSE (2006) Commissioning Code A: Air Distribution Systems

CIBSE (2002) Commissioning Code B: Boilers

CIBSE (2001) Commissioning Code C: Automatic Controls

CIBSE (2003) Commissioning Code L: Lighting

CIBSE (2002) Commissioning Code R: Refrigerating Systems

CIBSE (2010) Commissioning Code W: Water Distribution Systems

NEBB (2014) Procedural Standards for Whole Building Systems Commissioning of new construction

NEBB (2015) Procedural Standards for Testing Adjusting and Balancing of Environmental Systems



## Appendix A- Benefits, costs, drivers, risks and barriers

**A1** Extract from AIRAH DA27 on the Benefits, costs, drivers, risks and barriers for Building Commissioning.

It is generally recognised that building and system commissioning is often not performed correctly or optimally. There are many reasons for this that are widely acknowledged in the building industry; including lack of time, lack of understanding, lack of empowerment.

### Extract from AIRAH DA27 Building commissioning (2010)

#### 2.4. Commissioning benefits and costs

##### 2.4.1. Benefits

Commissioning is essentially a quality assurance/quality control process and the net benefit of quality control in any activity is a well-established fact.

The most common benefits associated with building commissioning programs are related to cost savings, although many of the intangible benefits achieved by the process may be more important in the longer term. Much of the value achieved by commissioning comes from avoided costs which are difficult to accurately quantify. Some of the direct savings and benefits associated with commissioning include:

- Savings in construction costs and time due to better integrated designs and less project changes. Early reviews by the commissioning manager and commissioning team can highlight design deficiencies from a commissioning point of view, and enable corrections to be made before the installation commences, saving potential rework and loss of time during the commissioning process.
- Savings in operation due to more efficient systems operation, better documented systems, better system knowledge, and a better training basis for ongoing operation and maintenance programs.
- Extended life of plant and systems with reduced maintenance costs, fewer failures and improved reliability.
- Improved coordination between design, construction, and occupancy improves system integration, reduces the tendency to oversize systems, and helps to produce the best long-term solutions for problems that arise during construction.
- Reduced project delays due to improved coordination and integration and early detection and resolution of technical problems, reduces the potential for cost blowouts.

- Improved indoor air quality and comfort due to the integrated commissioning process. Ensuring systems are operating efficiently, correctly and meeting their operational requirements can lead to productivity improvements within the building. Employers, whether they are buildings owners or building tenants, are well aware of the significant cost benefits that can flow from even very small increases in employee productivity.
- Improved indoor air quality and comfort will also assist in retaining employees or retaining tenants in a building. The costs of churn associated with re-tenanting a building can be considerable and significantly impact on return on investment. Commissioning reduces these churn costs by providing better and more flexible buildings so that re-tenanting is less frequent and churn fitout costs are reduced when it does occur.
- Commissioning is also risk management and ensures that buildings and their systems meet legislated safety, duty of care and OH&S requirements, including fully functioning and compliant essential services systems. Commissioning reduces building compliance costs and may reduce insurance and reinsurance costs.

#### **2.4.2. Costs**

The costs of commissioning include the first costs of procuring and implementing commissioning during the project design and construction and the ongoing costs of building tuning or recommissioning programs. First costs will vary depending on the size and complexity of the project and estimates range from 0.5 per cent to 3.0 per cent of the total construction costs depending on a variety of factors.

In many cases, when considering all of the tangible and intangible costs and benefits, properly managed and integrated commissioning is cost neutral or even saves costs on the overall building project.

Who pays for commissioning? The reality is that correctly managed and implemented commissioning often pays for itself in savings in construction costs and ongoing operational costs as well as an increased asset value. Initial commissioning costs however, must be paid for by the developer.

#### **2.5. Drivers for commissioning**

Apart from traditional purposes of quality assurance (QA), test and verification, and system proving, there are several significant drivers at play for building commissioning.

##### **Economic**

Commissioning adds value to a building asset. Improving building performance reduces the consumption of utilities such as water, power, and fuel. It may reduce insurance premiums and increase rental returns. The useful service life of building systems is increased while maintenance costs are reduced.

## **Delivery**

Building owners want certainty that buildings will deliver on their comfort and performance requirements. Commissioned buildings are likely to have less occupant complaints and better tenant retention.

## **Safety**

A significant driver for the commissioning team is safety. A key responsibility of the team is to assure that all building fire and life safety systems (essential safety measures) operate in accordance with the specified requirements, relevant building legislation, and reference Australian Standards. Ensuring that all life safety interlocks work and that all systems are operating within their defined limits will greatly improve the safety of the building occupants.

## **Design**

Typically, many designers are not fully aware of the problems encountered during commissioning when it has not been taken into account in the design. Having this input at an early stage in the design process is essential to ensure all aspects of commissioning have been considered and if cost and time delays are to be avoided later in the project.

## **Energy efficiency**

Commissioning buildings and associated systems assists owners to meet their building energy efficiency requirements such as those derived from National Australian Built Environment Rating Scheme (NABERS), Commercial Building Disclosure (CBD) program, regulations associated with the National Strategy on Energy Efficiency (NSEE), or HVAC High Efficiency Systems Strategy (HESS).

## **Occupant comfort**

Optimising comfort conditions for occupants can increase productivity, improve tenant retention and reduce the HVAC hygiene problems and health risks which can potentially be posed by an uncommissioned building.

## **Sustainability**

Building commissioning is recognised as contributing to improved sustainability in Australia through the Green Star Rating System and green lease agreements. Similar rating schemes operated in other parts of the world such as LEED (USA), BREEAM (UK), Estidama (Middle East) and the like, also recognise and encourage building commissioning. Greener buildings assist with establishing a company's environmental credentials and can often attract a rental premium. Energy management and energy rating systems such as NABERS have also embraced commissioning, building tuning, recommissioning, and retrocommissioning as effective tools for the management and optimisation of building energy use.

## **Specification**

Owners and developers are requiring construction and project managers to incorporate contractual commissioning requirements into the building delivery process.

## **Risk mitigation**

Commissioning features highly in risk management considerations for building projects particularly in regards to contractual dispute resolution, insurance obligations and public and occupational health and safety issues. It also ensures all life safety systems have been set up and are operational in accordance with the design requirements to mitigate risk of loss of life or injury due to incorrect operation of the systems.

## **Incentives**

In order to unlock the benefits available from building tuning, recommissioning and retrocommissioning, incentives may be available from government agencies or energy retailers to implement programs with a view to improving performance and reducing a buildings energy use.

## **2.6. Risks of not commissioning**

The benefits and drivers of commissioning have been discussed but the converse, the risks involved with not commissioning a building, also need to be considered. All buildings need to work well, regardless of size and complexity, and unless they are commissioned, they are unlikely to realise their full potential.

- Poorly performing systems cost more to operate and maintain, have a shorter service life and hence must be replaced or upgraded more frequently.
- Poor air quality or comfort may lead to losses in productivity and in extreme cases the cost of rent abatement or litigation may also need to be absorbed by building owners and operators.
- Non-commissioned buildings are more likely to perform poorly and contain dysfunctional systems. Poorly integrated designs, badly documented systems, inappropriate controls, lack of system knowledge, missing equipment, systems that don't work and can never work all contribute to unacceptable building outcomes.
- Non-commissioned buildings are difficult to occupy, difficult to lease and difficult to sell, they are more expensive and less functional; they are potentially dangerous and can contain high levels of risk. Not commissioning a building is a risky approach to building ownership and occupancy.

## 2.7. Barriers to commissioning

Commissioning is beneficial, important and cost effective so what are the barriers to implementing successful commissioning?

### Project schedule

Lack of time is often cited as the biggest barrier to effective commissioning. If the commissioning program is compressed due to overruns elsewhere in the project, it is likely that shortcuts will be taken and commissioning will be less effective. Commissioning must be included in the building schedule, integrated with all stages of project delivery, and not sacrificed when the contract timeline becomes compressed.

A major barrier to commissioning is the cost benefit for the main contractor in reducing the overheads for continuing establishment costs by reducing the commissioning time, as it is the only thing left at the end of a project that will enable the main contractor to make a saving. It may be worthwhile on certain projects to consider imposing financial penalties for not proving system performance within the contract programme, along with financial incentives if this is improved. This would need to be clearly laid out within the terms of the agreed contract.

### Cost

The first costs associated with commissioning management activities are often viewed by owners, project managers and contractors as high. If the potential for ongoing cost savings, and intangible benefits associated with commissioning are not understood, commissioning may be viewed as an unnecessary project cost that can be value engineered out of projects. Commissioning activities must be fully budgeted by all parties to ensure that the potential cost savings and benefits can be realised.

### Savings

Although commissioning is designed to optimise systems and building performance, and to verify that the design intent is met, there are no guarantees of cost savings. High levels of savings and other benefits are common but cannot be guaranteed for every project. Quantifying avoided costs, potential savings, and the value of intangible benefits is often open to interpretation.

### Documentation

Commissioning is sometimes seen as an unnecessary additional level of documentation and test. If the benefits of the commissioning process are not fully understood, this additional level of quality assurance may be resisted or not fully embraced.

### Integration

Commissioning is sometimes tacked on to the end of a project without a real commitment from management and stakeholders. Commissioning cannot simply be added to a project

- it must be integrated into all aspects of the project delivery design, installation, and handover, including in the early pre-design or conceptual stages, for the full benefits of the process to be realised.

### **Management buy in**

If commissioning is not required and enforced, it is often not implemented adequately, particularly at the end of a project. Commissioning must be championed by the building owner who is the ultimate beneficiary of the improved outcomes, and by the commissioning manager who is responsible for the overall application and enforcement of the commissioning requirements.

## Appendix B Why commissioning programs fail

**B1** Extract from AIRAH DA27 on why commissioning programs fail.

### Extract from AIRAH DA27 Building commissioning (2010)

#### 2.16 Why commissioning programs fail

There are many reasons why commissioning programs fail. The following is a brief list of some of them and some suggested strategies to resolve them.

##### **Compression of the commissioning program**

The biggest problem is time, or the lack of it. Commissioning activities must be integrated into the overall building program, not simply added on or used to fill any opportunistic building schedule gaps. Commissioning managers need to provide constant feedback of the status of the commissioning program throughout the project life so that all parties are aware of the time limitations at each phase. Overruns in other project areas must not be allowed to compress the commissioning program.

It is essential that the owner, builder, project manager or project programmer ensures that enough time has been allocated to commissioning tasks within the project program, and that enough time remains at the end of the project for the commissioning to be carried out effectively. This may need to be contractually enforced.

##### **Communication breakdowns in the commissioning process**

Communication is an essential aspect of the commissioning process and poor communications can lead to a breakdown of that process. Team building skills, people skills and listening skills are all essential in commissioning management. Commissioning managers need to be reasonable, cooperative, proactive, technically competent, and organised for leadership. Communications and relationships need to have a positive focus. The commissioning plan needs to be detailed and agreed early so that commissioning expectations for all participants are clear.

##### **Conflict due to changes and associated financial implications**

Conflicts can arise due to a poorly defined scope, changing design strategies or inadequate consultation and liaison. Early design reviews, specification and installation reviews and an established non-conformance tracking and resolution system, all act to reduce changes or the impact of changes during the project. Well documented responsibilities within commissioning specifications should outline the boundaries for each participant in the process.

##### **Lack of owner enforcement**

The enabling of the entire project team to produce a better designed and built project comes from the legal power of the owner. Ultimately, it is the owner's contracts that allow the withholding of payments if all else fails. If the owner refuses to commit to commissioning to this

extent, and the team refuses to correct mistakes, no amount of issues identification will make things right.

### **Vested interests**

As project pressures build up there may be a vested interest in particular issues from certain team members or stakeholders. Maintaining independence in the commissioning delivery process is key to balancing any dispute that may arise due to a vested or conflict of interest.

### **Lack of training/skills**

Commissioning and system integration can be highly technical and skilled at times requiring high level numeracy and computer literacy skills. Commissioning outcomes will be positive only if competent people and appropriately qualified personnel are employed.

### **No regulatory requirement**

If commissioning is not mandatory it may be viewed as a non-essential item which may be reduced in time and budget in response to project timeline or cost pressures. Commissioning needs to be championed by the owner and fully integrated in terms of costs and time into the building delivery schedule.

### **Poor documentation and process**

Commissioning relies on well documented procedures and processes including reporting results and non-conformances. Key commissioning documentation should be started early and evolve with the project.

### **Multiple activities**

Another reason why commissioning activities may fail is the fact that multiple parties tend to be working in the building during the final commissioning phase. People opening and closing doors and windows, starting and stopping individual systems, changing controls and settings can all affect commissioning outcomes.

### **Poor design and installation**

Commissioning cannot compensate for poor design, lack of commissioning provisions within a design or inappropriate installation practices. It does, however, identify and expose these issues either at early stages of the design (if the commissioning manager is appointed at the right time), or as faults during system testing and assessment. Commencing commissioning activities in the early planning and design stages of a project can address design and installation issues more completely.

**End of Paper**