

BEYOND DESIGN: A BEST PRACTICE APPROACH TO BUILDING COMPLETION, COMMISSIONING AND OPERATION

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ABSTRACT

While there is currently a large shift towards environmentally sustainable design when constructing or renovating buildings, there is little attention paid to the actual performance of sustainable buildings once completed. This has led to a level of 'greenwash' with buildings being marketed as environmentally friendly with little or no guarantee as to their actual performance. This paper outlines a process by which tenants / lessees can not only design and build a building which meets the needs of both themselves and the environment, but can also put processes into place ensuring the building achieves set goals over time. The building procurement process is discussed along with guidelines for building commissioning and post occupancy management plans. Finally the potential and application of green leases is discussed.

KEYWORDS

Building commissioning; aftercare; continuous commissioning; green leases.

INTRODUCTION

This paper proposes a best practice approach to commissioning, completion and ongoing operation for environmentally sustainable government buildings. It is one thing to design sustainable buildings. It is another to obtain the predicted performance and benefits in practice without the follow-up that a best practice approach should provide.

For example, a 1994 US study of 60 commercial buildings found that:

- more than 50% had control problems
- 33% had sensors that were not operating properly
- 25% had energy management control systems, economisers and/or variable speed drives that did not run properly
- 40% had problems with heating, ventilation and air-conditioning equipment
- 15% were missing specified equipment.

A more recent US study of the commissioning of 224 buildings for a variety of locations and building types found an average of 28 significant deficiencies in new buildings, and an average of 11 significant deficiencies in existing buildings (Mills et al, 2004).

Although similar studies have not been carried out in New Zealand, there is no reason to expect that the situation here is any different, and if anything it could be worse given the market constraints in terms of cost and time. These deficiencies often remain as latent defects in the building, which continue to affect a building's performance over its life.

Better commissioning is a way of improving the outcomes and performance of sustainable building projects. Commissioning is generally only associated with the normal testing, adjusting and balancing of Heating Ventilation and Air Conditioning (HVAC) systems. In reality it should encompass a much broader scope of activities and a more extensive range of services, including electrical, hydraulic, fire, security, communications and lifts.

The Chartered Institution of Building Services (CIBSE) defines commissioning as “the advancement of installations from the stage of static completion to full working order to specified requirements” (CIBSE, 2003). A fuller definition of a best practice approach to commissioning, as developed by participants in the first US National Conference on Building Commissioning (PECI, 2006), is as follows:

“Commissioning is a systematic process, beginning in the design phase, lasting at least one year after construction, and including the preparation of operating staff. It ensures thorough documented verification that all systems perform interactively according to the documented design intent and the owner’s operational needs.”

Sustainable buildings by their very nature require a high level of performance, and the New Zealand Green Building Council’s Green Star environmental rating scheme recognises the important part commissioning plays in achieving it. The management category of the new Green Star design tool allocates up to six points for commissioning-related features (NZGBC, 2007), which could represent nearly 10% of the required score for a four-star building and 7% for a five-star building. In the latest version of the Australian Green Star tool these weightings have been increased giving them even more importance. Furthermore the ‘in-use’ Green Star tool (yet to be released) will reward buildings for running efficiently after construction and is therefore likely to award points for a continuous commissioning process of some description.

The proposed changes to the New Zealand Building Code (NZBC) and compliance documents include a number of new requirements on the design of HVAC systems (DBH, 2006). Although there is no specific requirement relating to commissioning, there will need to be proof of compliance that HVAC systems as “specified systems” perform to the standard. Commissioning could be used to confirm that design features comply as installed. It should be remembered, however, that the NZBC represents minimum standards, and that in this document we are concerned with best practice.

Proper commissioning has traditionally had a low profile and priority in the construction industry. However the new trend towards sustainable buildings is likely to place greater importance on better commissioning practices by the construction industry.

THE CURRENT COMMISSIONING PROCESS IN NEW ZEALAND

As noted in the Introduction, there have been no specific studies of commissioning in New Zealand. However, a commissioning seminar organised by project managers Carson Group Ltd, in November 2004, highlighted the following issues with the current commissioning process.

The issues from a client’s perspective:

- Commissioning is under pressure at the end of a project and is often required to be compressed, and as a result is not done adequately.
- The commissioning timeframe, both during and after handover, is not usually well communicated.
- Timely issue of operation and maintenance (O&M) manuals is important to enable early familiarisation of systems and to identify potential defects during warranty periods.
- Adequate float is needed so that when problems are identified during commissioning there is sufficient time to resolve them correctly.
- Performance of the entire system may change as a result of local commissioning. The complete system may need to be checked and re-commissioned to maintain optimum plant performance and efficiencies.
- Consideration needs to be given to undertaking commissioning re-checks after occupation to determine if a system requires further adjustment or refinements (e.g. an increase in occupancy in an area may require additional cooling and air-flow rebalance).
- Comprehensive test reports must be recorded in operating manuals.

- It is important that the design intent and accurate and comprehensive test results are documented and recorded. These are the client's reference points if faults or problems arise.
- O&M manuals need to focus on the operation, design intent and description of systems. (Seminar participants noted a tendency to "bulk up" manuals with suppliers' "glossies".)
- The process of checking the accuracy of as-built drawings should be reviewed. Currently, clients must rely on the contractor to produce these.

The issues from a consultant's perspective:

- The builder's focus is on the static rather than dynamic status of services.
- Commissioning is often viewed as a luxury and fees have been spent, so time and input are restricted.
- A reduction in fee costs means a reduction in service, particularly in observation and site attendance.
- Often the design is not fully complete prior to construction due to design programme constraints, and this is difficult to resolve during construction.
- There is continual time pressure placed on the builder and subcontractor to achieve handover because of financial and contractual impacts triggered by practical completion. This is often mirrored by the developer, who is exposed to holding and financing costs prior to completion.
- Specification of zero defects improves commissioning expectations.
- You need a mix of building, systems and occupants to ensure commissioning is complete.
- Often the state of the base building is not suitable for commissioning to commence.
- More effort is needed in pre-commissioning activities (e.g. cleaning of pipe work, duct work).
- Controls commissioning is done badly. Full point-to-point checks need to be done. Typically, Building Management Systems (BMS) are only 80% commissioned, even at the end of the defects period.
- Budget pressures often mean design cut-backs and the removal of spare capacity / safety factors from the design.
- The quality and attitude of the builder's services co-ordinator can greatly affect the delivery and commissioning of the systems.
- There is often a lack of understanding by clients or users about the need for post-occupancy fine-tuning to be undertaken.
- In the UK it is common on large or complex projects to have a commissioning agent. Their role is to be proactive. They do a full design review prior to tender to ensure expectations match the documentation.

The issues from a contractor's perspective:

- Time creates the greatest pressure on most construction projects, and with commissioning coming at the end of the construction programme this is traditionally what gets squeezed.
- A tendering market tends to drive pricing down creating a 'you get what you pay for' environment from both a consultants and construction perspective.
- Typically, builders are not involved with post-occupancy commissioning activities.
- The sophistication of systems can complicate the commissioning process.

The issues from a commissioning subcontractor's perspective:

- The biggest issue is the builder. Often not enough time or consideration is allowed for commissioning activities as part of the construction programme. It is at the end of the construction period and is usually under pressure.
- There is only very rarely a commissioning programme interfaced with the construction programme. The builder is mainly focused on the static completion of building services.
- There is more focus on achieving handover (practical completion) than commissioning because of the financial and contractual implications triggered by practical completion.

- The consultants need to be heavily involved in the commissioning activities because they know the parameters of the design and the tolerances available.
- Poor installation is often only picked up during commissioning, which then creates further time pressure to get the faults rectified and re-commissioning completed.
- If zero defects completion and point-to-point BMS testing are specified, then they should be insisted upon because they are seldom implemented in practice, due to the onerous implications if practical completion is not given.
- Rightly or wrongly, clients view commissioning management and the role of a commissioning agent as being part of a consultant's normal duties and are reluctant to pay twice for what is perceived to be a double-up activity.

A BEST PRACTICE APPROACH TO COMMISSIONING

A best practice commissioning approach starts towards the end of the design phase, continues through the construction and handover phases, and is initially completed at the end of the first year of occupation or defects liability period. Ideally it should continue over the life of the building. A best practice commissioning approach integrates and enhances the traditionally separate functions of:

- design peer review and recording of design intent
- management of the commissioning process by a commissioning agent
- testing and commissioning verification by a commissioning agent
- O&M documentation, including a user guide
- staff training
- facilities and environmental management.

This section looks at the part commissioning plays in the four main commissioning phases – design, construction, warranty and post-warranty. It then covers the extent of the commissioning.

Design Phase

The developer or building owner should appoint a commissioning agent during the design stage to oversee the commissioning process. Early selection during the design phase allows the commissioning agent to play an advisory and review role.

The designer should provide a detailed design intent for the building in addition to the normal drawings and specifications. This can then be communicated consistently to the commissioning agent, construction team and building operators. The design should be reviewed for its ability to be commissioned, operated and maintained. This review would normally be carried out by the commissioning agent and, if available, by the facilities management staff.

Construction Phase

During this phase the commissioning agent should provide a commissioning plan and programme. They should also visit the construction site periodically and note any conditions that might affect system performance or operation.

The testing and commissioning process should be carried out by the installing subcontractors to accepted codes (i.e. CIBSE, BSRIA and ASHRAE) and should verify the proper operation of equipment and systems according to the design intent, design drawings and specifications. Point-to-point or end-to-end testing of the BMS is highly recommended. If corrective measures are required, the commissioning agent should make sure they meet the design intent. Acceptable performance is reached when equipment or systems meet specified design parameters under full-load and part-load conditions during all modes of operation, as outlined in the commissioning plan.

A high standard of verification, completion, clearance of defects and documentation should be achieved prior to granting handover. After completing pre-handover commissioning, the commissioning agent should write a handover commissioning report, which includes all commissioning documentation, and submit it for review by the building owner and designers. Prior to handover, building operators should be trained in the operation and maintenance of equipment and systems. The commissioning agent should oversee the training sessions provided by the installing contractors, designers and manufacturers' representatives.

The commissioning agent also verifies that operation and maintenance manuals include a user guide and are complete and available for use during the training sessions.

First-Year Operational or Warranty Phase

Even though the project is considered complete, some fine-tuning commissioning tasks should continue throughout the typical one-year defects/warranty period. The commissioning agent should initially return on a monthly basis for the first three months, and then quarterly through the defects/warranty period to review system operation and liaise with facility staff to address any performance problems. It is also helpful after six months to carry out a post-occupancy evaluation survey of the building's occupants to identify any issues with the building, and this can inform the need for any further fine-tuning.

A monthly log of energy and water consumption should be kept and reconciled with the agreed performance targets. Any non-performance problems should be addressed as part of the system's fine-tuning and operational practices. An environmental management plan (EMP) should be set up at the start of this period.

Post-Warranty Phase/Continuous Commissioning

It is a good idea for the building owner to consider re-commissioning their facilities periodically to ensure that equipment performance levels continue to meet design intent. This means that in order to maintain a high level of performance, in a sense commissioning never ends. Operation and management staff should be encouraged to audit and partially re-commission selected building systems on a regular basis, perhaps every three years depending on building usage, changes to layout equipment complexity and operating experience.

Extent of Commissioning and Facilities Management Provisions

The extent of the commissioning process will obviously vary depending on the size and complexity of the project and the ownership structure. In all cases the services design should be peer reviewed and the design intent recorded, along with the provision of O&M manuals, user guides and staff training. As building size increases (e.g. greater than 7,500m²) an independent commissioning agent should be employed as opposed to using a commissioning agent from the designing engineers. With a further increase in building size (e.g. greater than 10,000m²) come the resources to operate an in-house facilities and energy management team charged with ensuring the building is running smoothly and undertaking continuous commissioning procedures.

COMMISSIONING RESOURCES

The commissioning process is a team effort involving all the traditional stakeholders in the construction process, plus a commissioning agent with the specialised knowledge and experience to help plan and direct the commissioning activities. The role of the commissioning agent could be provided by either the building services engineer, the contractor, or an independent company. Each option has its advantages and disadvantages, and these are covered below. The final decision will depend on the scale and complexity of a particular project.

Independent commissioning agent

An independent company under contract to the developer/building owner can play an objective role and ensure that the developer/building owner gets the building performance they expect. For large and/or complex projects, especially buildings with highly integrated and sophisticated systems, future savings from commissioning often outweigh the slightly higher costs of an additional contract for an independent commissioning agent.

Independent third-party commissioning providers also bring a fresh perspective to the project because they collaborate with the design team. By joining the project team during the design phase, the commissioning agent can suggest improvements and savings at the stage when changes can be made on paper rather than by costly on-site changes. This arrangement is required by Green Star NZ design tool for one point.

Design engineer

A separate engineer from the building services consultants could be asked to take on the commissioning agent's role. This option has some advantages because the engineering consultants are already familiar with the project requirements and don't need to spend time getting up to speed. Managing the commissioning is not normally included in a design professional's basic fees, so the developer/building owner must pay the designer extra for this additional role. To manage the potential conflict of interest created by having the commissioning services managed by the building services consultants, all findings of the commissioning process should be directly reported to the developer/building owner. This arrangement is not recognised by the Green Star NZ design tool.

Builder's services co-ordinator

Although builder's services co-ordinators may have the knowledge and capability to programme, plan and supervise installation activities, they may not be skilled in design-related or system-testing and commissioning matters. In addition, some contend that it is difficult for builder's representatives to objectively assess their own work, especially since repairing deficiencies found through commissioning may increase their costs and delay completion. This arrangement is not recognised by the Green Star NZ design tool.

THE BENEFITS AND COSTS OF BETTER COMMISSIONING

Benefits

The potential benefits of proper commissioning of a building include:

- improved quality assurance, documentation and co-ordination between design, construction and occupancy, leading to a better-quality product
- lower energy usage over the life of the building and greater potential for meeting energy targets, particularly for sustainable buildings
- lower water usage over the life of the building and greater potential for meeting water-use targets, particularly for sustainable buildings
- improved indoor air quality, and reduced noise and draughts, with consequent increases in occupant comfort and satisfaction
- reduced operation and maintenance problems and costs over the life of the building (studies indicate cost savings of 8–20%)
- fewer on-site variations and associated costs
- fewer complaints or call-backs to the building owner, contractors and design consultants
- improved tenant satisfaction for a leased building

- a mechanism for proving compliance with the proposed New Zealand Building Code Clause H1 amendments.

Costs

The cost of commissioning depends on a number of factors, including the building type, size and complexity, and whether it is a new building or an existing building. Typically, the cost of commissioning ranges from 0.5 to 1.0% of the total construction cost. For a new office building this might equate to \$9 to \$18/m². Better commissioning would be at the higher end of the scale. The cost of commissioning management is in the order of \$2 to \$3/m². The cost of re-commissioning an existing building is estimated at 25 to 30% of the cost of a new building, or \$2 to \$5/m².

The following section provides a more detailed economic analysis to present a value case for better commissioning.

THE VALUE CASE FOR BETTER COMMISSIONING

Using a \$10,000 m² air-conditioned office as an example, and making the following assumptions, a value case for better commissioning can be made.

ASSUMPTIONS

Capital cost assumptions

Commissioning agent’s cost	\$35,000
Additional point-to-point BMS testing	\$30,000
Additional design input into design intent and user guide	\$15,000
Additional design input into post-occupancy stage	\$15,000
Present value of re-commissioning at year 5	\$9,313
Present value of re-commissioning at year 10	\$5,783
Total	\$110,096

Operating and maintenance cost reduction assumptions

Annual operating and maintenance cost	\$270,000
Operating and maintenance cost saving (14% average)	\$37,800

Economic assumptions

Discount rate	10%
O&M inflation rate	3%

ECONOMIC ANALYSIS

Simple payback	15yr lease period NPV	IRR
2.9 years	\$236,273	33%

The 15-year net present value (NPV) is 2.1 times the initial capital cost premium and represents one of the best sustainable building investments that can be made. The above analysis ignores any potential savings due to reduced reworking/variations as a result of the design review and commissioning management process improvements.

GREEN OR PERFORMANCE-BASED LEASES

Until recently the development of 'green' buildings in New Zealand, particularly for commercial offices, has been ad hoc. Briefs were very vague, designs were unchallenged and a building’s performance has not been guaranteed in any shape or form. There has been an element of 'green wash'.

The new generation of 'green' commercial buildings for major government and corporate tenants overcome these shortcomings through the use of a 'green' or performance-based lease to clearly define lessor and lessee obligations in terms of meeting agreed environmental outcomes. A green or performance-based lease is similar in most respects to a standard lease for a conventional building, but also provides for the lessor and lessee to maintain and conform to the Environmentally Sustainable Design (ESD) aspects included in the building to minimise environmental impacts and to achieve agreed energy- and water-use outcomes, with associated reduced operating costs.

Green or performance-based leases are starting to be developed overseas for sustainable commercial buildings. Probably the most prominent Australasian example of this type of lease is that developed for the 60L building in Melbourne. The Australian Federal Government has also issued a Green Lease Schedule Template, and is intending to procure all new lease arrangements on this basis. Performance-based contracts have been used for some years in the energy contracting area, where companies take over the energy supply to a client's business and guarantee a minimum level of energy cost saving.

In New Zealand there is particular interest in these types of leases from government tenants due to the obligations of the Govt³ programme, which seeks to improve the environmental performance of government operations. These types of leases also support more collaborative property solutions by tending to favour long term lease/total occupancy cost arrangements between the lessor and lessee rather than traditional short-term leases with net rentals and recoverable operating expenses.

KEY FEATURES OF GREEN OR PERFORMANCE-BASED LEASES

A green lease builds on the features of conventional leases but also includes commitments from both the building owner and the tenant. This type of lease will generally include a specific environmentally sustainable design (ESD) schedule, which is generally structured as follows:

- ESD outcomes
- ESD outcome assumptions
- ESD outcome calculation
- Lessor obligations relating to the ESD outcomes
- Lessee obligations relating to the ESD outcomes
- Co-operation required
- Dispute resolution.

Environmentally sustainable design outcomes

Setting measurable targets that can be transformed into achievable outcomes for environmental performance is extremely important to enable the lessor and lessee to measure their own and each other's performances. For example, the lease could specify the achievement of a certain environmental rating score and/or specific energy, water and waste outcomes over the life of the lease for both the lessor's base building and the lessee's fit-out. These should be evaluated every year for the entire term of the lease, and will require the co-operative efforts of both the lessor and lessee to maintain.

Lease terms to achieve these objectives could include any or all of the following:

- Achievement of an agreed as-built environmental rating and score for the base building and fit-out (eg, Green Star NZ)
- An obligation on the lessor to separately meter the energy and water consumption of each lessee and the building end uses for diagnostic purposes

- Establishing a mechanism for the appointment of a qualified and independent consultant to monitor energy and water consumption, and to assess compliance with the ESD outcomes prescribed by the lease to ensure these are achieved
- Prescribing a fair and reasonable calculation formula for failing to comply with the lease obligations or to achieve prescribed ESD outcomes. It is important that the parties assess and agree to a penalty that provides sufficient incentive for them to comply with the lease terms and achieve environmental outcomes and performance criteria prescribed by the lease. For example, the lease might require a reduction in the rent commensurate with the increased costs associated with the lessor's failure to achieve the ESD outcomes.

Environmentally sustainable design outcome assumptions

Given the number of variables that could reasonably be used to predict a building's performance, it is important to have a clear basis on which to derive the ESD outcomes. This should:

- Define the assumptions on which the ESD outcomes are based and identify variables that are beyond the scope of the outcomes (eg, use of the building, loading of the building, climatic data)
- Apportion obligations for meeting the ESD outcomes to both parties.

Environmentally sustainable design outcomes calculation

For ESD outcomes to be acceptable and not merely regarded as a potential penalty, they must be equitable to both the lessor and the lessee. To achieve this they should:

- Include a tolerance on the outcome given the accuracy of modelled versus real building performance
- Make allowances or corrections for factors that will influence energy usage but are beyond the control of the lessor (eg, non-average climatic effects or an increased intensity of use of the building)
- Define a calculation basis for fair cost recovery if the ESD outcomes are not met.

Lessor's obligations in respect of environmentally sustainable design outcomes

The lessor will have obligations, which would include:

- meeting an agreed as-built and/or in-use environmental rating score for the base building
- meeting agreed performance targets, normally for energy and water usage under the building owner's control, including: the energy used by heating, cooling, ventilation; common area lighting; pumping; lifts and hot water
- the flushing water contribution
- ensuring all fundamental building elements and systems are installed and operated with maximum efficiency, which may require certification by an engineer with relevant qualifications
- monitoring and, where necessary, adjusting air-conditioning levels to reduce energy use
- ensuring that an easily accessible and dedicated area for recyclable collection and storage of waste is set aside and ensuring recyclable waste is actually being recycled
- providing bicycle storage and changing rooms.

ESD outcomes prescribed by a lease must be achievable. The lessor should be in a position to demonstrate to the lessee that the building can, under normal operating circumstances, achieve the proposed ESD outcomes provided the lessee conducts its operations in a particular manner.

Lessee Obligations Relating to Environmentally Sustainable Design Outcomes

In conventional commercial leases, fit-out is usually the responsibility of the lessee, although this should be integrated with the base building and subject to approval by the lessor. A lessor of a green building will wish to impose obligations on the lessee regarding the nature or type of materials used in

the fit-out to achieve ESD goals, or require the lessee to comply with a fit-out policy annexed to the lease. In essence, the environmental standard of the fit-out should be consistent with that of the base building and the lessee would be required to meet an agreed as-built environmental rating for the building, including the fit-out.

Commercial properties typically have building rules, and for a green lease these would be extended to prescribe the lessee's ESD obligations. An environmental management plan or user guide would be prepared for the building, which the lessee would have to comply with. There would also be an obligation on the lessee for a proportion of the building's ESD energy outcome, including:

- on-floor small power equipment energy use
- on-floor-lighting energy use
- potable (drinkable) water use.

Co-operation Required

Achieving the desired ESD outcomes will require the full co-operation of each party at every stage of the design and construction process, and during the lessee's occupation of the premises. The lessor and lessee need to review the achievement of the ESD outcomes at an agreed frequency, normally quarterly, via a building management committee (BMC) meeting. If required, they also need to review and agree on any potential remedial measures needed by either party to bring the outcomes back on track if they are not being achieved. The lessor and lessee may need to appoint professionals to help achieve this co-operation.

Dispute Resolution

A green lease should not only specifically define the responsibilities of the lessor and lessee, but ideally should include a dispute resolution mechanism in the event of a disagreement between the parties as to why a particular target or objective prescribed by the lease has not been achieved.

The manner and form of the dispute resolution mechanism is, as always, negotiated on a case-by-case basis. If, however, the lease includes a requirement for an annual independent audit, then the lease could include a requirement that the auditor's brief not only advise on the performance of the building, but also include:

- an explanation as to why the building is not achieving a prescribed target
- advice on who, in the auditor's opinion, is responsible for that non-performance.

Depending on what the parties agree to, the auditor's report may be binding on the parties or form the basis of triggering the dispute resolution mechanism.

CONCLUSIONS

Commissioning is a systematic process that ensures buildings work as they are supposed to, and this becomes crucial when it comes to designing buildings that are environmentally sustainable. It is widely accepted that many buildings are not properly commissioned, and this is borne out by poorly performing buildings and complaints from their occupants. This report identifies a better approach to commissioning.

The basic idea is to extend the current process that is carried out immediately prior to handover by bringing it forward into the completion and review of the design, and extending into the first year of operation. Ideally, the building's performance should also be regularly audited over its lease term or life, as its uses and demands change and equipment deteriorates. A process of "continuous commissioning" should therefore be adopted.

The benefits of proper commissioning of a building include: improved quality assurance, documentation and co-ordination between design, construction and occupancy, leading to a better-quality product; lower energy and water usage over the life of the building and a greater potential for meeting targets, particularly for sustainable buildings; improved indoor levels of occupant comfort and satisfaction and; reduced operation and maintenance problems and costs over the life of the building.

Environmental ratings schemes such as the New Zealand Green Building Council's Green Star rating system also recognise the importance of commissioning by allocating up to six points for commissioning-related features. These points represent just over 10% of the required score for a four-star building and 7% for a five-star building, so they represent a cost-effective way of achieving a good Green Star rating.

Of all the measures that can be taken to make a building more sustainable, better commissioning is perhaps the most influential. This is reflected in the value case for better commissioning, with simple paybacks in the order of three years and a 15-year net present value (NPV) equivalent to twice the initial investment.

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