

Achieving Energy Performance in spite of complex systems and dis-jointed design

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Abstract:

The extensively refurbished heritage government department office building in Canberra's Parliamentary circle, has managed to achieve its target energy performance levels contrary to expectations following difficult design and construction processes, through careful and thorough commissioning and tuning.

The existing two storey 5,000m² sandstone building was completely gutted and brought to a new life as a head office for one of Australia's federal government departments. The building was stripped back to a bare shell, before being re-created to a Grade A office with numerous tenant systems, including a 125kW data centre with a series of complex multi-layered alarm and protection systems.

Given the extent of incomplete or contradictory designs, the commissioning team needed to carry out substantial planning, coordination and framing of test scenarios in order to bring all issues to a close, all the while being cognisant of the final desired energy performance outcome and close scrutiny by the Tenant representative of all commissioning planning and witness testing.

This paper presents an overview of the challenges that needed to be resolved during the course of the commissioning and tuning processes to achieve/maintain the target energy performance outcome (4.5 Stars NABERS – approximately 70-75kg/CO_{2e}/m²/year) after 12 months of occupation and operation. In order to aid understanding, we have assessed the procedures and steps taken against the Soft landings guidelines and core principles.

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Keywords:

Commissioning, energy performance, heritage, refurbishment, tuning.

1. Introduction

This case study looks at the successful achievement of the desired energy performance targets in an office refurbishment project and asks “Why”, what did we do right?

The objective of this paper is to demonstrate that with focussed effort and attention during the commissioning and tuning phase of a project, that the target performance can be achieved within a reduced timeframe.

In addition, it has been shown that with the application of the Soft Landings core principles and some additional elements, that industry best practice outcomes can be achieved in a timely manner without compromising operational function and thermal comfort.

This project has confirmed that the Soft Landings core principles carry substantial benefit when applied diligently.

This paper presents an overview of the challenges that needed to be resolved during the course of the commissioning, tuning and handover processes to achieve/maintain the target energy performance outcome.



Fig. 1. Aerial view of 2 National Cct office building – Canberra Australia



Fig. 2. Sandstone façade, heritage listed office building – Canberra Australia

2. Background

The existing two storey 5,000m² sandstone building was brought to a new life as a head office for one of Australia's federal government departments. The building was re-created as a Grade A office with numerous tenant systems, including a 125kW data centre with a series of complex multi-layered alarm and protection systems.

The refurbishment was planned and designed as an integrated fit-out project to meet the specific needs of the end occupant, a high security federal government department. These needs were recorded in a Functional Requirements Brief (FRB) by the occupant/tenant representative and provided to the design team and owner at commencement of the project.

The head contractor was engaged under a standard "Lump sum" contract. While the desired performance targets were indicated in the Specifications, there was no specific legal requirement to deliver the target performance outcomes.

During the course of the construction works on site, a number of core design issues were identified and the owner took steps to have these rectified. This occurred either through the use of an independent electrical design consultant or through engaging the mechanical contractor in a Design and Construct contract.

As a risk management initiative, shortly before commissioning commenced, the Contractor engaged an independent energy efficiency design and commissioning management consultant.

Given the extent of incomplete/contradictory design elements, the commissioning team needed to carry out substantial planning, coordination and framing of test scenarios in order to bring all issues to a close, all the while being cognisant of the final desired energy performance outcome and close scrutiny by the Tenant representative of all commissioning planning and witness testing. The team also prepared comprehensive training and tuning plans, which have proved to be of significant value.

In spite of the difficulties, the extensively refurbished heritage building managed to achieve its target energy performance levels contrary to expectations, through the application of the CIBSE Soft landings principles and a few additional planning and analysis steps.

3. Achieved performance

After 1 year of operation and occupation, the base building energy (emissions) performance is tracking at a little better than the target level – 4.5 Stars NABERS (National Australian Built Environment Rating), while the tenancy (non-data centre) energy performance is well above target. For buildings located in NSW and ACT, 4.5 Stars equates to approximately 87 kg/CO₂/m²/pa [CO₂-e/m²] (NABERS, 2012)

The graphs in Figures 3 and 4 below commence at the time of occupation, October 2011 and shows there were a few digressions from target before the occupants and systems "settled in".

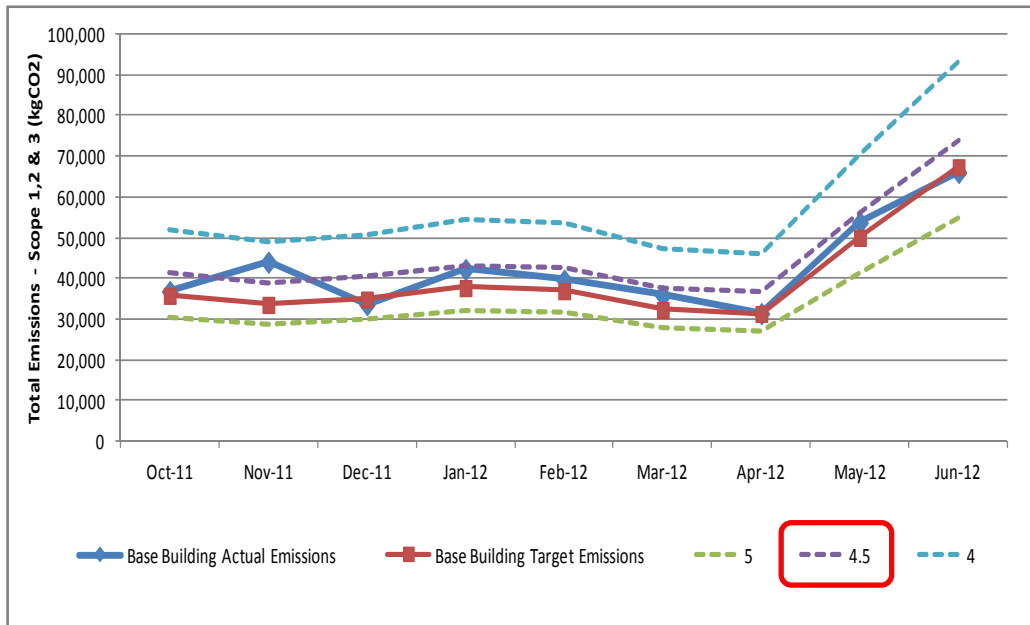


Fig. 3. Base Building Total Emissions compared with NABERS star bands

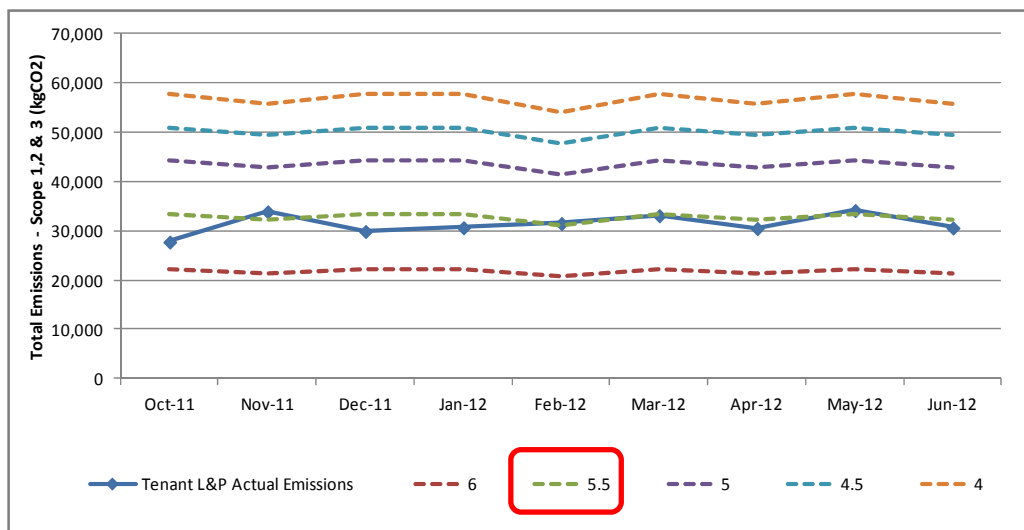


Fig. 4. Tenancy light & power emissions compared with NABERS star bands

Experience on a number of other energy efficiency projects has shown that it is uncommon for significantly refurbished or new buildings to achieve their desired energy targets in such a short time period. In the majority of cases reviewed, most buildings only achieve target 18 months post occupation. The performance generally fluctuates dramatically over the first 3-6 months as systems are tuned to respond to the actual building loads.

4. Soft Landings framework

The Soft Landings framework is an open source construction protocol/procedure developed by BSRIA and Usable Buildings Trust for the improved delivery, hand over and operation of high performance buildings.

The framework has been developed to work alongside the complete design, construction and hand-over processes and beyond. It aims to close the loop between each of the stages and feedback into new designs. There are 5 stages defined under the frame work, starting with “Inception and briefing” all the way through to “Extended after-care years 1-3”

Soft Landings has 12 core principles that guide the application of the process. (BSRIA, 2012)

In order to carry out a structured assessment of the process used in achieving the target energy performance on this project, we have used the Soft Landings framework and core principles to assess the approach and methodology. This is not to prove/disprove the Soft landings concept, but rather to reinforce how the implementation of a structured continuous performance focused process is able to deliver the required outcomes.

Due to our late engagement on this project, the assessment and review has been focussed on the latter 3 stages:

- Pre-handover,
- Initial Aftercare and
- Years 1-3 Extended Aftercare

5. Project design and commissioning issues

As noted above, during construction there had been substantial issues identified with the design of the engineering systems, many of which had not been resolved.

At the time of commissioning, these issues once again became apparent when sub-contractors were unable to determine clear testing acceptance criteria.

This was exacerbated by the lack of attendance by the design engineers at all the commissioning meetings, resulting in the sub-contractors having to establish “acceptable” commissioning standards based on experience and interpretation of the specifications.

A further complication was the extensive alarm and protection systems installed into the data centre. The tenant requirements brief called for all of these systems to report through more than one “head end”, while the engineering specifications lacked any detail of how this integration was to be achieved.

Another significant constraint was the security requirements of the project which prohibited the use of cameras, mobile phones or other electronic devices on site. This was especially troublesome during integration testing and also in the tuning stage where no remote access to control systems was allowed.

6. Methodology

The methodology used on this project is based on the Soft landings principles broken down as follows:

Planning stage

- Development of a commissioning plan

- Determination of clear commissioning objectives with sub-contractors
- Establish leadership, and define roles and responsibilities
- Development of commissioning procedures for non-standard situations

Implementation stage

- Structured and frequent communications (feedback loop)
- Continuous monitoring and verification of testing procedures
- Development of handover, training and tuning plans
- Registration of issues requiring further attention

Tuning stage

- Completion of As-builts, O&M Manuals and deliver training
- Engagement with Building manager and maintainers
- Provide leadership of tuning and monitoring activities
- “Close out” issues identified during implementation stage

6.1. Planning

Directly after engagement of the independent commissioning manager, work commenced with the Head Contractor to develop a clear commissioning plan. The plan included the following elements:

- Operational objectives and performance outcomes
- Roles and responsibilities
- Commissioning stages and cross-system integration testing
- Delivery schedule

As a result, the engineering sub-contractors were required to explain their intended commissioning approach and timeframes. It was clear that the sub-contractors required a defined structure and guidelines to follow.

Weekly commissioning planning meetings were restructured to move to a focused discussion on testing procedures and proving reliable yet efficient operation of systems. In addition, collaborative planning of the control system integration matrix was carried out. The change in focus of commissioning meetings required the whole team to take ownership of the systems they were installing and identify how they could be best commissioned. Minutes covered items such as:

- Review of previous weeks testing progress – recording failed or incomplete tests
- Identification of testing and witnessing in the following fortnight (look ahead schedule)
- On-site scope items and risks impacting commissioning
- Documentation reviews (Commissioning plans, test plans, As-built drawings and O&M manuals)
- Assessment of control and measurement system reporting

The meetings were attended by the owner’s representative, project manager and tenant representatives. All of whom actively participated and showed significant interest in the delivery of performance outcomes, and did not simply focus on practical completion.

As each member became aware of the challenges and the need to achieve the performance outcome, with clear leadership and drive, they were able to contribute to the development of the commissioning pathway. They moved from a hap hazard approach to commissioning, to one with a structure plan, with defined expected outcomes.

6.2. Commissioning implementation (Pre-handover)

With increased interest and commitment from the team, many of the outstanding design issues were resolved and agreement reached on testing methodologies. This included the development of an extensive controls integration matrix, covering all control, alarm and warning systems.

The improved progress monitoring and reporting, substantially increased the transparency of the process resulting in better “buy-in” by the owner and tenant representative, and commissioning planning meetings changed from confrontational encounters to problem solving sessions.

Commissioning of the control systems was carried out using a non-typical approach. Instead of the standard industry practice of single point-in-time verification of control operation, the adopted process included a period based analysis of operations. This included in-depth analysis of the operation of field controllers and equipment through their recorded activity in the control system trend logs. See example trend logs of the VAV's and AHU's operations in Figures 5 and 6) This process meant that all time scheduled and staging actions were fully validated and rectified ahead of handover.

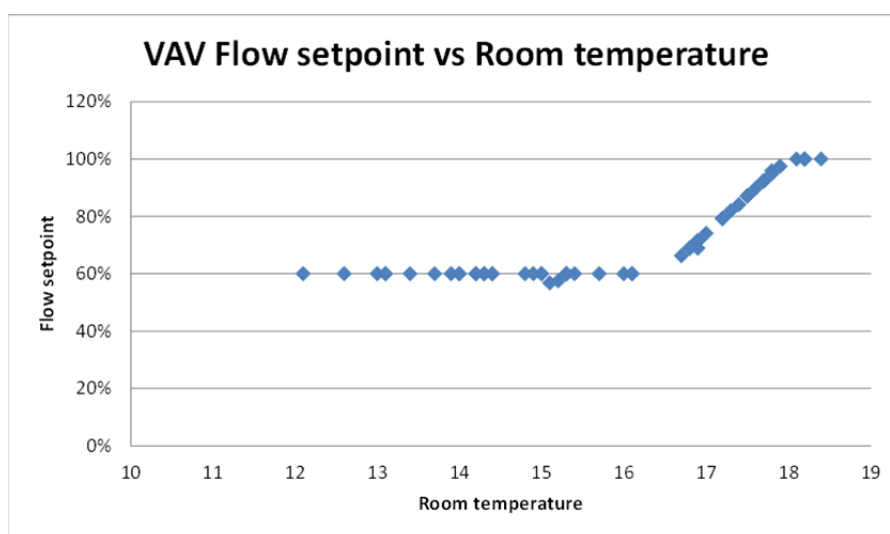


Fig. 5. Trend log confirming Flow set point algorithm (Moffitt, 2011)

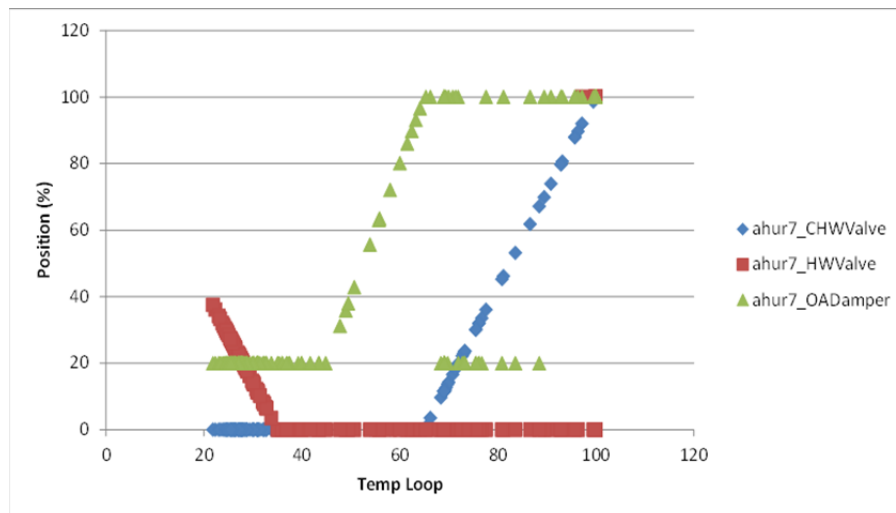


Fig. 6. Trend log confirming AHU response to temperature loop (Moffitt, 2011)

This verification of the control systems (specifically the BMS, lighting controls and generator load controller) identified a number of issues and defects that would need to be addressed once the building was occupied. In many cases this was because systems were under-loaded during commissioning as there were no occupants or tenant systems in place. These issues and defects were recorded and agreed with the owner for later resolution.

Another critical development was the preparation of the training and tuning plans. With the increased focus on performance outcomes, these plans provided team members with clear cut action lists that described the expected carry over from construction into the operational phase of the project.

6.3. Tuning stage (After care – year 1)

Following Practical Completion, a thorough review and verification of the As-built drawings and O&M manuals, played an important role in ensuring that the transition to operation by the tenants was as streamlined as possible.

Active involvement of the Building Manager and maintenance personnel commenced during the witness testing stage. However, this was ramped up at the time of Practical Completion to ensure that the maintenance team was comfortable with how the systems operated and understood the control systems and interfaces for day to day operations.

Directly after Practical Completion was awarded in September 2011 and occupation was complete, the team commenced with tuning the building and the engineering systems. There were a few issues with false alarms on the generator fuel indicator system and the daylight harvesting controls that required particular attention, although neither had any impact on energy performance.

Due to the high security requirements preventing remote log in to the control systems, the team members were forced to interact with the tenant representatives and in doing so, were exposed to direct feedback about performance and thermal comfort. This ensured that issues of thermal comfort and excess energy consumption were attended to immediately.

Comprehensive energy monitoring and analysis commenced directly after occupation and has continued each month, with detailed reports and recommendations prepared. These recommendations, together with the findings from the quarterly operations reviews were discussed with the tenant, maintenance service contractors and commissioning manager before being implemented. In this way, each recommendation is evaluated and agreement reached prior to making system changes.

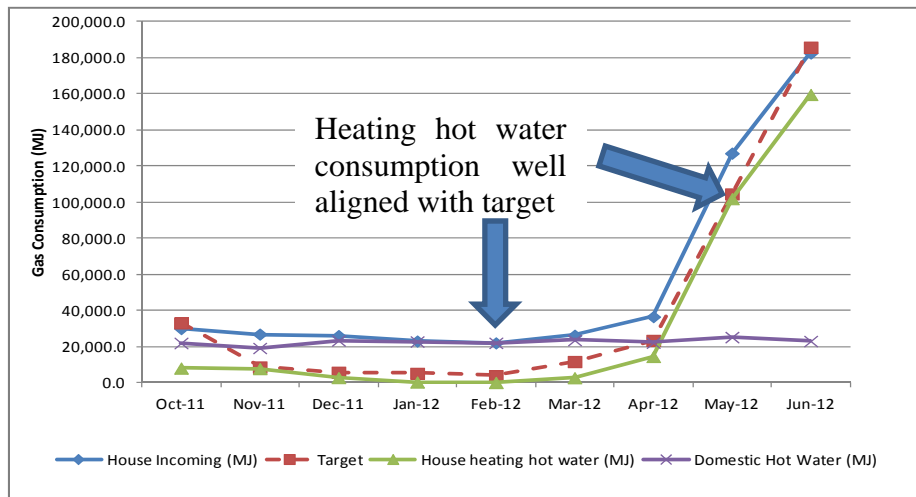


Fig. 7. Trend log of Base Building gas consumption – against target (Moffitt, Ardren, 2012)

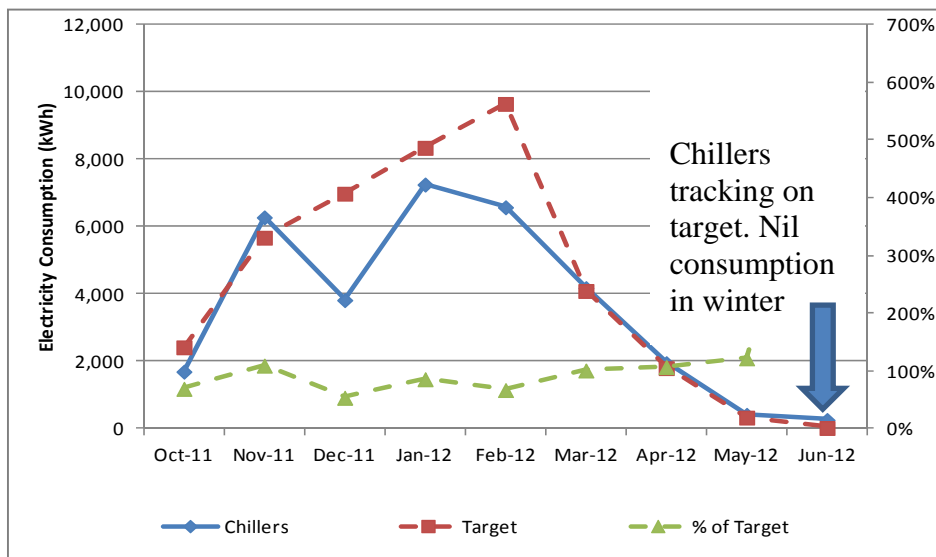


Fig. 8. Trend log of Base Building Chiller energy consumption (Moffitt, Ardren, 2012)

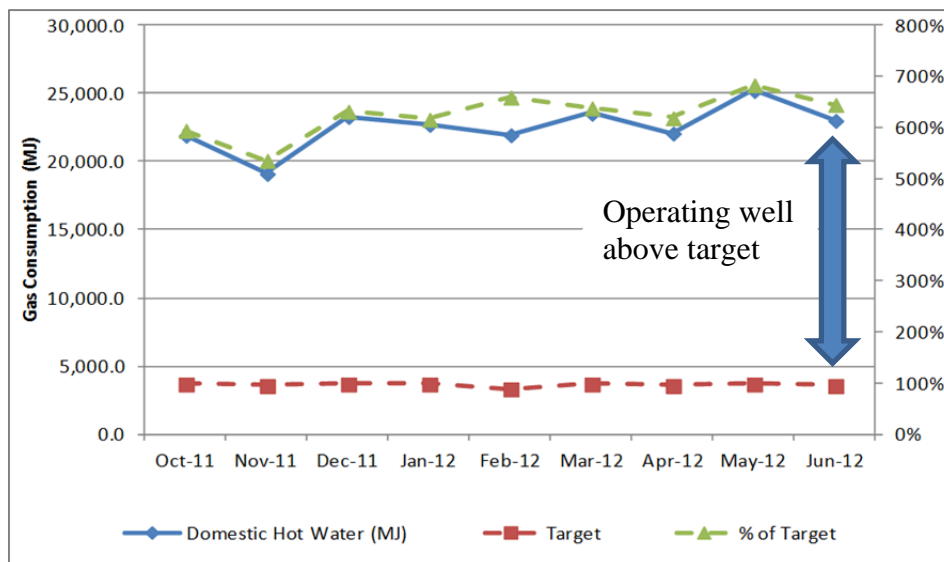


Fig. 9. Trend log of Domestic Hot Water energy consumption (Moffitt, Ardren, 2012)

The graphs above (Moffitt, Ardren, 2012) show that after the initial “bedding down” period, all major systems are tracking very close to target performance parameters. However, Figure 7 shows that the Domestic Hot Water energy (gas) consumption, while small in comparison to other systems, was excessive and needed to be addressed. (Turning off the circulating loop at night and over weekends)

In addition to the monthly energy and water consumption reviews, quarterly operational reviews of the various mechanical systems performance in terms of functionality, hours of operation and achievement of thermal comfort conditions have occurred. The initial phase of these operational reviews consisted of investigation on site of anomalies found in the trend logs and issues raised by the occupants. This was followed with face to face meetings with the tuning team and occupant representatives in order to agree on remedial actions. An action list was issued to relevant sub-contractors and followed up by the team leader.

After implementation of the agreed remedial actions, independent verification was undertaken to confirm that the action had the desired effect. Thus, completing the feedback loop.

7. Evaluation of process under Soft Landings framework and core principles

While this project was not carried out from the outset as a soft landings project, once the commissioning managers were engaged, the Soft Landings concept of a smooth and informed transition and follow up after handover were put in place.

The purpose of this evaluation is not to prove or disprove the Soft Landings framework, but rather to test which elements were demonstrated to be absolutely essential and also to confirm if the majority of the benefits can be realized if the project did not follow the framework and principles from commencement.

Table 1: Evaluation against Soft Landings framework and principles

Item	Framework and core principle	Applied Yes/No	Effectiveness
1	Adopt the entire Soft Landings process from commencement. Be explicit in implementation through all 5 stages	No	Our observation is that it is <u>essential</u> to be brought in to play <u>before commissioning planning</u> begins. Earlier is preferable, but maybe not as critical
2	Provide leadership and have champions for Client and Contractor. Engender trust and open/honest collaboration	Yes	Clear <u>leadership definitely helped</u> the team embrace and focus on performance outcomes. While there was a bit of a “contractual” mindset overshadowing completion, in terms of demonstrating operation of systems, all parties had a “ <u>no blame</u> ” attitude and “ <u>pulled together</u> ” to make sure it all worked correctly and efficiently
3	Set roles and responsibilities for all stages and ensure continuity. Active participation of client/owner and occupant representative	Yes	Initially role definitions were unclear and resulted in a lack of ownership of outcomes and poor progress. As leadership was established (and accepted), the focus on outcomes improved dramatically. The same leadership continued through into the post-handover stage and is still making sure tuning activities are correctly identified and implemented. <u>Continuity of performance intent is essential from construction to occupation and operations</u>
4	Ensure continuity of Soft Landings thread throughout the entire project	No	As noted above, a <u>successful outcome</u> has been achieved, <u>even though</u> the initial stages of the project <u>did not focus on the performance outcomes</u> Our observations would indicate that there is a person nominated to be responsible for carrying the <u>continuity of intent through from one stage to the next.</u>

Item	Framework and core principle	Applied Yes/No	Effectiveness
5	Commitment to post Practical Completion “aftercare” for 3 years with continuous feedback in place	Yes	<p>Both the Contractor and Owner have committed to post-completion tuning and monitoring “aftercare”. This has proven to be <u>critical to the achievement of the target performance</u></p> <p>Having a structured and planned tuning process and regular measurement/reporting of energy use against targets has ensured that remedial actions are carried out in a timely manner, allowing for earliest possible rating of performance</p>
6	Share risk and responsibility in a collaborative “no blame” approach	Yes	<p>Since there was no contractual obligation for the construction team to achieve the performance outcomes, sharing of risk was practiced.</p> <p>In addition, given the initial design failings and lack of participation by the design engineers, there was a collaborative mindset to resolving design issues.</p> <p>This “<u>no blame</u>” mindset definitely <u>contributed to the willingness</u> of parties to contribute and <u>collaborate</u>.</p>
7	Use feedback and surveys to inform design	Yes	<p><u>Feedback and contribution of ideas and experience</u> from previous projects had a <u>big role to play in the success</u> of this project. Lessons learnt by the commissioning and tuning teams have already been brought to bear on performance improvement and on other recent projects.</p> <p><u>Occupant observations</u> and feedback have had <u>significant input into the resolution of issues</u> and identification of energy efficiency opportunities</p> <p>However, lack of participation by the design engineers in the construction and commissioning stages, has prevented them from incorporating these lessons in future designs.</p>

Item	Framework and core principle	Applied Yes/No	Effectiveness
8	Focus on operational outcomes in-use and refine targets	Yes	<p>The <u>continuous focus</u> and attention to <u>in-use performance</u> outcomes has <u>unquestionably contributed to the success</u> of the outcomes to date.</p> <p><u>Regular tracking</u> and monitoring of energy use <u>against target</u> has been <u>essential in maintaining focus</u>.</p> <p>Targets are expected to be reviewed and refined after the first 12 months of operation</p>
9	Involvement of Building Manager and maintenance crew	Yes	<p><u>Early involvement of the Building manager</u> and maintenance crews, <u>prior to commissioning</u> provided <u>substantial value</u> to the process.</p> <p>Both in streamlining the training process, and in the identification of time-based efficiency opportunities.</p>
10	Involve end-users in all stages of the project	Yes	<p><u>Early involvement ensured</u> that the occupants were able to <u>operate</u> the building <u>efficiently in record time</u>.</p> <p>A Building Users guide was developed that specifically addressed operation from the perspective of occupants. In addition, customised “<u>Quick reference</u>” <u>cheat sheets</u> were produced and placed above <u>each piece of equipment</u>.</p> <p>As noted, <u>direct feedback</u> from occupants, while difficult due to security restrictions has been <u>crucial in the identification of efficiency opportunities</u> in the work spaces</p>
11	Set realistic performance objectives	Yes	<p>In Australia, the <u>NABERS rating</u> scheme provides a <u>realistic industry benchmark</u>. This allows for the identification of achievable performance goals.</p> <p>NABERS covers energy (emissions), water and waste – for the base building</p>

Item	Framework and core principle	Applied Yes/No	Effectiveness
			services and for tenancy spaces. All <u>monitoring and measurement</u> is carried out <u>following strict protocols</u> against these standard benchmarks.
12	Communication and information sharing between all parties over each stage	Yes	Regular and <u>open communication</u> in terms of expected outcomes and required activities <u>played a major part</u> in the finalisation of the commissioning and handover processes. During the latter part of the 12 months of “aftercare” to date, communication has diminished and as a result remedial works and performance improvements are lagging behind.



Fig. 10. “A” Grade office spaces and amenities

8. Conclusions

Contrary to indications and expectations of failure during the final stages of construction, concerted and focussed effort and attention has delivered a performance outcome that exceeds industry experiences and timelines.

Application of the majority of the Soft Landings core principles and some additional elements and procedures has demonstrated that industry best practice outcomes can be

achieved in a timely manner without compromising operational function and thermal comfort.

While this project did not explicitly follow the Soft Landings framework, it has confirmed that the core principles carry substantial benefit when applied diligently and there are potentially a few additional practices that could be adopted into the framework. These include:

- more structured in-depth analysis of system operations prior to hand-over
- clearer planning requirements for the tuning process
- defining the Soft Landings lead role that is continuous through-out all stages
- requiring an element of active independent verification of commissioning planning and execution
- defining the scope and how to procure services post 12 months DLP
- defining the need for post-occupancy training and coaching for occupants and maintainers

References:

BSRIA, Usable Buildings Trust, (2012) *Soft landings core principles*, BSRIA BG 38/2012, www.softlandings.org.uk

BSRIA, Usable Buildings Trust, (2009) *The Soft landings framework*, BSRIA BG 4/2009, www.softlandings.org.uk

Office of Environment and Heritage, (2012) *How NABERS works- Benchmark factors*, www.nabers.gov.au

Sam Moffitt (2011) *2 National Circuit BMS Commissioning report*, Exergy Australia, Canberra Australia

Sam Moffitt and Caoimhin Ardren,(2012) *2 National Circuit June 2012 Base Building Energy Report*, Exergy Australia, Canberra Australia