

What do we learn for our buildings' users?

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Abstract

This paper presents a case study of users' responses to two commercial office buildings in NZ. The Meridian Building is a four storey 5,000m² 5 Star Green Star – Office Design Version 1 rated building. The 15 storey Asteron Centre is a 33,000m² 5 Star Green Star – Office Design Version 1 rated building, with the main tenancy receiving a 4 Star Green Star – Office Interiors 2009 rating.

Prior to commissioning the design of these buildings, both major tenants spent time understanding how their current office buildings were working and what they could learn from their staff about what makes their working environment productive, via a pre-occupancy evaluation. This was done using an occupant survey method developed by Building Use Studies (BUS) to assess occupant satisfaction with internal conditions of their existing premises, and to compare this with the Building Use Studies' New Zealand and international benchmarks.

Using this information, a Building Performance Specification (BPS) was created to help guide the design team with the goals, aspirations and required performance metrics the two tenants required. The design team was required to constantly report on their progress against this BPS throughout the design and construction period of the new buildings.

After a year of occupation of the new buildings (allowing staff a chance to get over the "holiday effect" of simply enjoying their new offices), the same occupant survey was applied to determine if the buildings met the performance requirements set down by the organisations during the design phase.

The results of these Pre and Post-Occupancy Evaluations allow building occupiers and managers to understand how a building is used by its occupants and to undertake optimisation of the building's systems. This can result in a building providing a more comfortable working environment for its users while potentially improving energy efficiency.

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1. Introduction

How often do we actually not only ask people what they think of their work environments and how it affects them, but actually follow up? More often than not, as designers we rely on the absence of feedback to imply that our designs are successful in providing a productive work environment and meeting users' needs.

The investment in office buildings (and indeed other building types) is now being driven by more than just capital expenditure. Investors, developers, building owners and tenants are looking for buildings that improve productivity, have low environmental impacts and are good long term investments. Leaman (2005), in his paper on 'What the Users Say', stated "Buildings which work well in all three categories are very rare - one in a hundred is an optimistic estimate".

Two New Zealand organisations, Meridian Energy (Meridian) and the Department of Inland Revenue (IRD), recognised early on the need to provide productive workplaces for their staff. They employed Environmentally Sustainable Design (ESD) consultants to undertake evaluation of their staff so as to understand how their existing office buildings were working, and what they could learn from their staff about what makes their working environment productive. Both Meridian and IRD were looking to move into new buildings and create new head offices for their respective organisations, and wanted to help guide the design team.

This paper presents the results of the 'pre' and 'post' occupancy evaluations of the Meridian and IRD office staff in Wellington, New Zealand and what lessons we can learn from these buildings' users.

2. The Buildings

2.1 The Meridian Building

Completed in 2007, the Meridian Building is a four storey 5,000m² 5 Star Green Star – Office Design Version 1 rated building. Meridian Energy occupies all office floors of this landmark building on Wellington's waterfront in New Zealand. It was one of the first buildings in New Zealand to achieve a Green Star rating from the New Zealand Green Building Council.

This building provides Meridian with accommodation aligned with the company's focus on positioning itself as a global reference company in renewable energy. The project had goals to achieve ambitious targets of using 60% less energy and 70% less water than comparable buildings at the time.

The key features of this building include:

- a 'mixed mode' ventilation system allows operation using natural ventilation when conditions are appropriate, or energy efficient HVA C mode with enhanced ventilation rates;

- over 90% of office area within 8m of an external view, with high levels of daylight to over 60% of the office areas;
- a climate responsive active façade that automatically adjust to suit ambient weather conditions, with ventilated double-skin façades and automatic retractable blinds, plus fixed and motorised solar shading systems;
- an active chilled beam HVAC system, with energy recovery ventilation; and
- low volatile organic compound and low formaldehyde materials used throughout.

2.2 The Asteron Centre

The IRD are major tenants in the Asteron Centre. It is currently the largest office building in Wellington, New Zealand with a floor area of 48,000 m², 12 office floors and has achieved a 5 star Green Star Office Design v1 rating. The building incorporates ESD principles in the water, heating, lighting, ventilation and building management systems.

The client for this project was a leading property developer and a long term building owner so whole of life costs and sustainability were critical drivers for this development. By using an innovative active chilled beam air conditioning system with heat pump chillers and sophisticated lighting controls, this building that consumes significantly less energy and other resources than comparable buildings in Wellington.

Key features of this building include:

- Harvesting and reusing storm water for flushing toilets;
- waste heat from the cooling process is used to provide heating to the building and to preheat the domestic hot water;
- 50% greater than code levels of fresh air with CO₂ monitoring;
- low volatile organic compound and low formaldehyde materials used throughout;
- occupancy and daylight sensors that dim and turn off lights when not required; and
- energy and water metering connected to Building Management System;

The fitout of the IRD floors has also achieved a 4 Star Green Star – Office Interiors 2009 rating.

2.3 Surveying People in Buildings

Evolved over decades of research and application, Building Use Studies (BUS) has developed a two page questionnaire occupant survey method to assess occupant satisfaction with internal conditions. It measures perceived satisfaction of the buildings; the survey asks 63 questions covering 12 areas. This survey is used to assess how the building performs on ten important variables (comfort, lighting, noise, design etc.).

The occupant survey originated from a full PROBE (Post-occupancy Review Of Buildings and their Engineering) process which also included a building pressure test and energy audit (see BRI Special Issue, 2001).

This survey method was used and successfully implemented because it is:

- easy to understand for most building users;
- quick to fill in (10 minutes maximum);
- rapid to administer (only takes a day);
- not a threat to anybody (managers can veto questions if they wish);
- a wide selection of coverage (over 40 variables);
- provides sufficient information for different viewpoints (e.g. architecture, building services, facilities management);
- has benchmarking capability;
- balanced between qualitative and quantitative data;
- reasonably easy to analyse, given the complexity of buildings;
- can be used by others;
- costs can be kept down, especially using the standard version; and
- uses a database, so data can be further interrogated if required.

Why do this? We are trying to find simple answers to difficult questions about buildings and their occupiers which will be of use to designers and managers in procuring and designing new buildings and to improve existing buildings.

The purpose of the survey is to provide occupants' feedback on the performance of the building, and to compare their ratings with the BUS international benchmarks. This benchmarking capability is by far the most valuable component of this survey method. It allows the survey recipient to understand where their buildings fits on a world scale and if a score of 5 out of 7 for lighting is indeed acceptable or not (for example).

The results of the surveys allow building managers to understand how the building is used by its occupants and to undertake optimisation of the building's systems. This in turn results in the building providing a more comfortable working environment for its users while potentially improving its energy efficiency.

3. Pre Occupancy Survey

Prior to commissioning the design of the new buildings, both Meridian and IRD spent time understanding how their existing office buildings were performing, and what they could learn from their staff about what makes their working environment productive (or not).

A 'Pre Occupancy' survey was undertaken of both buildings using the BUS Survey Method, this allowed benchmarks to be set for the design brief, lessons to be learned on what staff saw as helping or hindering their productivity in the building along with a raft of other performance metrics (albeit self-assessed).

BUS uses a number of scale types for assessing the buildings, generally a 1 – 7 point scale where 1 is "very poor" and 7 is "very good". Summary Indexes scores (measured on a -3 to +3 scale) were used to give a more detailed measure of building quality. Main study variables use three "Traffic Light" ratings - green shows that building is performing better

than the dataset, amber is the average, red shows the building is underperforming and that there is room for improvement.

3.1 Meridian Building Pre Occupancy Survey Results

The Pre Occupancy survey of Meridian’s three existing buildings in Wellington was carried out in June 2005 (Building Workshop, 2005). There were 94 respondents to the survey giving a reasonable response rate of 65%.

Using the BUS overall rating system, BUS rated the buildings as “Average” (rated 4) on the 7-point scale, with 55 points on the 100-point scale. The Meridian Buildings scored as follows:

- Comfort Index (based on overall comfort, lighting, noise, temperature and air quality scores) of +0.13 (just above average).
- Satisfaction Index (based on design, needs, health and productivity scores) score of -0.2 (just below average).
- Summary Index of +0.06 (average). The Summary Index is a measure of building quality calculated by averaging the comfort and satisfaction indices.

Table 1 summarises the ‘next level’ scores for each of the main study variables.

Table 1: Meridian – Summary Results for Main Study Variables

Study Variable	Traffic Light Rating	Mean Score
Comfort Overall	●	4.32
Temperature in Winter	●	4.54
Temperature in Summer	●	3.84
Lighting	●	4.70
Noise	●	3.72
Space at Desk <i>(value closer to 4 is better)</i>	●	3.70
Furniture	●	4.83
Availability of Meeting Rooms	●	3.70
Suitability of Storage	●	3.43
Design	●	4.59
Needs	●	4.49
Image	●	4.70
Health	●	4.54
Productivity %	●	-6.37

Overall Meridian staff didn’t rate their existing premises well, with most scores either average or below. At the time of the survey the New Zealand benchmark for productivity was -1.87%, so this drove Meridian to set a goal of improving their productivity score in the new building.

3.2 IRD Building Pre Occupancy Survey Results

The Pre Occupancy survey of IRD's existing buildings in Wellington covered four separate buildings and was carried out in August 2006 (eCubed Building Workshop, 2006). There were 254 respondents to the survey, giving a reasonable response rate of 65%.

Using the BUS overall rating system, the buildings were rated as follows:

Table 2: IRD – Overall Ratings

Building	7-Point Scale Rating	100-Point Scale Rating
1	7 (Exceptional)	86
2	3 (Below Average)	32
3	5 (Above Average)	58
4	7 (Exceptional)	92

What was interesting in these surveys was that three out of the four buildings scored fairly highly, but comments in the surveys suggested otherwise.

As with Meridian Summary Indexes are used to give a more detailed measure of building quality (scores on a -3 to +3 scale), the IRD Buildings scored as follows:

Table 3: IRD – Summary Indices

Building	Comfort	Satisfaction	Summary
1	0.89	0.45	0.67
2	-0.37	-1.21	-0.79
3	0.10	-0.52	-0.21
4	0.94	0.70	0.82

Table 4 summarises the 'next level' scores for each of the main study variables.

Table 4: IRD – Summary Results for Main Study Variables

Study Variable	Building 1		Building 2		Building 3		Building 4	
	Traffic Light Rating	Mean Score	Traffic Light Rating	Mean Score	Traffic Light Rating	Mean Score	Traffic Light Rating	Mean Score
Comfort Overall	●	4.90	●	3.72	●	4.30	●	4.97
Temperature in Winter	●	4.77	●	3.87	●	4.14	●	4.70
Temperature in Summer	●	4.50	●	4.12	●	3.65	●	4.22
Lighting	●	5.22	●	4.22	●	4.86	●	5.17
Noise	●	4.35	●	3.45	●	4.45	●	4.94
Space at Desk <i>(value closer to 4 is better)</i>	●	4.52	●	3.47	●	4.20	●	4.59
Furniture	●	4.90	●	4.62	●	4.51	●	5.64

Availability of Meeting Rooms	●	4.50	●	3.00	●	3.77	●	5.28
Suitability of Storage	●	4.04	●	3.30	●	3.86	●	4.82
Design	●	5.02	●	3.25	●	4.32	●	5.30
Needs	●	4.92	●	3.31	●	4.32	●	5.57
Image	●	4.60	●	2.81	●	4.12	●	4.97
Health	●	3.81	●	3.22	●	3.13	●	3.41
Productivity %	●	-2.39	●	-11.88	●	-8.11	●	2.77

At the time of this survey the UK benchmark for 2006 was minus 1.87% (noting IR elected to go with an international benchmark dataset). The average productivity score for all buildings was minus 4.9%. This should be read to mean that 'occupants think the building reduces their productivity at work by about 5% compared with their experience of other working environments'.

As with Meridian, IRD were keen on ensuring that they provided a new facility for their staff that was as conducive to productivity as possible.

4. Building Performance Specification

The goals of both Meridian and IRD was that their new office buildings were to be designed with ESD principles in mind, with state of the art and appropriately valued solutions to services design, architecture, material choices and environmental management. Designs were also to be in line with Green Building Council Office Design rating tools (at the time of the Meridian Building a New Zealand tool was not yet available). The aims of the BPSs were to:

- review the design against current best practice in sustainable design;
- set measurable goals and targets for the sustainable design;
- set up a working process to be used by the design team to drive the sustainable design; and
- set up a project specific ESD worksheet to monitor and record the sustainable design process.

The projects were to include best practice and practical measures with respect to:

- energy efficiency;
- water conservation;
- healthy and sustainable materials;
- landscape and stormwater;
- site and transport; and
- ongoing operation of the building.

For both Meridian and IRD, the Pre Occupancy Evaluations were used to help create a Building Performance Specification (BPS) to guide the design team on the goals, aspirations

and required performance metrics they required. The design team was required to constantly check their progress against this BPS throughout the design and construction period of the new buildings.

ESD performance in use was also monitored initially on a monthly basis during the first quarter and then quarterly for the first year of operation with any fine tuning or corrective actions required being identified to meet performance targets.

5. Building Tuning

When a building reaches practical completion it is normally unoccupied. This means that the plant and systems are signed off at best under simulated operating conditions. The tuning process enables a building's plant and systems to be tuned to suit the building's actual operating conditions under full tenant occupancy. It also allows systems to be adjusted and optimised for energy efficiency and tenant comfort in a way that is not possible during the construction process.

Both Meridian and IRD ensured that as part of the contract for designing and constructing the building, there was a requirement for a one year fine tuning program. This program involved the owner/manager, construction company, services engineers (all relevant trades), services contractors (all relevant trades); and controls suppliers (mechanical and electrical).

The tuning process involved a number of investigations and processes which included:

- Investigating the Building Management System (BMS) – the tuning engineer gained an in depth knowledge of the BMS and based on their experience quickly established what systems appeared to be operating correctly and what did not.
- Detailed plant analysis – once the tuning engineer had established and dealt with any obvious system performance issues, an in-depth check was carried out on every piece of plant indicated on the BMS. During this process patterns became apparent which pointed to any problems with specific plant items or control logic.
- Daily visual checks – quick daily visual checks were carried out on the BMS. This helped the tuning engineer gain an understanding of seasonal weather effects on the building, enabling control logics to be adjusted as necessary to suit. It also indicated any zones or plant consistently underperforming which could then be further investigated.
- Sensors – sensors of all types were randomly checked for accuracy.
- Lighting controls – lighting controls and power meter checks including visual checks that lighting control systems were working. Checks included things like a visit externally to site at night to check the control systems had turned off all lights.
- Excessive power and water use – checks were carried out on plant or equipment fed from any meters indicating excessive power or water use. A key check was usually weekend power and water use which would indicate any zones using power that should not be.
- Meter calibration – cross checks between utility company meter readings and BMS meter readings were made.

- Tenant complaints – tenant complaints were investigated. This was limited to ensuring that plant in the relevant zone was working correctly.
- Time schedules – all plant time schedules were reviewed to ensure the plant operated for the correct periods and was not working after hours (as it should not usually be on at these times).
- Data recording – key data was recorded on a monthly basis and graphed for benchmarking purposes.
- Quarterly tuning reports – quarterly tuning reports were a vital tool of the tuning engineer and were used to provide in-depth on site performance checks. These checks were based on the investigations carried out by the tuning engineer. These reports included various tasks to be carried out including:
 - Water use checks e.g. things like toilet cisterns checked for leaks, meter accuracy checks etc.
 - Power usage checks e.g. lighting controls checked for areas, meter accuracy checks etc.
 - Cooling and heating water flow check e.g. pumps, terminal unit flows etc.
 - Airflows e.g. AHUs, terminal units etc.
- User guide – a guide was produced (or updated if one already existed) at the end of the tuning process to provide ongoing guidance on the running of the building.

Substantial savings have resulted from the tuning, with the Asteron Centre building owner even commenting that the tuning bill is one of the only bills he has actually enjoyed paying as he sees real long term (and short term) benefits.

6. Post Occupancy Evaluation

After at least a year of occupation of the new buildings (allowing staff a chance to get over the "holiday effect" of simply enjoying their new offices) the same occupant survey was applied to determine if the new building had met the standards and requirements set down by Meridian and IRD during the design phase.

Of all the statistics produced from this survey, perceived productivity receives the most attention, although it is the most difficult to define and measure properly. Although productivity is based on occupants' subjective estimates of performance (there is no practical method of measuring productivity "objectively" in a building), the technique has been used across many buildings and gives a relative picture. Both Meridian and IRD saw this figure as one of the key variables in determining the success of the new buildings.

6.1 Meridian Post Occupancy Evaluation

The Post Occupancy survey of Meridian's new head office building in Wellington was carried out in August 2008 (eCubed Building Workshop, 2008). There were 111 respondents to the survey, giving a reasonable response rate of 57%.

With comparison to the original Meridian Buildings the new building scored as follows:

Table 5: Meridian – Summary Results Comparison

Rating	Original Building Score	New Building Score
7-Point Overall Scale	4	7
100-Point Overall Scale	55	100
Comfort Index	+0.13	+1.58
Satisfaction Index	-0.20	+2.58
Summary Index	+0.06	+2.08

Certainly from an overall summary perspective the staff in the new Meridian Building rated it as outperforming the former buildings.

Table 6 summarises the ‘next level’ scores for each of the main study variables.

Table 6: Meridian – Summary Results for Main Study Variables

Study Variable	Original Building Rating	New Building Rating
Comfort Overall	●	●
Temperature in Winter	●	●
Temperature in Summer	●	●
Lighting	●	●
Noise	●	●
Space at Desk <i>(value closer to 4 is better)</i>	●	●
Furniture	●	●
Availability of Meeting Rooms	●	●
Suitability of Storage	●	●
Design	●	●
Needs	●	●
Image	●	●
Health	●	●
Productivity %	●	●

Comparatively speaking, the new building outperforms the former Meridian office buildings in almost all areas, particularly perceived productivity. At the time of the survey in 2008 the New Zealand benchmark for productivity was minus 2.69%, with the international benchmark at plus 3.45%. The productivity score at the Meridian building is plus 8.96%. Therefore occupants think that the new building boosts their productivity at work by about 9% compared with their experience of other working environments. The Meridian Building was rated highly by staff, achieving a level of occupant satisfaction in the top ten-percentile of the 2007 BUS New Zealand Benchmark data-set relevant to comfort, and rated number two (out of the approximately 20 buildings surveyed at that time) in New Zealand of all the buildings surveyed. On this basis, the Meridian Building is considered very comfortable, with excellent scores for satisfaction and comfort and comparing well in the national and international markets.

6.2 IRD Post Occupancy Evaluation

The Post Occupancy survey of IRD's new head office building in Wellington was carried out in May 2012 (Aurecon, 2012). There were 805 respondents to the survey giving a reasonable response rate of 46%.

With comparison to the original IRD Buildings the new building scored as follows:

Table 7: IRD – Summary Results Comparison

Rating	Original (average) Building Scores	New Building Score
7-Point Overall Scale	5.5	6
100-Point Overall Scale	67	73
Comfort Index	0.12	0.61
Satisfaction Index	0.39	1.18
Summary Index	-0.15	0.90

Table 8 summarises the 'next level' scores for each of the main study variables.

Table 8: IRD – Summary Results for Main Study Variables

Study Variable	Original Building 1 Rating	Original Building 2 Rating	Original Building 3 Rating	Original Building 4 Rating	New Building Rating
Comfort Overall	●	●	●	●	●
Temperature in Winter	●	●	●	●	●
Temperature in Summer	●	●	●	●	●
Lighting	●	●	●	●	●
Noise	●	●	●	●	●
Space at Desk <i>(value closer to 4 is better)</i>	●	●	●	●	●
Furniture	●	●	●	●	●
Availability of Meeting Rooms	●	●	●	●	●
Suitability of Storage	●	●	●	●	●
Design	●	●	●	●	●
Needs	●	●	●	●	●
Image	●	●	●	●	●
Health	●	●	●	●	●
Productivity %	●	●	●	●	●

Comparatively speaking, the new building outperforms three of the four the former IRD office buildings in most areas, particularly perceived productivity. It rated at a similar level to one of the former buildings, with lighting and noise perceived as worse. At the time of the survey in 2011 the New Zealand benchmark for productivity was minus 1.93%. The productivity score at the Asteron Centre building is plus 2.18%. This means occupants think

that the building boosts their productivity at work by about 2% compared with their experience of other working environments.

7. Conclusions

The results from the IRD and Meridian projects has shown that using a collaborative design process, the buildings have achieved sustainability through the fundamentals of good design and delivered robust, effective systems that balance environmental concerns with financial constraints.

Increased comfort, productivity and health reported by staff in the new buildings could prove to save these organisations in the future by way of reduced sick days, absenteeism and increased productivity.

Some of the lessons learned on both projects support the culture shift that the “Soft Landings Framework” (Bunn R, 2009) suggests we need to undertake as designers to close the gap between expected and achieved performance:

- the need to have a better understanding of how buildings actually work;
- building users can provide valuable insight;
- review, brief setting and fine tuning result in higher quality building outcomes; and
- closing the loop with post occupancy evaluation provides valuable experience and lessons learned that can be fed back into exiting projects and future work.

No longer is “I have been doing it like this for years and had no complaints” an excuse for complacency within design teams, they must respond to what we are learning from our buildings’ users.

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