

WHAT THE USERS THINK OF SUSTAINABLE BUILDINGS – A GLOBAL OVERVIEW

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ABSTRACT

The author has investigated the performance in practice of a range of commercial and institutional buildings worldwide. Around 30 buildings in 11 countries (Australia, Canada, Germany, India, Ireland, Japan, Malaysia, New Zealand, Singapore, the UK, and the USA) have been studied - in all cases either recipients of national awards for sustainable design or highly rated in terms of the relevant building sustainability rating tool.

These investigations involved the author in one or more visits to each of the buildings and the personal distribution and collection of a questionnaire survey seeking the users' perceptions of a range of factors: Operational; Environmental; Personal Control; and Satisfaction.

In this paper the overall perception scores of the building users for some 45 aspects of building performance will be presented and described, together with an analysis of the nature of the comments received from them. The paper concludes with a brief discussion of some of the common issues and the lessons that may be learnt from a study of the performance of sustainable commercial and institutional buildings in practice, from the point of view of the people who use them. In a footnote, the case for a truly independent, statistically valid, set of performance benchmarks is put forward.

KEYWORDS:

Sustainable Buildings; Users' Perceptions; Questionnaire Surveys; Building Evaluations.

INTRODUCTION

Driven by a growing awareness of the major impact buildings have on the environment, there has been increasing interest in the development of more sustainable building designs over the last two decades or so. However, writing of these developments in 2003, Cole sounded a note of caution. His concern was for the apparent emphasis being put on technical systems and their potential for 'reduction in resource use and resultant ecological loadings' however laudable and well-intentioned on the part of designers (Cole, 2003: 57). This emphasis is particularly evident in the world-wide development of building sustainability rating tools which up till now have been concerned mainly with the technical features of new designs. Cole's concern was that buildings 'designed with excellent "green" performance standards can be severely compromised because the specification and technical performance fail adequately to account for the inhabitants' needs, expectations and behaviour'.

At present, most of these tools are focused on the design and as-built stages of the building process, taking some account of the quality of the environment that the building is intended to provide for the users. However, with moves afoot to develop BSRTs for buildings in operation, there is the opportunity to make a more direct assessment by, for example, asking the users directly.

In this research, my particular aim was to provide an independent and unbiased evaluation of how the users perceive some of our recent sustainable building developments (Baird, 2010). Buildings that the users perceive to be flawed are hardly likely to be sustainable. Longer term, I intend to assess the

potential for including ratings based on users' perceptions in future building sustainability rating tools (Baird, 2009).

SURVEY METHODOLOGY

The main method used to gather data was a questionnaire survey, distributed and collected personally at the building during working hours by the author. Experience has demonstrated that this is by far the best way to ensure a good response. The surveyor is readily available to answer any questions, is able to encourage responses directly, and can get some sense of the nature and ambience of the building.

The questionnaire has evolved over several decades, from a 16-page format used for the investigation of sick building syndrome in the UK in the 1980s, to a more succinct 2-page version. Developed by Building Use Studies (BUS, 2004) for use in the Probe investigations (BRI, 2001/2), it is available under licence to other investigators.

The sixty or so questions cover a range of issues. Fifteen or so elicit factual background information on matters such as the age and sex of the respondent, how long they normally spend in the building, and whether or not they see personal control of their environmental conditions as important. However, the vast majority ask the respondent to rate some aspect of the building on a seven-point scale; typically from 'unsatisfactory' to 'satisfactory' or 'uncomfortable' to 'comfortable', where a '7' would be the best score (note however that in several instances a '4' would be the best score, while in others a '1' would be best).

The following aspects are covered:

- Operational - space needs, furniture, cleaning, meeting room availability, storage arrangements, facilities, and image;
- Environmental - temperature and air quality in different climatic seasons, lighting, noise, and comfort overall;
- Personal Control - of heating, cooling, ventilation, lighting, and noise; and
- Satisfaction - design, needs, productivity, and health.

Analysis of the responses yields a mean value (on a 7-point scale) for each variable.

In this paper the nature of the buildings and their users will be described, and an outline given of the working arrangements of the latter and the extent of their involvement with the building. Following that, an overview of the findings from the entire set of buildings will be presented – the users' average perception scores for individual performance factors are tabulated.

As well as asking the users to rate the individual factors on a seven-point scale, the questionnaire also invited brief comment on several of these – their general tenor is reported. Finally, some of the main overall issues that emerged from the study of this set of sustainable buildings are summarised.

THE BUILDINGS

The 30 buildings surveyed were spread over 11 countries and a number of continents: six from North America; eight from Europe; ten from Australasia; and six from Asia, as follows:

- Australia: 60 Leicester Street, Melbourne; 40 Albert Road, South Melbourne; Red Centre, UNSW, Sydney; Institute of Languages, UNSW, Sydney; Student Services Centre, Newcastle

- University; General Purpose Building, Newcastle University; Scottsdale Forest Ecocentre, Tasmania.
- Canada : Computer Science and Engineering Building, York University, Ontario; Liu Institute, University of British Columbia; Toronto Military Families Resource Centre; National Works Yards, Vancouver.
 - Germany : Sciencepark, Gelsenkirchen.
 - India : Torrent Research Centre, Ahmedabad (both conventionally and evaporatively air conditioned buildings).
 - Ireland : St Mary's Credit Union, Navan.
 - Japan: Tokyo Gas, Yokohama; Nikken Sekkei Building, Tokyo.
 - Malaysia : Menara UMNO, Penang; Ministry of Energy, Water and Communications Building, Putrajaya .
 - New Zealand : Campus Reception and Administration Building, Auckland University of Technology; Landcare Research Laboratory, Auckland; Mathematics Statistics and Computer Science Building, Christchurch.
 - Singapore : Institute of Technical Education, Bishan.
 - United Kingdom: Arup Campus, Solihull; City Hall, London; Foundation Building, Eden Project, St Austell; Gifford Studios, Southampton; Renewable Energy Systems Building, Kings Langley; ZICER Building, University of East Anglia, Norwich.
 - USA: Natural Resources Defence Council, Santa Monica, California; NRG Systems, Hynesburg, Vermont.

Virtually all were recipients of national awards for sustainable or low energy design, or were highly rated in terms of their respective country's building sustainability rating tool (BREEAM in the UK, CASBEE in Japan, LEED in the USA, Green Star in Australia, Green Globes in Canada, etc) or in some way pioneered sustainable architecture.

The 30 buildings were all commercial or institutional in nature, housing anything from 15 to around 350 staff with a mean of approximately 66 per building. Thirteen of the buildings accommodated office activities predominantly, ten were tertiary-level academic teaching buildings, four housed laboratories or research organisations, and two contained a combination of light industrial and administrative functions.

In the vast majority of cases, the clients for these buildings had a strong commitment to the principles and practice of sustainability. Indeed, several had environmental policies in place within their organisations well prior to the design and construction of these buildings, and those that had not were open to giving serious consideration to this kind of approach. Most had been built or refurbished in the course of the last decade, and all of them had been occupied for a year or more before the survey work was carried out, giving most occupants sufficient time to experience their new surroundings over at least a full annual cycle. Of course, willingness on the part of the building owner and tenants to be surveyed was also an essential prerequisite, and not all building owners felt in a position to accept my overtures, and a small number proved unsuitable for one reason or another.

THE OCCUPANTS

Overall, there were some 2035 respondents to the questionnaires. While not everyone scored every question (the questionnaire simply asked them to fill in as many as they could) the vast majority did so. The staff numbers responding ranged from a low of 13 (the small staff group at the Toronto Military Families Resource Centre) to a high of 334 (London City Hall), with a mean of approximately 66 persons per building.

For 98 per cent of the respondents (43.3 per cent female; 56.7 per cent male), the building was their normal place of business – the rest tended to be contractors of one kind or another. They worked 4.73

days per week on average and 8.01 hours per day, of which around 6.48 were spent at their desk or work space and 5.47 at a computer screen. The ratio of under to over 30s was 32.6 to 67.4 per cent and most (75.1 per cent) had worked in the building for more than a year, but only 38.5 per cent at the same desk or work area. In broad terms, around 30 per cent of respondents either had a single office or shared with more than eight others: while around 13.3 per cent each sharing with either one, two to four, or five to eight colleagues. On average, slightly over half the occupants (51.5 per cent) had a window seat.

SCORING OF THE INDIVIDUAL FACTORS

Table 1 lists the means and standard deviations of the users' perception scores for each of the 45 factors that respondents were asked to score. Each factor corresponds to a specific question – these are necessarily abbreviated to fit the table, but reflect the nature of the full question posed to the building users.

The factors have been grouped into the following categories:

- Operational (eight factors)
- Environmental, with the following four sub-categories:
 - temperature and air in winter (eight factors)
 - temperature and air in summer (eight factors)
 - lighting (five factors)
 - noise (six factors)
- Personal Control (five factors)
- Satisfaction (five factors)

For some twenty-two of the factors a score of '7' would be considered the ideal; in fifteen cases, a score of '4' would be deemed best; and in seven instances a score of '1' would be the ultimate target. The relevant factors are noted in the table. The only exception to these guidelines is *Productivity* which is expressed as the percentage by which the respondents thought their productivity had increased or decreased.

Of the twenty-two factors for which a score of '7' would be the ideal, no less than seventeen had an average score greater than 4.00, the mid-point of the scale. Seven of these were greater than 5.00, indicating that for this set of buildings, the occupants perceived the following factors as reasonably satisfactory, on average:

Image (to visitors)
 Furniture (in the occupant's work area)
 Cleaning (standard of)
 Availability of meeting rooms
 Meets work requirements
 Lighting Overall
 Needs (building as a whole)

That is not to say that every building scored well on these factors. As indicated by the Standard Deviation (SD) figures there was quite a spread of scores (but more on that later). The five factors below the mid-point of the scale were all in the Personal Control category (more on these later too).

In the case of the fifteen factors where a score of 4.00 would be deemed best, the averages for no less than eleven of them were clustered between 3.50 and 4.50. The four exceptions all related to temperature and air in winter and summer, where it was perceived to be too cold and dry in winter, and too hot and still in summer, on average.

For the seven factors where a score of '1' would represent the ultimate, all of the average scores were less than 4.00, the mid-point of the scale. It is good to see, given the effort that had been put into the design of the ventilation systems for these buildings, that the air was perceived to be well on the odourless side of the odourless/smelly scale in both winter and summer.

Finally, in this overview of the individual factors, it was particularly encouraging to see that the users considered their productivity to have been increased by 4.07 per cent on average as a result of the environmental conditions in the building.

Table 1 - Means and Standard Deviations of the users' perception scores for each factor they were asked to rate on a 7-point scale.

FACTOR	mean	SD	FACTOR	mean	SD
OPERATIONAL					
Image to visitors	5.62	0.959	Cleaning	5.27	1.010
Space in building	4.81	0.840	Availability of meeting rooms	5.15	0.853
Space at desk - too little/much ⁴	4.32	0.533	Suitability of storage arrangements	4.20	0.740
Furniture	5.18	0.529	Facilities meet work requirements	5.32	0.638
ENVIRONMENTAL					
Temp and Air in Winter			Temp and Air in Summer		
Temp Overall	4.42	0.682	Temp Overall	4.32	0.966
Temp - too hot/too cold ⁴	4.65	0.564	Temp - too hot/too cold ⁴	3.43	0.705
Temp - stable/variable ⁴	4.23	0.625	Temp - stable/variable ⁴	4.23	0.485
Air - still/draughty ⁴	3.55	0.660	Air - still/draughty ⁴	3.26	0.540
Air - dry/humid ⁴	3.39	0.341	Air - dry/humid ⁴	3.82	0.506
Air - fresh/stuffy ¹	3.71	0.724	Air - fresh/stuffy ¹	3.85	0.798
Air - odourless/smelly ¹	3.03	0.654	Air - odourless/smelly ¹	3.17	0.634
Air overall	4.44	0.611	Air overall	4.33	0.858
Lighting			Noise		
Lighting Overall	5.15	0.733	Noise Overall	4.42	0.836
Natural light – too little/much ⁴	3.94	0.485	From colleagues – too little/much ⁴	4.31	0.446
Sun & Sky Glare - none/too much ¹	3.73	0.616	From other people - too little/much ⁴	4.35	0.583
Artificial light - too little/much ⁴	4.14	0.325	From inside - too little/much ⁴	4.09	0.620
Art'l light Glare - none/too much ¹	3.37	0.523	From outside - too little/much ⁴	3.87	0.749
			Interruptions – none/frequent ¹	3.94	0.707
PERSONAL CONTROL			SATISFACTION		
Heating [30.97 & 16.768]	2.82	1.134	Design	4.99	1.079
Cooling [31.97 & 14.853]	2.81	1.003	Needs	5.16	0.775
Ventilation [28.48 & 17.541]	3.42	1.091	Comfort Overall	4.91	0.835
Lighting [26.41 & 14.710]	3.85	1.210	Productivity	+4.07%	10.02%
Noise [27.14 & 15.355]	2.48	0.756	Health	4.25	0.712

Notes:

- a – the means listed in this table are the averages of the mean scores for each building (as opposed to the mean of the individual respondent scores which could have a slightly different value).
- b – unless otherwise noted, a score of 7 is 'best'; superscript ⁴ implies a score of 4 is best, superscript ¹ implies a score of 1 is best.
- c – the numbers in square brackets are the percentages of respondents [mean & SD] who thought personal control of that aspect was important.

Turning now to the mean scores within each of the categories, it can be seen that of the eight Operational Factors, five were greater than 5.00. However, the mean score for *Storage* was only 4.20 indicating that a perceived lack of storage could be an issue in many cases. Interestingly, with an average score of 4.32 (on a scale where 4.00 represents the ideal) there is a hint that some occupants consider they have too much *Space* at their desk or work area.

In the case of the four Environmental sub-categories, there were mixed results. *Temperature Overall* and *Air Overall* averaged out at around 4.43 and 4.32 in winter and summer respectively, just over the mid-point and on the satisfactory side of their respective scales. As mentioned earlier, the *Air* was perceived to be well on the odourless side of the odourless/smelly scale, but only just on the fresh side of the fresh/stuffy scale in both winter and summer. In general, conditions were perceived to be on the cold, still and dry side in winter and on the hot and still side in summer.

Of the Environmental Factors, *Lighting Overall*, with a mean score of 5.15 was the highest by far, with mean values close to the ideal for the amount of both natural and artificial light. While the scores for *Glare* were less than the scale mid-point (the ideal was 1.00 in this instance) the SD values hint at some variability in users' perceptions.

The mean score for *Noise Overall*, at a modest 4.42, was similar to that for *Temperature* and *Air Overall*. Noise from colleagues and other people seemed to be the main 'culprit' in this instance, with interruptions scoring 3.94 on a scale where '1' would be the ideal.

As noted earlier, all five of the Personal Control Factors rated well below the mid-point of their scales (where '7' would be the ideal). *Lighting*, at 3.85 had the highest figure, while *Noise*, at 2.48 had the lowest. On average, around 29 percent of the occupants rated personal control as important.

As far as the Satisfaction Factors were concerned, *Design*, *Needs*, and *Comfort Overall* all averaged out close to a score of 5 (on a scale where 7 is the ideal) while *Health*, at 4.25 was over the scale mid-point implying that the occupants perceived themselves to be healthier in these buildings, on average. Interestingly, an earlier analysis had indicated that the occupants of these buildings perceived themselves to be healthier than the occupants of a more conventional set of buildings (Baird and Oosterhoff, 2008). The fifth factor, *Productivity*, also scored well on the positive side, though with an SD value of around 10 per cent there is clearly some variation between the building averages.

Further to these analyses a number of Rating Scales and Performance Indices that attempt to integrate particular sets of individual scores have been developed. The outcome of these is described in an earlier paper (Baird et al, 2008).

OVERVIEW OF THE USERS' COMMENTS

In addition to scoring the various factors listed on the questionnaire, the building users were invited to comment on ten aspects of the building. These corresponded directly to the following factors: *Design*; *Needs*; *Meeting Rooms*; *Storage*; *Desk/Work Area*; *Comfort Overall*; *Noise Overall*; *Lighting Overall*; *Productivity*; and *Health*. In addition, respondents were invited to give examples of 'things which usually *Work Well*' and 'things which can *Hinder* effective working'.

By no means all the occupants took up these invitations, but a significant number did so and it is of interest to overview the nature of their responses. As far as the average comment rate is concerned (the number of respondents who made a comment on individual factors, compared to the total number of respondents) this amounted to approximately 35 percent overall, ranging from just under 20 to just over 60 per cent.

In terms of the nature of their responses, the comments were placed into three categories: *positive* (extolling the virtues of the building), *negative* (noting problems attributed to the building), and *balanced* (where the respondent was neutral about the effect of the building on their work, or made a combination of positive and negative comments). Table 2 lists the overall numbers of respondents offering comments on these various aspects of the building and calculates the ratio of negative to positive comments.

Table 2 – Overall numbers of respondents offering positive, balanced, and negative comments on twelve aspects of performance (35% average comment rate).

ASPECT	NUMBER OF RESPONDENTS				RATIO -VE/+VE
	+VE	BALANCED	-VE	TOTAL	
Overall Design	314	151	413	878	1.32
Needs overall	101	76	417	593	4.13
Meeting Rooms	96	54	410	560	4.27
Storage	47	73	407	527	8.66
Desk/Work Area	134	86	341	561	2.54
Comfort Overall	126	57	208	391	1.65
Noise Overall	37	92	494	623	13.35
Lighting Overall	140	90	304	534	2.17
Productivity	114	150	209	473	1.83
Health	114	111	255	480	2.24
Work well	715	–	–	715	1.27
Hinder	–	–	905	905	
TOTALS	1938	939	4363	7240	2.25
PER CENT	26.8	13.0	60.2	100	–

The overall nature of the comments certainly supported the view that building users are more likely to complain rather than praise. Overall, only around 26.8 per cent of comments were positive, while 13.0 per cent were balanced and 60.2 per cent negative – the overall ratio of negative to positive comments was 2.25:1. Nevertheless, five of the factors had ratios better than or similar to that figure – in ascending order these were *Design* (1.32), *Comfort* (1.65), *Productivity* (1.83), *Lighting* (2.17), and *Health* (2.24), while the ratio of *Hindrances* to things that *Work Well* was 1.27. At the opposite extreme, *Noise* and *Storage* had ratios of 13.35:1 and 8.66:1 respectively – portents of a common issue.

In terms of numbers of comments received *Design* attracted by far the most with 878 – over 12 per cent of the total received - and also had the lowest ratio of negative to positive comments. Next in order was *Noise* with 623 comments (around 8.6 per cent of the total), but with far and away the highest ratio of negative to positive comments. Clearly, both figures are useful in making an assessment of any particular aspect of performance.

DISCUSSION AND CONCLUSIONS

As evidenced by the nature of the comments and to some extent the scores for these factors, Noise and Storage issues were by far the commonest source of complaint. In the case of the former, juxtaposing offices with other activities such as auditoria, meeting rooms, showrooms, visitor areas, even corridors with hard surfaces and wooden floors is probably a planning issue. Noise and disturbance within the open plan offices themselves could probably be alleviated by the establishment of appropriate etiquette and some education of the staff on the implications of moving from cellular to open-plan offices, as well as appropriate layout and acoustical design. In the case of Storage, despite an average score of 4.20 the high ratio of negative to positive comments indicates that this is an issue for many people – it would appear that the paperless office is still some way off.

Amongst the other issues that seemed to arise reasonably frequently was the incidence of direct glare from the sun. This was noted in buildings in every climatic zone and is somewhat surprising, given the predictability of sun angles – perhaps more care needs to be taken with internal layouts and the positioning of workstations in relation to the sun.

Temperature issues of one kind or another were relatively pervasive too, with summer overheating being noted in several of the naturally ventilated or mixed-mode temperate zone buildings. By contrast, several of the fully air conditioned buildings were deemed to be on the cold side in summer – a hint that their set points could possibly be raised. Of particular interest was the finding that many of the buildings in the warm-temperate zone were felt to be on the cold side in winter – an indication that more attention should be given to this aspect of design.

Despite the temperature issues noted above, as far as the occupants were concerned there were indications of a growing acceptance of a wider temperature band and tolerance for internal thermal conditions to change gradually in accordance with the seasons. The occupants also appreciated being able to see or feel the effect of their operating any of the control systems to which they had access – natural ventilation openings were mentioned in this respect.

While the focus of this paper has been on the overall performance of a particular set of sustainable buildings, readers are frequently interested in how such buildings compare with more conventional buildings. The author has not yet undertaken a study of this nature, but would draw readers' attention to a recent paper by Leaman and Bordass (2007) entitled "Are users more tolerant of 'green' buildings?". There, based on occupant surveys (conducted using the same questionnaire as the present author) of 177 UK buildings, statistical comparisons have been made between conventional and green buildings. It was concluded, albeit tentatively, "that users are more tolerant of green buildings, but one must be extremely careful in interpreting the evidence". The authors noted, *inter alia*, that "ratings scores for green buildings tend to be better than conventional buildings for more all-embracing, summary variables such as 'comfort overall' or 'lighting overall' [but] when these are divided into their components, the favourable responses for green buildings are much less clear cut."

As noted previously in this paper, Baird and Oosterhoff (2008), in an analysis of the 'health' scores for this set of sustainable buildings found them to be perceived as healthier on average than both the green and the conventional buildings in Leaman and Bordass' sample, the mean scores being in the order of 4.25, 3.75 and 3.25 respectively. A more extensive comparative analysis is planned.

FOOTNOTE: USER BENCHMARKS AND BSRTs

Here in New Zealand moves are already afoot which could lead to the establishment of a reliable and comprehensive set of user performance criteria for commercial and institutional buildings. The overall aim is to improve the performance of existing commercial and institutional buildings from the point of view of the building users by establishing an independent and unbiased set of performance

benchmarks for users' perceptions of the buildings in which they work, and developing a methodology for incorporating these benchmarks into relevant New Zealand building sustainability rating tools (BSRTs).

The first objective is to establish user performance benchmarks based ideally on a representative cross-section of New Zealand commercial and institutional buildings, rather than awaiting the compilation of an ad-hoc and potentially biased sample based on buildings where surveys had been commissioned by the building owners. These surveys will be undertaken in conjunction with the Building Energy End-use Study (Isaacs, 2009).

The second objective is to develop a methodology for incorporating these benchmarks into relevant New Zealand sustainability rating tools for buildings in operation. I believe it is essential for user perception benchmarks to be incorporated into these tools as they are developed and applied to the much larger stock of existing buildings – establishment of statistically valid benchmarks will be the first step.

Fulfilment of these objectives will ensure that the tools we use in New Zealand will lead to improvements in the performance in our existing buildings.

ACKNOWLEDGEMENTS

Acknowledgements are due to Victoria University for contributory funding, Adrian Leaman of Building Use Studies for questionnaire and analytical support, the academics who collaborated with me on some of the overseas buildings, the building owners and designers, my research assistants, and of course all those building users who responded so willingly to the questionnaire.

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