

## Topic C6: Low energy buildings

### Do Certified Buildings Enhance Indoor Environmental Quality and Performance of Office Work?

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#### INTRODUCTION

With the growth of sustainability consciousness, the awareness of stakeholders for high performance buildings has also increased. The concept of green buildings has appeared. Several voluntary environmental rating schemes for buildings were created. Their focus has been energy conservation and environmental impacts. The schemes use different credit system for various variables and different approaches to rate indoor environmental quality (IEQ) (Figure 1). It is interesting to examine, whether human related

factors are properly addressed in the schemes, especially considering the potential effects on productivity and that an average employee cost can be >10-100 times higher than the rental operation and maintenance costs (Morrell, 2005; Persramet al., 2007). There is however lack of consistent and systematic data benchmarking benefits of green building, in particular as regards IEQ and the effects on humans. Health, comfort and work performance outcomes are more difficult to quantify than the effects on energy. As a result, it may be expected that credits for IEQ in the schemes be traded with other credits. If so, although claimed to have an outstanding IEQ as compared with conventional buildings (Lee, 2011), the green building do not have to necessarily meet this postulation. Quite limited numbers of credits for enhancing IEQ offered by the schemes will certainly not very much help that the high IEQ is guaranteed. The present paper surveyed literature on green buildings to examine whether there is any systematic evidence that these buildings outperform conventional buildings as regards IEQ either through actual IEQ measurements, subjective assessments made by occupants and/or objectively and self-estimated work performance.

#### METHODOLOGY

Published papers and reports were explored and those meeting the criteria for selection in the present survey were identified and carefully examined. Besides the information on the type and level of the certification schemes and general data regarding the protocols and study size as well as procedures for selection of buildings, the following information was extracted: (i) self-estimated performance, perceptions of comfort and health symptoms; (ii) absenteeism, self-estimated motivation to work and objectively measured performance; and (iii) measured IEQ parameters.

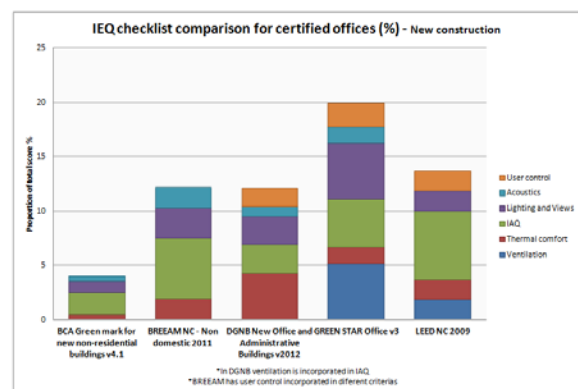


Figure 1- Comparison of IEQ credited by different green building schemes in case of the new construction

## RESULTS

Thirty-four peer-reviewed papers and 18 white papers, or corporate studies/reports or governmental reports were included in the present survey. The data in the collected literature were from cross-sectional studies performed either in green buildings alone (n=9) or by comparing conventional and green buildings (n=28). The post occupancy surveys were the main source of information; very few studies included also the pre-occupancy evaluations. Measurements of IEQ parameters were very limited. The data collected were mainly the subjectively assessed acute health symptoms and comfort, and self-estimated work performance. In few cases, sick leave was registered. Most data were not adjusted for confounding factors such as, social relations, culture, etc. Main results without references (due to space limitations) are summarized in Table 1, where colors indicate the direction of overall effect on a specific outcome: green positive effect (improved outcome), yellow no effect and red negative effect (reduced outcome) of exposure in green building; grey shows the type of measurements performed to collect data on the specific outcomes.

## DISCUSSION

Most of the corporate reports and communications, although widely available, lack the proper scientific rigor as regards the protocols and methodologies. Their observations are merely anecdotal. Unless systematic benchmarking with the proper control for bias is implemented the green buildings cannot be regarded to provide regular and measurable benefits for health, comfort and work performance. Intervention and the long-term follow-up studies after moving to the green buildings could be one approach to provide more scientifically valid information.

There are often no specific requirements in certification schemes to promote outstanding IEQ that are different from the current building codes. These codes need to be followed by the new conventional and certified buildings. This is probably one of the reasons why it is hard to observe, whether green buildings perform systematically better than the conventional buildings. Certification criteria providing credits only for outstanding IEQ are required.

## CONCLUSION

Although for some parameters in green buildings seem to perform better than the conventional buildings, there is no firm and systematic data showing that by default green buildings will always outperform conventional buildings as regards IEQ. Credit system giving too little emphasis on IEQ can be one of the reasons. Because most of the information on performance of green building is from subjective evaluations with no proper control of confounding, the improved subjective responses in green buildings can merely mirror the expectations and pride of working in such a building rather than the true tangible effect.

## REFERENCES

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Table 1-Main results provided in the literature collected through this survey; ⊕ = Data from green buildings; ⊖ = Data from green buildings compared with conventional buildings

Subjective assessments by building occupants (n=6) studies have pre-occupancy measurements. The results show that the best green buildings outperform conventional ones in benchmarking studies. (n=4 benchmarking studies showed no improvements on green	Overall IEQ	⊕ High satisfaction with greenery, design, views and openness of the space. Daylight improved (n = 7) ⊖ On average green superior to conventional buildings. After a move or retrofit, overall IEQ rated higher in green buildings (n=19).
	IAQ	⊖ In most cases IAQ rated high in green buildings compared with the conventional buildings (n=19).
	Comfort	⊖ On average green buildings rated better in questions related to the overall comfort scores (n=20).
	Health	⊕⊖ Generally improved self-reported acute health symptoms (n=13). No studies where green buildings scored low on health.
	Self-estimated productivity	⊕⊖ Generally improved in green buildings (n=15) (n=1 reverse effect). Self-estimated productivity strongly correlated with subjectively assessed health and comfort. Effects estimate between 2% and 16%.
	Tolerance	⊖ Collected data suggest that occupants are more tolerant, engaged and forgiving to inadequate IEQ (e.g. temp.) in green buildings compared to conventional buildings (n=8), at least after moving to such building. Whether this “affection” remains longer or is temporary is unclear.
	Satisfaction	⊕⊖ Green buildings achieve better satisfaction scores when occupants are committed with sustainability, and proud of their workplace. Premium location and outside views may also influence actual perceptions reported.
	Personal Control	⊕ Lack of controls is one of the main causes for discomfort. There is no tendency in the results when compared with conventional buildings.
	Thermal	⊕ Overheating, overcooling and draft are reported (n=6) but in (n=13) of studies, occupants have been satisfied. Results suggest that complaints are the result of preferences and the facility management.
	Lighting Glare	⊕⊖ Acoustic and lighting environment are frequently characterized as comparable as or worse than conventional buildings, especially in case of the open-plan offices where excessive noise and lack of privacy affecting concentration. Dissatisfaction with glare, bad layout design, and low light controls is also reported in green buildings (n=14). Users are commonly more dissatisfied with these parameters above compared with conventional buildings.
	Acoustics	
Objective Data n=6	Productivity	Mostly cohort studies (Pre/Post-Occupancy). ⊖ Values are the same or better, in most of the case studies. Sick leave reduction estimated to be between 5%- 39% (n=1 increase of absenteeism). No information whether effects remain after years of working in the buildings or are temporary.
	Absenteeism	
Physical Data n=6	Measured IEQ	⊕⊖ Overall measured IEQ parameters in green building are in the range recommended by building codes and standards, less departures than observed in conventional buildings. Sporadic cases of temperature departures are seen.
Stakeholder valuation	Appraisal	Online surveys, interviews, and annual barometers show that green buildings are perceived by tenants to help improving productivity, recruitment and retention of employees. Practitioners draw attention to the uncertainty about the size of productivity and health benefits. Stakeholders perceive the lack of documentation on IEQ payback values and long-term benefits are still a barrier.