DEVELOPING AN 'AS PERFORMING' BUILDING ASSESSMENT

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ABSTRACT

The building profession is increasingly becoming more demanding with respect to building environmental performance. Intentions are to provide best practices into our buildings. In part, this is a response due to the Australian government and other independent organisations that have developed policy on rating tools and performance ranking measures, all with the intention of accomplishing environmentally sustainable buildings.

With rating systems endorsing innovative environmental design solutions, it could be asked: Are our buildings really operating as rated? Do we know whether our designs are in compliance with what was calculated or simulated? Is there a feedback loop informing the design process on successes or failures in our designs or mechanical services?

While ratings continue to focus on 'by design' or 'as built' rewards, few tools acknowledge perhaps the more crucial bottom line: 'as performing'. With the exception of an AGBR (Australian Green Building Rating) scheme on actual annual energy consumption, there appears to be no 'as performing' assessment. Furthermore, practically every building is a prototype (a one-off) and requires commissioning, programming and scheduling of its services. It would certainly appear that as stakeholders (the procurers, owners, facilities managers and users) of the newly built environment, that what we really want to know is actual on-site confirmation of performance. It is the objective of the Mobile Architecture and Built Environment Laboratory (MABEL), to provide such a service.

KEY WORDS

building ratings, building performance, Indoor Environmental Quality (IEQ)

INTRODUCTION

The recent strike back on rating systems is real and evident when reviewing articles from the engineering profession. The concern is even more serious in regards to the validity and credibility of existing rating tools when reviewing such harsh criticisms about their short-falls (Hinge and Winston, 2009). 'Why are points given to buildings that actually perform and provide what they are supposed to do in the first place?' (Lstiburek, 2008).

This review is about MABEL and its place within the broader context of building efficiency practices and policies as well as existing rating tools. It is intended here to provide the reader with the reasoning, development and value of an on-site building environmental performance measurement (IEQ—indoor environmental quality) program. MABEL is a facility conceived upon the principle of investigating environmental performance in situ. It provides the first means of integrated, on-site measurement of key environmental aspects (energy, light, sound and comfort) using state-of-the-art technology and instrumentation (see Figure 1).

MABEL does not operate under existing rating schemes such as Greenstar or NABERS, nor does it claim to comply with the criteria addressed under these rating programs. On the contrary, MABEL is based on the capability of measurable parameters and their analysis from advanced state-of-the-art equipment. MABEL relates to that which is physically and reasonably possible to be measured on site (non-laboratory) and in compliance with standards or best practices. MABEL also involves further processing of interrelated data (such as external temperature with comfort, or wind speed and direction with interior air change rates) through computational algorithms as related to accepted and recognized methods. Therefore, other rating tools may not subscribe, comply, or agree with, the methods applied by MABEL for Indoor Environmental Quality (IEQ) assessment. Nevertheless, the MABEL methodology of evaluation is derived

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FIGURE 1. A Selection of Building Environmental Performance Instrumentation: MABEL.

Thermal Comfort & CO_2

Thermal Imaging and Ventilation (air change rates)

Weather & Solar Station

Facade Heat Transfer

Lighting Comfort Cart

from basics of on site measurement capability and the expertise thereof. MABEL has established its own measurement criteria and evaluation process based on state-of-the-art equipment, practicality and the associated standards (national or international) therein. Figure 1 illustrates a selection of MABEL's equipment as applied to on-site building performance evaluation.

BACKGROUND TO ON-SITE MEASUREMENT

In its four years of operation, MABEL has encountered the measurement of over 30 buildings including offices, schools, hospitals, airports and houses. Projects have ranged from Darwin to Hobart and from Brisbane to Melbourne. It could undoubtedly be stated, that there is no other single program in Australia (and perhaps anywhere else in the world) that has undertaken such a rigorous endeavor towards obtaining actual performance results of our built internal environment. Interestingly enough the European Union Commissions organization has established a committee for the development of a standard on 'Criteria for the Indoor Environment including thermal, indoor air quality (ventilation) light and noise' (CEN Standards, 2004). Yet, MABEL remains to be developed in its measurement, data collection and processing methods, as well as accepted within the niche of building ratings, and to disseminate its knowledge in a 'standardized' format acceptable to the industry.

The greatest challenge in the development of an on-site building environmental performance program is the recognition of parameters that can be measured (directly through instrumentation), others that can be calculated (from results) and those that can be combined (recognized relationships) to provide the desired reported information as well as advance our knowledge on building performance. In accordance with standards and best practices an abridged version of the MABEL measurement parameters and their deliverables are outlined in Table 1.

A PROPOSED ASSESSMENT

Given the above mentioned provisions of MABEL, a stakeholder in the building's performance (an owner, facilities manager, or user) might find it more useful to have the measurement results interpreted into something more meaningful, ranging from remedial works to the organization's corporate image, to guaranteed energy performance. In consideration of justifying 'return on investment' MABEL has constructed an alternative method of evaluation. It is suggested here that the delivered interpretation of the measured results might support the following four categories of 'performance measures', adding information value for the client:

1. **Fit-for-Purpose:** this category determines whether the actual spaces within the building have complied with their 'program' or intended spatial use by the occupants in regards to environmental factors (light, noise, comfort, ventilation etc.). This category benchmarks:
   - accomplishment of minimum standards.
   - assurance that the current usage meets the design program requirements.
   - an evaluation of the design and its possible flexibility to adapt to other uses.
   - conditions of occupant comfort & healthy environments.
2. **Value for Money:** is most likely considered the first off-the-rank category by the facilities manager, owner or CEO of the organization. It is identified as the economical/financial category, justifying the 'return on investment'. However, the prospects of achieving optimized performance through retro-commissioning might also consider:
   - energy savings of optimized performance—leading to an improved AGBR (Australian Green Building) rating.
   - an increased capital value and demand of the property
   - marketing and improved corporate image
   - increased productivity and well being
3. **Triple Bottom Line:** is the holistic 'environmental sustainability' category investigating the social, environmental and economical aspects of the commercial organization. It is considered this category reaches beyond the building design and its performance, extending into the philosophy and corporate image of the organization occupying it.
   - *social:* responsible corporate image, setting an example, dissemination of knowledge

TABLE 1. MABEL Measurement Parameters & Deliverables.

Parameter	Description & Deliverables
POWER	
Energy Use	Excessive energy use, period of operation, AGBR compliance. Energy monitoring
System Defects: equipment efficiency	Diagnostic fault finding in HVAC control systems, equipment scheduling, and operational periods
Flow Rates in pipes and ducts	Measurement of flow rates & temperature (energy) in chilled / hot water HVAC systems
Building Envelope Analysis	Measurement of façade heat transfer and thermal imaging for diagnostic & visual analysis.
LIGHTING	
Background Illuminance	Natural and artificial light levels at the workplace.
Task lighting Illuminance	Workstation light levels from observer to screen and screen to observer: total of six lux measurement points
Correlated Colour Temperature (CCT)	Investigated light sources and ranges of colour Light colour variation can have a psychological influence on comfort.
Work place brightness/contrast	The glare problem is quantified in accordance with international best practice—regarding glare and discomfort
Daylight Autonomy	Daylight factors or ratios indicate how much electrical lighting is needed to supplement the natural lighting
COMFORT	
Weather, Solar and Light (external on site data)	Determines the external conditions which influence the internal measured parameters.
Thermal Comfort levels	A "Comfort Cart" is used to measure (PMV/PPD) occupant comfort at the workplace.
Surface temperatures & Radiant Asymmetry	Influence of Mean Radiant Temperature balance within the space
Drafts in air distribution	Draught index at a specific cross-section within a space. Air distribution performance index (ADPI)
Air Temperature Stratification	The variation of air temperature with height within the space.
VENTILATION & INDOOR AIR QUALITY	
Air Change Rates	Room ventilation rates (effective air change): HVAC normal operation & HVAC off : air infiltration
Uniformity of supply air distribution	The tracer concentration is measured at a number of locations to determine the balance of the air supply.
Indoor Air Quality (CO_2, VOC's, dust particulate)	Diagnostic testing of air quality levels over time and location within an environment.
Fume Hood Testing	The efficiency of capture of contaminants from laboratories
Air leakage and Building Envelope analysis	Fan pressurisation testing is used to quantify building envelope leakage
SOUND	
Background Noise: Interior	Background Noise levels at each workplace—frequency dependent. Percentages of loudness over time.
Background Noise: Ingress	Speech privacy vs. speech intelligibility.
Reverberation time	Acoustic 'liveliness' (sustained sound) in a room.
Partition sound transmission	Sound transmission class (Rw) through partitions
Sound intensity; noise sources	Identification of sound leakage areas and sound sources

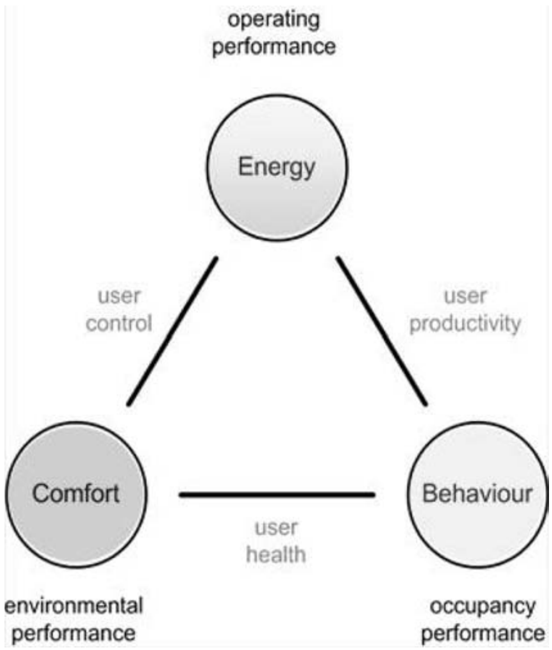
- *economical:* value-adding to the return on investment through reduced operating costs, increased productivity and carbon trading,
- *environmental:* reducing greenhouse gas emissions and our environmental footprint as well as improving the building rating.

The triple-bottom-line recognizes future needs and is responsive, flexible and capable of adapting to change.

4. **Risk Assessment:** considers the previous three categories and acknowledges the ramifications of not responding to them. It also recognizes the environmental and corporate risks of not responding to *climate change adaptation* and *climate change mitigation*. All of these risks lead to:
   - potential loss of market share—company viewed as irresponsible to public concerns.
   - caught off-balance with ever-increasing operational (energy) costs.
   - non-compliant to client demands.
   - decreased occupant productivity
   - increased sick leave and absenteeism
   - a building with limited use and life.

   Ultimately, the above assessment methodology acknowledges value-adding to both the operation of the building as well as the organisation or company that occupies it. Undoubtedly, an evaluation of the previously discussed performance measures is in the interests of the stakeholders.

FIGURE 2. Occupancy-Environment-Operation Framework for Building Performance Evaluation.



TOWARDS TOTAL BUILDING PERFORMANCE EVALUATION

MABEL has long recognized that total building performance measurement extends beyond its own boundaries and must consider the building occupants (users) as well as the operational energy consumption and equipment scheduling strategies (see Figure 2).

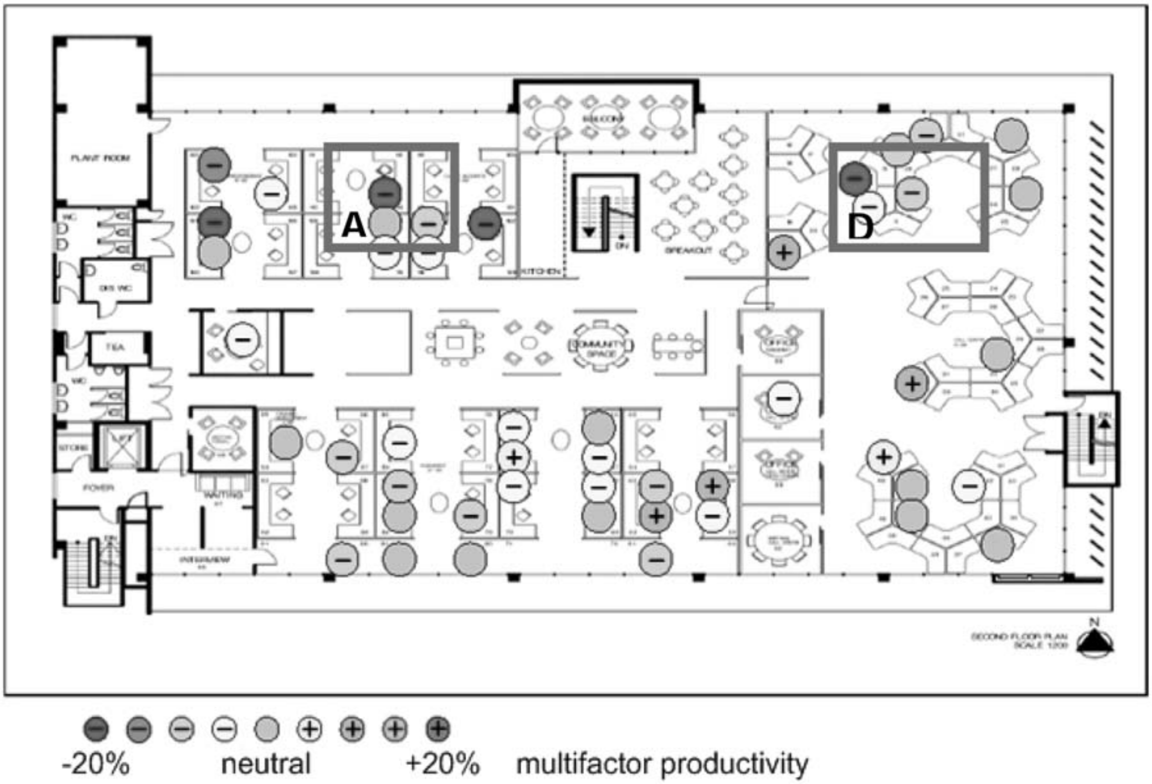
This a model considers the importance of all three categories of building performance evaluation. It is only when all three have been investigated and analyzed together that the stakeholders can be assured of a comprehensive and total evaluation.

In a recent case study MABEL worked together with KODO, an organization performing occupancy performance surveys (Purdey and Luther, 2008). MABEL results were used to inform the design of specific building improvement measures based on objective physical measurement in response to performance shortcomings perceived and reported by occupants in the KODO survey. Together MABEL and KODO inform the organization of the most cost effective performance improvement solutions that require little or no additional capital investment.

The collaboration between the two parties of building performance evaluation has lead to the invention of 'productivity maps' where the results of both are combined to graphically illustrate the problematic areas (i.e. in an office) so that management can enact upon them (see Figure 3). Empirical and user response information is provided here to allow building facilities managers (ie. owners) to seek further assistance.

A wider application for Building Performance Evaluation is the production of relevant information for design measures and technologies, beyond the operation of the specific building. This information is then fed back into future design work where it

FIGURE 3. KODO Productivity Topographical Map and MABEL Investigated Locations (Purdey and Luther, 2008).

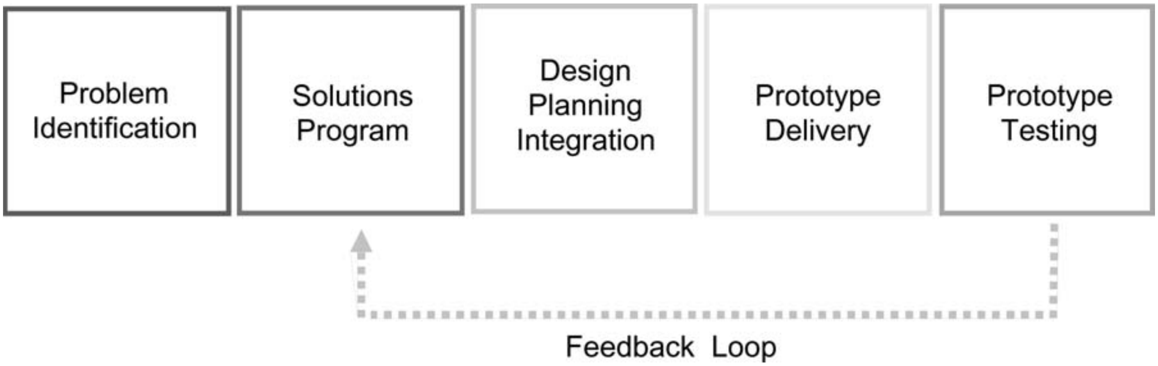


can initiate development by providing assessment of technologies, design options and complete building concepts (Luther & Schwede, 2006). Such an application results in general design knowledge for improving design practice, standards and building policies. Dr. Hyde (2000) states that such knowledge generation is required as good professional practice by RAIA, as well as AIA (American Institutes of Architects), but is seldom performed systematically. In response to this, MABEL has embraced and acknowledged the importance of *feedback* within a *total building performance evaluation* process if sustainable operational processes in buildings are to be accomplished (Figure 4).

We may recognise, in accordance with this feedback loop, where we stand in the pursuit of environmental sustainability. Figure 4 suggests that we all have a long way to go in improving and assuring that our methods toward sustainable practices are actually effective. Al Gore's 'An Inconvenient Truth' has identified the problem, but where do we go from here in revolutionizing building construction and its operation? Perhaps the 'Clinton Initiative' offers an initial intention towards improving our cities, however, the verdict has yet to be announced and its reporting methods witnessed.

Unless we begin to develop an evidence-based policy, inclusive of testing existing and newly introduced solutions, we will only provide fictitious claims of sustainability. This new model suggests that a 'baseline' of existing building stock be thoroughly examined and compared to innovative solutions. It further implies that new solutions 'deserve a chance' and require refinement of the innovative prototype.

FIGURE 4. Implementing the Feedback Loop in Design Processes.



THE NEXT STEP: RATING AS PERFORMING

Are we 'star stricken'? Can building performance be represented and reduced to its least common denominator? Is it legitimate to simplify complex building prototypes into a single figure rating? Perhaps there is a place for the 'stars' and such is mandatory for marketplace acceptance. MABEL has considered developing its own evaluation tool based on the parameters it measures, as well as results that can be calculated (see Figure 5). In this case, each of the five major categories of IEQ would receive a 'grading of environmental performance' where the higher the number, the greener, the better. Ultimately, the more 'green' the five point star becomes (among all the categories) the higher the environmental rating of the building.

The objectives of the diagram in Figure 5 are to outline all of the parameters measured and assessed by a full indoor environmental quality assessment made by MABEL. It is also to give the building stakeholders guidance into the area(s) where improvements are needed. However, not all of MABEL's projects have permitted such to take place and a client often desires only certain sectors of a full measurement. This implies that there are different applications and purposes for MABEL aside from rating systems altogether, which may:

- Identify best-practice technologies for environmental building performance.
- Provide diagnostic assessment for commercial, industrial and residential buildings.
- Establish benchmarks of performance levels for: energy, light, acoustics, comfort, ventilation and indoor air quality.
- Provide evidence-based results for compliance or contribution to building improvement.
- Provide data for building simulation program verification.
- Perform in situ product performance evaluation.

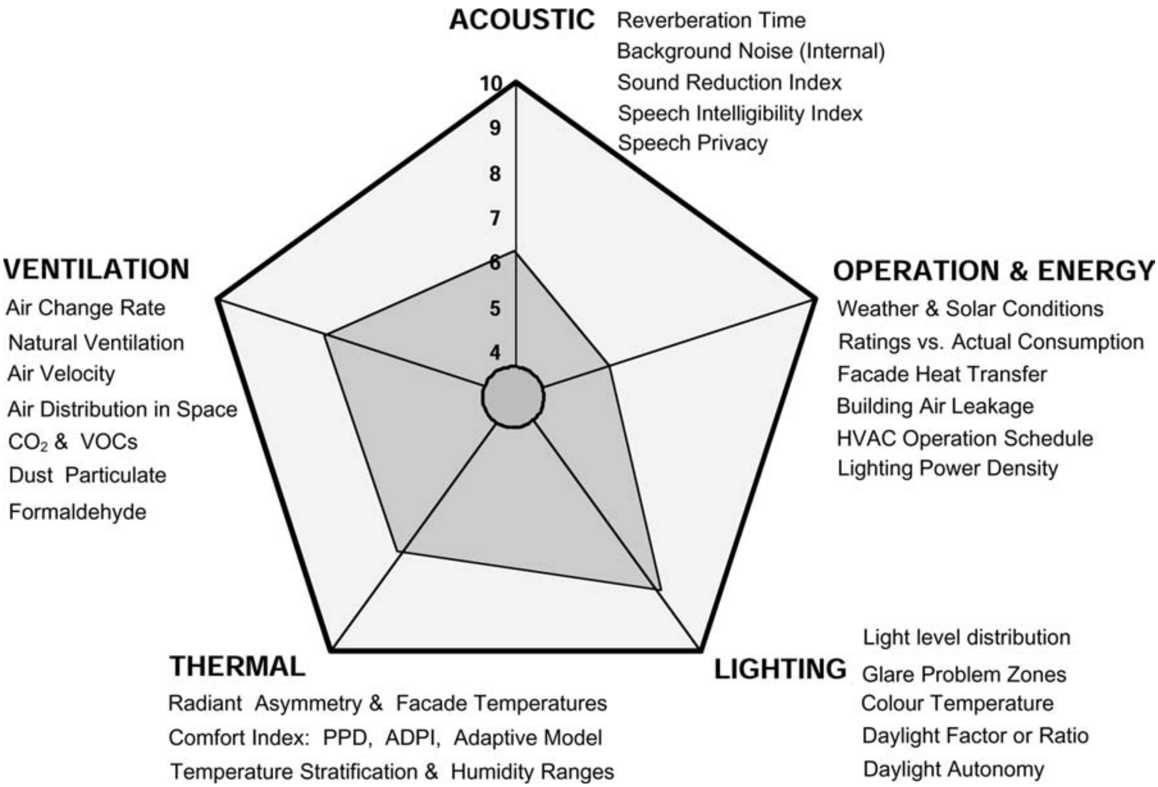
CONCLUSION

This review on MABEL was intended to introduce and define 'the product' and its potential for the building industry. It was also to provide an awareness of the capabilities of an 'as performing' rating system through actual on-site measurement, as one sector only, in the three major categories of building performance evaluation: Indoor Environmental Quality, Energy Consumption / Operation, and Occupant Evaluations. In other words, Building Environmental Performance measurement, in itself, is greater than the MABEL facility.

Finally, MABEL endeavors to introduce a program to the industry and to guide building stakeholders towards achieving performance above and beyond rating systems. It must be noted that actual reporting of MABEL results and cases studies are to be found elsewhere.

What is most revealing to the subject matter is that the European Commission has identified

FIGURE 5. MABEL's development towards a single IEQ evaluation scheme.



a similar need for action in its development of an on-site building performance assessment standard. Unlike MABEL, there are several countries and dozens of high-profiled laboratories involved in contributing to all the different sectors of Indoor Environmental Quality, leaving no doubt that an 'as performing' evaluation is in the future.

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