The development of a simple multi-nodal tool to identify performance issues in existing commercial buildings

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Abstract

Australia's building stock includes many older commercial buildings with numerous factors that impact energy performance and indoor environment quality. The built environment industry has generally focused heavily on improving physical building design elements for greater energy efficiency (such as retrofits and environmental upgrades), however there are noticeable 'upper limits' to performance improvements in these areas. To achieve a step-change improvement in building performance, the authors propose that additional components need to be addressed in a whole of building approach, including the way building design elements are managed and the level of stakeholder engagement between owners, tenants and building managers. This paper focuses on the opportunities provided by this whole-of-building approach, presenting the findings of a research project undertaken through the Sustainable Built Environment National Research Centre (SBEnrc) in Australia. Researchers worked with a number of industry partners over two years to investigate issues facing stakeholders at base building and tenancy levels, and the barriers to improving building performance. Through a mixed-method, industry-led research approach, five 'nodes' were identified in whole-of-building performance evaluation, each with interlinking and overlapping complexities that can influence performance. The nodes cover building management, occupant experience, indoor environment quality, agreements and culture, and design elements. This paper outlines the development and testing of these nodes and their interactions, and the resultant multi-nodal tool, called the 'Performance Nexus' tool. The tool is intended to be of most benefit in evaluating opportunities for performance improvement in the vast number of existing low-performing building stock.

Keywords: Energy efficiency, building performance, indoor environment quality, occupant satisfaction, whole of building performance evaluation

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1. Introduction

The built environment has a significant impact on the sustainability and liveability of our cities. Commercial buildings in particular are responsible for considerable flows of energy and resources, in part because many existing buildings were designed and constructed before sustainability was a primary concern. Similarly, commercial buildings have a significant impact on the health and well being of occupants, who spend an increasingly large proportion of their time indoors. But many of these buildings were designed and built before the health and productivity became common and explicit design goals. The result is a glut of older inefficient buildings that are not providing a high quality environment for their users.

There has been limited focus on improving the performance of older existing commercial buildings, yet these buildings typically represent the vast majority of the building stock in many cities. Australian cities have approximately 21 million square metres of commercial office space spread across nearly 4,000 buildings (PCA, 2008), most of which, if measured by net lettable area, consists of low-grade office buildings (Davis Langdon, 2008). As the performance of much of this low-grade stock has yet to be improved there is growing interest in cost-effective energy management options. Further, tenants themselves are increasingly demanding high performance spaces that contribute to improved occupant comfort and satisfaction whilst also maintaining good environmental performance (Colliers International, 2012). There is consequently a significant opportunity to improve the sustainability of our cities by focussing on refurbishing these buildings for energy efficiency and human health objectives.

Significant efficiency gains are possible through isolated upgrades to building plant and equipment, such as HVAC, lighting, and office equipment. However, there are also numerous opportunities to improve performance through a focus on improving existing equipment and integrating building systems. Additionally, there is also a resurgent awareness of the potential for occupants to take a more proactive approach to energy efficiency and individual comfort. The last few decades have also seen an increased awareness of the importance of occupant feedback in contributing to improved building performance, as evidenced by the increased use of post-occupancy evaluations. However, a number of barriers have prevented the widespread improvement of existing buildings, including high perceived capital cost and the problem of split incentives. Another significant barrier is that building managers and facilities managers often simply lack sufficient information to help determine where to begin and how to consider whole-of-building performance when investigating upgrade options. As user needs change, buildings may also be used in ways that differ from their original design intent, and this often has impacts on energy consumption and indoor environment quality. Furthermore the energy consumption profile of buildings may vary over time as office fit outs are modified, equipment ages, and tuning and maintenance is neglected.

The issue is further complicated by the fact that efforts to improve environmental performance do not necessarily result in improvements to indoor environment quality or health and productivity (Leaman *et al*. 2007; Kato and Murugan, 2010). For example,

increased day-lighting can reduce reliance on artificial lighting, but can increase the potential for glare if not well executed or if occupant controls are not available for individual adjustment. This is of particular concern as energy and maintenance costs represent only about 4-5 per cent of total costs over a building's life cycle, while occupants' salaries are around 85 per cent (Collins *et al,* 2008). It is thus highly counterproductive to focus on energy efficiency in isolation to the building occupants. Improving the energy performance of buildings in a way that also supports a productive workplace is a complex issue that is still not yet well understood, yet it represents a key strategy in transitioning towards a healthy and low carbon society. Australia faces a challenge in improving the performance of existing commercial buildings, and in light of the challenges and opportunities mentioned above it is clear that it will require an integrated approach and a greater level of collaboration between building stakeholders.

As such, this research project focused on developing a low cost, low complexity resource to assist efforts to improve existing commercial buildings. The research project, supported through the Sustainable Built Environment National Research Centre (SBEnrc) examined how the energy performance of existing commercial buildings could be improved while maintaining high a quality indoor environment conducive to a productive workforce. The research focused on identifying issues being faced by the industry in optimising the performance of commercial buildings, through a whole-of-building approach. This was based on the rationale that in order to improve both energy performance and productivity there is a need for a holistic approach that involves communication and cooperation between the many stakeholders and sub-contractors involved in operating buildings. Such an approach challenges standard practices and requires a new framework that brings together various areas of building operation and management that often occur independently.

2. Methods

This mixed-method, industry-led research project comprised literature review, workshops, evaluation trials, and case-study analysis as detailed below.

2.1 Literature review

A review of literature was conducted by the research team to investigate the current state of green building in Australia and the impacts of 'green' design on occupant health and productivity (Hall, 2010). This provided background knowledge of the industry and potential areas for further investigation, and provided a basis for the subsequent stakeholder engagement process. The literature review revealed a number of important issues faced by industry:

- Existing buildings are significant users of energy and large emitters of greenhouse gases.
- Indoor Environment Quality (IEQ) in buildings can have significant impacts on the comfort, health and productivity of occupants.
- Addressing inefficiencies in existing buildings represents a significant opportunity for energy savings.

- Buildings can be built to the highest efficiency standards using leading edge technology, but the way they are managed and used can profoundly influence their performance.
- Productivity improvements are of keen interest to the market but can be difficult to quantify in practice.
- Buildings are complex systems with many stakeholders involved, and there is often a lack of communication between the various parties.

2.2 Workshops

Three stakeholder workshops were held in the early stages of the project with 50 key stakeholders to identify areas of interest for the project to develop (SBEnrc, 2011). The workshops were facilitated using the 'Community Social Learning' (CSL) methodology designed by Emeritus Professor Valerie Brown, ANU (Brown, 2008). The CSL methodology is designed to guide participants through a process to identify key issues, as well as enabling and disabling factors, that relate to a given enquiry area. Participants were asked to vision their ideal green buildings and then consider the enablers and disablers to achieving these visions. Participants then identified what could occur to enhance the enablers, and reduce the disablers, that were relevant to the research project.

Stakeholders indentified the a key disabler for the ideal green building to be split incentives, lack of feedback loops and continuing communication/education, perceptions/fear of change, a lack of knowledge and education professionals, short term focus on capital expenditure over long term benefits, and lack of quantifiable evidence. When asked how to overcome these disablers, stakeholders discussed the need for a standardised post-occupancy evaluation for buildings that can be used across the commercial buildings sector (rather than using a different one for each building), as there is some trepidation towards single building evaluations. Also raised was the need to measure indoor environment factors, quantification of occupant experience, measuring and mandating building performance, and offering incentives to upgrade buildings.

Some other key outcomes from the workshop were:

- *A focus on existing commercial buildings:* The need for further attention on existing and older buildings was emphasised over the focus on new design given the dominance of this building type in the sector.
- *A holistic approach to energy management*: Much discussion also revolved around understanding how buildings are being managed and used by building managers and occupants, as no matter how efficient the building is designed to be if it is not being operated correctly it will not perform.
- *Options for enhancing stakeholder collaboration in buildings*: There was interest in seeing the project consider the various stakeholders within a building and their relative contributions to improving building performance
- *Consideration of the impact on productivity of energy programs*: Particularly the link between energy management initiatives and productivity. Understanding that productivity is difficult to quantify in practice, a focus on indoor environmental quality and occupant perceptions of their own productivity could be considered as an acceptable proxy.

2.3 Development and trial of the Performance Nexus

The research included three evaluation trials as part of the tool development process, comprising existing commercial buildings in Brisbane and Perth. The intention of these trials was to develop and test the 'Performance Nexus' framework. The first trial employed an occupant experience questionnaire and basic IEQ monitoring with a handheld device in order to evaluate a traditional low-cost post-occupancy evaluation procedure. The trial was undertaken in a commercial building in Brisbane. The second trial involved use of the project-specific occupant survey and conducting basic handheld IEQ measurements in addition to detailed indoor environment quality analysis by an environmental services contractor. A pre- and post-occupancy evaluation was conducted on a tenancy in Perth undertaking a Green Star Interiors retrofit. Data was gathered from this building for three nodes; 'Occupant Experience', 'IEQ', and 'Design Elements'. Data from this trial is currently being analysed.

Following this trial it could be seen that some of the biggest communication barriers came between owners, tenants, and building managers. At this point the *Performance Nexus* was expanded beyond consideration of IEQ, design elements, and occupant experience to include building management, corporate culture and the legal and non-legal agreements in place between tenants and owners. An expert team at Queensland University of Technology assisted with the development of these areas in line with the growing use and trend of green leases in Australia. Targeted surveys/checklists were thus developed and refined for each of the five nodes of the *Performance Nexus*, namely; Design Elements; Building Management; Agreements and Culture, Occupant Experience; and Indoor Environment Quality. The intention of tools was to target information to specific stakeholders to identify key systems and practices and potential areas for improvement, as shown in Table 1. The questions were discussed with multiple project partners in the area of building management to ensure the answers would inform improving the buildings energy performance in a way that created a productive workplace.

Table 1: Lines of questioning across the Performance Nexus

AUDIENCE	Design Elements	Building Management	IEQ	Occupant Experience	Agreements and Culture
Base Building	Building Owner	Building Manager	Building Manager	Occupants	Building owner
Tenancy	Tenancy Representative	Property Manager	Tenancy Representative	Occupants	Tenancy Representative

The surveys were constructed so as to help identify key factors and interrelationships between the nodes to help identify opportunities for improvement. The *Performance Nexus* is particularly valuable as a pre- and post-retrofit evaluation tool that can highlight the impacts of retrofits on a workplace, identify areas that may need improvement, and identify relationships between areas that could be strengthened. The surveys are intended to serve as a freely available tool that can be used to inform upgrade initiatives. The final surveys were trialled in an owner-occupied local government building in Western Australia. The Occupant Experience, Indoor Environment Quality and Agreements and Culture

questionnaires were fully completed. For both this trial, and the post-occupancy trial of the tenancy building, building management was the most difficult stakeholder to engage and complete the questionnaires. Data from these trials is currently being analysed to determine the linkages and reliability of questioning methods. The next step would be for a final review of the survey methods, and peer reviewed scoring to the survey questions.

2.4 Case studies

In addition to the actual trial of the *Performance Nexus*, a series of publicly available case studies on existing building retrofits were selected and analysed using key criteria from the *Performance Nexus* nodes to identify key features of the building performance improvement process:

- *QV.1, 250 St Georges Tce, Perth, WA*
- *60 Leicester Street, Carlton, VIC*
- *201 Charlotte Street, Brisbane, QLD*
- *115 Batman Street, Melbourne, VIC*
- *500 Collins Street, Melbourne, VIC*
- *40 Albert Rd, South Melbourne, VIC*
- *Trevor Pearcey House, ACT*
- *500 Bourke Street, Melbourne, VIC*
- *187 Melbourne Street, Brisbane, QLD*
- *182 Capel Street, Melbourne, VIC*

An initial desktop review was conducted to determine buildings that had completed retrofits considering multiple nodes of the *Performance Nexus*. This was followed by interviews with key personnel involved in the day-to-day operation of the building, such as building managers and facilities management staff. Interviews were conducted by phone and/or email during August and September 2012. The aim was to explore multi-node and cross-node interactions and distil key lessons that could inform a greater understanding of high performance buildings. The next step involved examining the collection of case studies to identify key lessons that could potentially be transferrable beyond that building to inform a whole-of-building consideration of performance.

3. Results and Discussion

Initially, the research project began by looking at the relationships between design elements, indoor environment quality, and occupant satisfaction. Together, these three areas constitute a standard post-occupancy evaluation framework that provides a reasonable understanding of how certain design elements can impact the internal environment and building occupants. However, it became apparent that it was also important to focus on stakeholder agreements, organisational culture, and building management practices in order to more fully understand the performance potential of commercial buildings. Recently, innovative leasing arrangements are beginning to emerge in Australia and internationally, intended to support high performance objectives (Roussac and Bright, 2012). Tenant agreements may be used to align tenant and owner objectives, and also make various stakeholders accountable for using, managing and maintaining a building effectively. This node therefore looks at what specific areas of commercial leases can encourage or inhibit building performance from both an energy and IEQ perspective. It has also become apparent that the organisational culture of stakeholders within a commercial building, and the communication between all the various parties involved, has a significant impact on performance outcomes and should therefore be considered.

Experience from the trials undertaken during the project suggests that there is often insufficient communication between owners, tenants and building managers, yet successful implementation of any energy efficiency initiatives depends increasingly upon close collaboration between these parties. The Nexus thus included wider consideration of building management, corporate culture and the legal and non-legal agreements in place between tenants and owners to help identify where these could be strengthened. There is also a re-emerging awareness of the key role of occupants in contributing to energy efficiency outcomes. Even the most efficient design elements will not deliver high performance outcomes if they are not being used as per their design intent. The occupant experience questionnaire was thus further refined to include consideration of the education and training that occupants had received to facilitate improved individual comfort and energy efficient operation of the building. For example, instead of just asking if occupants are satisfied with the amount of light, the questionnaire asked if occupants have received any training on how to use lighting systems and shading elements properly, and if they understand how to adjust design elements or use controls. It is possible to compare the results of the Occupant Experience questionnaire to the results of the Building Management and Agreements and Culture questionnaires in order to highlight any communication or information breakdowns.

Analysis of the case studies suggests there is often a focus on installing more efficient technologies in order to improve energy performance, but that the contribution of good building management practices to achieving high performance outcomes are often not given as much coverage. There is an underutilization of occupant surveys and indoor environment quality monitoring as tools to inform better building design and management. Additionally, there is still a lack of focus on using tenant agreements to contribute to improved building performance. There are many opportunities to improve performance by taking a more holistic approach to identify interrelationships between existing building systems and procedures and aligning them for improved performance.

3.1 Addressing multiple nodes in a whole of building approach

When refurbishing a building for energy efficiency there is often a focus simply on installing better design elements in order to improve performance, however if these building systems and technologies are not adequately maintained and operated the entire system will be sub-optimal and may have negative impacts on energy, IEQ and occupant satisfaction. Therefore, it is important to consider other factors that can contribute to improved building performance, such as building management practices, tenant agreements, and occupant education and feedback processes, which when combined represent key factors in understanding building performance.

Improving the energy performance of buildings in a way that also supports a productive workplace is currently not yet well understood. However, providing a framework to assist efforts to revitalise existing buildings such that the dual objectives of energy efficiency and occupant satisfaction are achieved represents a key strategy in transitioning towards a healthy and low carbon society. The resultant '*Performance Nexus'* tool for commercial buildings provides such a framework and is intended to save industry time and reduce the complexity and cost involved in performance improvements. As a pre- and post-retrofit evaluation tool, it can help highlight the impacts of retrofits on a workplace, identify areas that may need improvement, and identify relationships between areas that could be

strengthened. The tool helps guide users through a holistic approach to the building evaluation process, and ensures that key metrics and considerations are included in the process, shown in Figure 1 and Table 2. In summary, the key performance areas are as follows:

- **Design elements**: This node of the *Nexus* focuses on key existing energy efficient design elements within a building and on appropriate additional retrofit technologies that could be considered. The node considers monitoring and control technology; lighting; heating, ventilation and air-conditioning; plant and equipment; building fabric; and the tenancy design and fit out.
- **Building Management**: This node of the *Nexus* considers the way design elements are used and maintained, and how information from the other *Nexus* nodes is used in decision-making processes. The node considers operation and management practices, reporting and evaluation, maintenance and cleaning, commissioning and tuning, management personnel, communication and education, and procurement.
- **Occupant Experience:** This node provides an occupant experience questionnaire that can be used to gather feedback and information from occupants about the building and tenancy. It is important to identify problem areas that are contributing to dissatisfaction in order to rectify the situation, and occupants are often an underutilised source of information. The node considers perceived productivity; communication and reporting; training, education and guidance; and the use of controls.
- **Agreements and Culture:** Agreements can be in two forms, namely ‘hard’ and ‘soft’. Hard agreements include legal agreements such as green leases that affect the occupants of buildings, while ‘soft’ agreements include other non-legal arrangements that can support high performance objectives. This node considers lease agreements; ratings, mandates and incentives; commitments and targets; organisational culture; and communication and education initiatives.
- **Indoor environment quality:** Indoor environment quality can have a significant impact on occupant health and productivity. This node considers basic IEQ monitoring, advanced IEQ monitoring, IEQ management programs, health and well being, and reporting and communication of results.

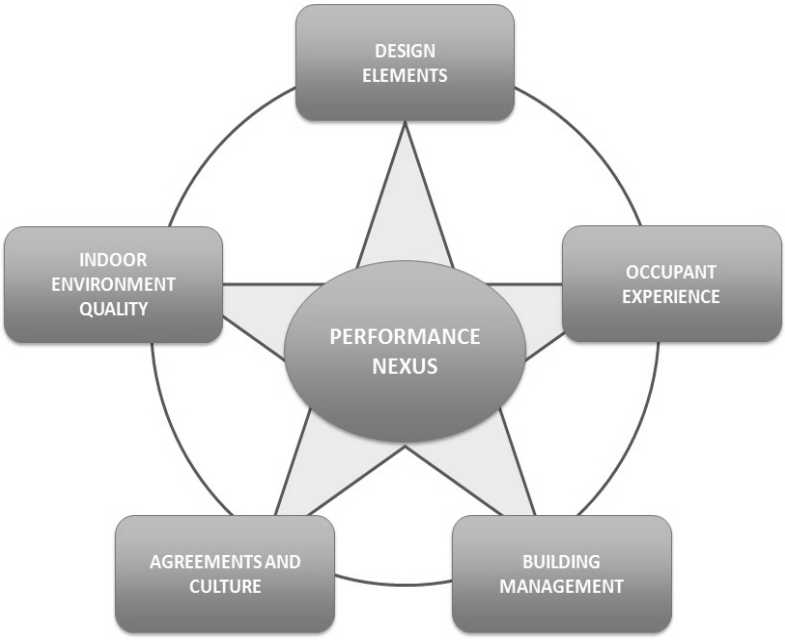

Figure 1: Performance Nexus tool, highlighting the multi-nodal considerations in a whole of building approach to improving performance

Table 2: Summary of considerations for each node of the Performance Nexus

Node: DESIGN ELEMENTS	
- *Monitoring and Control Technology* - *Lighting* - *HVAC* - *Other plant and equipment* - *Building Fabric* - *Tenancy design and fit out*	- *Focusing on physical technologies and systems in the building, this node can inform design of both new buildings and retrofits.* - *Design elements have a large role in the building's energy demand profile, and a focus here can achieve significant energy consumption reductions that, if done holistically, may also improve indoor environment quality and occupant satisfaction.* - *The design elements will be a key determinate of the type and scope of the building's management practices.* - *Design elements are increasingly operated and affected by occupants (e.g. with individual lighting controls and operable windows).*
Node: BUILDING MANAGEMENT	
- *Operation and management practices* - *Reporting and evaluation* - *Maintenance and cleaning* - *Commissioning and tuning* - *Management personnel* - *Procurement*	- *Building management can directly impact the energy performance of a building, while indirectly impacting the indoor environment quality and occupant experience.* - *Substantial reductions in energy can be achieved using existing technology, focusing on the way design elements are used and maintained, and how information from other nodes is used.* - *Building management is often a combination of automated systems, routine schedules and user interfaces.*
Node: OCCUPANT EXPERIENCE	
- *Occupant satisfaction and perceived productivity* - *Communication and reporting* - *Training, education and guidance* - *Use of controls*	- *When considered with the other nodes of the Nexus , occupant experience may be the most accessible way to inform efforts to create a productive workplace.* - *Although interpretation of survey results in the workplace is difficult, it can increase understanding about the potential response of occupants to changes to reduce energy demand.* - *Engaging occupants in the design of energy conservation initiatives is also a way to increase occupants' support for and involvement in such programs to assist in their implementation.*
Node: INDOOR ENVIRONMENT QUALITY (IEQ)	
- *Basic IEQ monitoring* - *Specialised IEQ monitoring* - *IEQ management programs* - *Health and well-being* - *Communication of results*	- *The indoor environment quality can have a significant impact on occupant health and wellbeing that may affect productivity. Initiatives to reduce energy consumption need to ensure they don't negatively affect IEQ.* - *Monitoring and considering key IEQ parameters can provide valuable insights that enhance energy demand reduction programs.* - *Consideration of IEQ covers a number of parameters, including air quality and ventilation, acoustics, lighting and thermal comfort.*
Node: AGREEMENTS AND CULTURE	
- *Lease arrangements* - *Organisational Culture* - *Communication and education* - *Ratings, mandates, and incentives* - *Commitments and targets*	- *This covers the types of binding and non-binding agreements between the various building stakeholders such as owners, building managers, facilities managers, service providers, tenants and occupants.* - *It considers emerging legal instruments such as green leases that can underpin greater energy conservation and improved IEQ (e.g. covenants to repair, break clauses, relocation notices, rent and rent review clauses, and gross / net leases)* - *It also considers social aspects including organisational culture and communication practices.*

3.2 Enquiry methods for node evaluation

The *Performance Nexus* has been designed to consider both the base building and tenancies through the use of structured surveys. The Design Elements node of the *Nexus* can act as an anchor point with each element being examined across each of the other four nodes. Structuring the *Nexus* in this way enables building stakeholders to assess what design elements are in place, investigate how these are being managed and what other agreements and systems are being used to support performance objectives, and also to consider how effective these are through the IEQ and occupant experience components, as shown in Table 3 for the case of lighting.

Table 3: Example of application of each node of the Nexus to 'lighting'

Design Element	IEQ	Occupant Experience	Building Management	Agreements and Culture
Is the lighting system energy efficient?	*Are the lux levels sufficient and suitable for tasks?*	*How satisfied are occupants with light levels and lighting controls?*	*Is there a maintenance schedule for lighting?*	*Is there a fit out guide in place for lighting systems?*

The *Performance Nexus* can be used to identify links between the five key performance areas and to generate strategies for improvement, as illustrated in Table 3. Table 4 shows a sample of how each of the key performance areas in the *Performance Nexus* can be harnessed to enhance energy efficiency initiatives.

Table 4: Sample of interactions between various nodes of the 'Performance Nexus'

DESIGN ELEMENTS This node focuses on the effectiveness of the lighting design as it has a major impact on occupant satisfaction and energy demand in the building. Electric lighting is a large user of energy and also generates waste heat which places additional load on building HVAC systems, estimated to account for up to 15-20 per cent of cooling demand.	
BM	Ensure lighting controls are in accessible locations with clear labelling or occupants will not use them. Consider reducing maintained artificial illuminance levels in general office areas and providing task lighting.
AC	Consider the inclusion of specific energy and IEQ performance requirements for lighting in tenant leases. These can be supported by education on use of lighting controls and how this impacts building performance.
OE	Consider the occupant experience of the level and quality of light as improved lighting can increase individual productivity though increased working speed, reduced error rate, and improved concentration.
IEQ	Check the actual lighting levels at workstations horizontally and vertically to assess compliance with guidelines for workstations and general areas. Supplement with task lighting where required to improve productivity.
BUILDING MANAGEMENT This node focuses on the processes to ensure design lighting levels are maintained, as cleaning lights can improve output by as much as 25-30 percent. Poor maintenance and management of installed luminaires can negate the benefit of any retrofits.	
DE	Ensuring high efficiency lighting is maintained with correctly matched lamps and ballasts can reduce energy consumption. Commissioning ensures correct equipment compatibility for optimal efficiency.
OE	Ensuring lighting quality is monitored and faulty lamps replaced reduces disruption to staff and avoids negative impacts on productivity and occupant experience. Appropriate lighting layout and design can reduce glare and reflections that may affect visual amenity inside the building.
IEQ	Good building management practices such as regular cleaning of lamps, luminaires and surfaces can increase light output, potentially avoiding the need for lighting retrofits or facilitating de-lamping options.
AC	Implement policies to ensure contractors and maintenance staff are informed of correct lighting components and replacement schedules.

INDOOR ENVIRONMENT QUALITY This node focuses on the impacts of lighting design and maintenance on the quality of the indoor environment. This is important as the costs of low productivity and illness in a workplace can be 100 to 200 times the cost of energy bills, with just a 1% productivity change in Australia equating to AUD $1.2 billion.	
DE	Encourage increased natural day-lighting over artificial lights using correct tinting on windows and external or internal shading as this reduces energy consumption.
OE	Encourage increased natural day-lighting as studies have shown that this can lead to increased worker productivity, reduce absenteeism, Increased vitamin intake, and mood improvements.
BM	Ensure lights and windows are adequately maintained to maximise light levels and consistency. This can be done through schedules that can also include checks on wattage and fixture conditions.
AC	Consider policies for restricting after-hours light use, providing adequate labelling and mapping of light switches, and providing clear reporting procedures for complaints on lighting.
OCCUPANT EXPERIENCE This node seeks to identify if occupants know how to use available lighting controls including light switches, external shadings, internal blinds, and desk task lighting. Effective use of lighting controls by occupants can reduce energy consumption by more than 30 percent.	
DE	Consider the inclusion of occupant controls in the design as this can dramatically reduce energy demand with occupants turning off lights that are not in use and reducing lighting levels to meet task requirements. Providing some degree of control over lighting levels also has a large impact on satisfaction.
IEQ	Measure lighting levels to ensure that they are within recommended task lighting requirements, as users may have differing tolerance for lighting levels that may change if they are informed about recommended levels.
BM	Check occupants are aware of correct communication channels to report lighting issues. Good communication with occupants and prompt response to lighting complaints and can avoid dissatisfaction and distraction.
AC	Consider policies that ensure minimum task lighting standards are met as per appropriate guidelines and design standards. Provide education to ensure occupants understand how to operate the lighting system to improved energy efficiency and individual comfort.
AGREEMENTS AND CULTURE This node investigates if the organisation considers sustainability or energy efficiency as part of their core strategy and if this focus is embedded in the culture.	
DE	Consider policies that require the use of efficient lighting technologies to ensure that replacements are in line with the design intent, such as part of 'repair and alteration' clauses in lease agreements.
OE	Building organisational culture around sustainability can assist encouraging occupants to take ownership and more responsibility for their actions which impact performance.
IEQ	Consider policies that require compliance with minimum lighting levels to ensure that appropriate lighting is provided and daylighting is harnessed where appropriate.
BM	Consider policies that set minimum requirements for maintenance schedules to ensure efficient operation of lighting, such as part of 'repair and alteration' clauses in lease agreements. Consider policies for after-hours lighting use, adequate labelling and mapping of light switches, and reporting procedures for complaints.
BM: Building Management DE: Design Elements OE: Occupant Experience **IEQ: Indoor environment Quality AC: Agreements and Culture**	

4. Conclusion

This project focused on creating a tool, the *Performance Nexus*, to assist efforts to improve the energy performance of existing commercial buildings while fostering a productive environment, considering five key interdependent areas of building performance; namely 'Design Elements', 'Building Management', 'Agreements and Culture', 'Occupant Experience' and 'Indoor Environment Quality'. The tool has been developed through research, stakeholder workshops, and trials on buildings, to identify the key metrics and

considerations related to building performance that need to be considered when designing an intervention. The research took into account a range of key factors influencing the energy performance of buildings, including the actual physical design elements, the way the building is operated and maintained, the experience of occupants, legal and non-legal agreements and the quality of the indoor environment. The project suggests that the tool is a low cost, low complexity approach that can be used to encourage the greening of existing commercial buildings with a focus on energy efficiency and enhanced productivity. The project's research output includes an accompanying workbook to guide building stakeholders through a process of identifying issues preventing their building from operating at an optimum level for energy efficiency and for the health of occupants.

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