Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 00 (2017) 000–000

Procedia Engineering

www.elsevier.com/locate/procedia

International High- Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016

Development of a regenerative design model for building retrofits

W. Craft[a,] *, L. Ding[a], D. Prasad[b], L. Partridge[a], D. Else[c]

[a]*Faculty of the Built Environment, University of New South Wales, Sydney 2052, Australia*
[b]*CRC for Low Carbon Living Australia, Tyree Energy Technologies Building UNSW, Sydney 2052, Australia*
[c]*Brookfield Multiplex, 22/135 King St, Sydney 2000, Australia*

Abstract

Current building retrofits are predominantly focused on energy and cost efficiency at an individual building or building component scale. Whilst the aspirations of these retrofits are crucial to the sustainable development of our built environment, we can and need to do better. Many argue that we need a shift in worldview from mechanistic to regenerative, and in order to do so we must engage with the living world by (re)aligning human and natural systems. This paper proposes a 'proactive' retrofit approach which seeks to integrate net-positive, restorative and regenerative design concepts into building retrofits. A regenerative design model that explores the key interactions between physical, human and natural systems is developed to achieve these proactive outcomes. A set of regenerative design principles for building retrofits are proposed to emphasise the positive interactions an existing building can have with its surrounding environment. More specifically, this paper will explore how an energy efficient building retrofit can improve occupant health and wellbeing, and restore and enhance local ecosystems. A detailed example will then be used to demonstrate the principles as a means of shifting the way designers and decision makers view the building retrofit design process.

Keywords: Building Retrofit; Regenerative Design; Energy Efficiency; Health and Wellbeing; Ecosystem Restoration

* Corresponding author. Tel.: +61 424 332 811.
E-mail address: w.craft@unsw.edu.au

1. Introduction

Current sustainable or green approaches to building retrofits are a result of a technological driven mindset that reduces a building to its components to achieve a greater cost or energy efficiency. This mechanistic approach to achieving certain sustainability standards or ratings leads to a fixation on reducing the ‘negative’ impacts a building can have. Although these aspirations are crucial to the development of sustainable, green or high performing buildings, we can and need to do better than this. Many believe that in order to do so we require a fundamental shift in worldviews towards a regenerative one [1,2,3,4,5,6]. This requires moving away from a fear-based approach focused on scarcity of resources, uncertainty and sacrifice towards a positive model which aligns humanity within a larger community of life [5].

This shift towards regeneration is manifested in *BNIM’s* (Berkebile Nelson Immenschuh McDowell) REGEN tool [7] and *CLEAR’s* (Centre for Living Environments and Regeneration) LENSES framework [8], alongside existing frameworks such as One Planet Living and the Living Building Challenge. As a result there are very promising examples of buildings designed within this regenerative worldview. While most, if not all of these frameworks can be applied to building retrofits, the majority of these buildings seem to be new developments in unique or favourable locations. Considering that in developed countries the majority of buildings which will exist in 2050 have already been built [9], it is essential that building retrofits start to make this shift towards regeneration. Interventions should therefore be seen as an opportunity to produce and regenerate rather than just damage control. However these opportunities cannot be realised solely at a building scale. A single building retrofit must go beyond its site boundaries and positively interact with its surrounding human and natural systems in order to shift to this regenerative paradigm.

This paper will explore how the concept of regeneration can start to be applied specifically to building retrofits. A ‘proactive’ retrofit approach is proposed which seeks to integrate net-positive, restorative and regenerative design concepts into building retrofits. A regenerative design model that considers the key interactions between physical, human and natural systems within the built environment is developed to achieve these proactive retrofit outcomes. This involves the development of regenerative design principles for building retrofits that emphasise the positive interactions a building can have with its surroundings. By promoting these positive interactions, the focus of building retrofits can now be to support, maintain and enhance a co-partnered relationship between human and natural systems.

2. Regenerative Design and Development

If we do not make this fundamental transition towards regeneration it will be impossible to go beyond simply slowing the rate of depletion and degradation [3]. In order to do so we must engage with the living world by (re)aligning human and natural systems. Pamela Mang and Bill Reed support this by defining regenerative design as the “reconnection of human aspirations and activities with the evolution of natural systems – essentially co-evolution [3].” Chrisna du Plessis suggests that the two underlying questions of this regenerative worldview are, ‘how can we learn to live in harmony with nature’ and ‘how can our efforts make the world a healthy and life-enhancing place [2]’?

The first step towards regenerative design and development is not a change of techniques but a change of mind [3]. This is emphasised through the development of a regenerative methodology by Regenesis which provides a set of guiding principles and concepts grounded in this regenerative worldview. This approach has three phases, understanding the right relationship to place, designing for harmony and co-evolution. An understanding of place highlights the importance of a shared connection to place and belonging, designing for harmony presents the vision of what could be, and co-evolution ensures the ongoing mutually beneficial integration of human and natural systems [5].

Janis Birkeland also explores this paradigm shift with her Positive Development which suggests that the natural life support systems must grow in proportion to increases in population, poverty, pollution and biodiversity losses [1]. Positive Development actively seeks opportunities to create net-positive outcomes so as to expand both the ecological base (natural life supporting system) and the public estate (access to means of survival) beyond presettlement conditions [5]. Birkeland suggests that to support current human systems, “cities must be retrofitted to increase indigenous ecosystems and eco-services [1].”

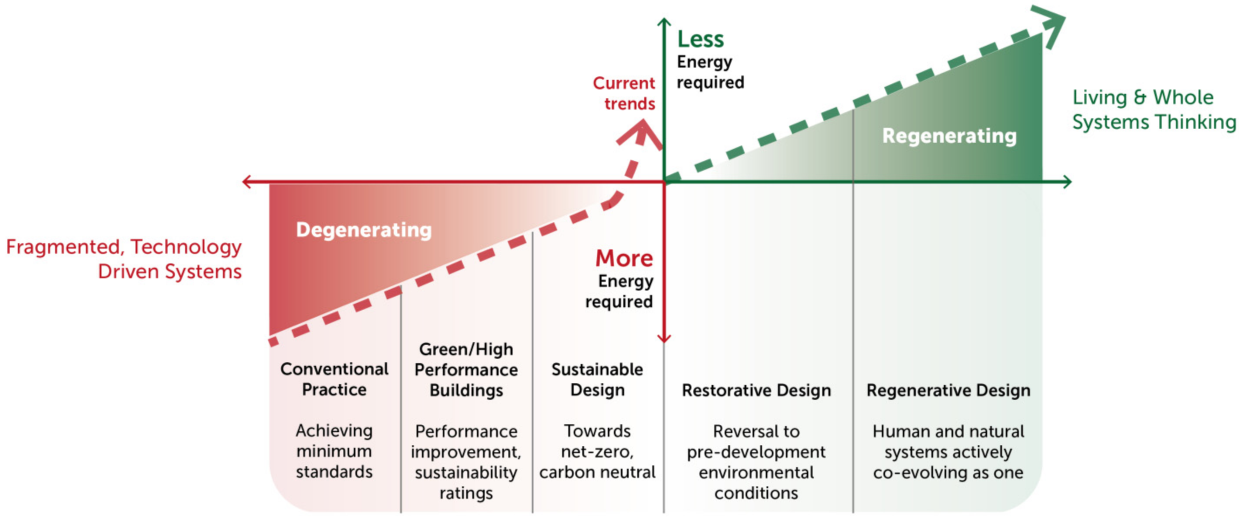

Fig. 1. Range of sustainability approaches. (Developed from Bill Reed, 2007 [10])

Figure 1 highlights the range and trajectory of the different sustainability approaches so as to emphasise the need to shift from degenerating to regenerating systems. The fragmented, technological driven systems that are evident in today’s conventional, green and high performing buildings can only hope to achieve a net-zero or carbon neutral impact. Current approaches to sustainable design in the built environment tend to fall into these degenerating systems as there is a strong focus on reducing any negative impacts of a design by improving the efficiency of its components. In order to shift towards restorative and regenerative design, less emphasis needs to be placed on an isolated element or building and more on a design process that focuses on the evolution of the whole system. However, Bill Reed suggests that these sustainability approaches and their trajectory are a progression and not exclusive of one another as all practice levels are necessary to achieving this change towards regeneration [10].

3. Regenerative Design Model for Building Retrofits

3.1. Reactive to proactive retrofitting

The ‘Levels of Work’ framework (Fig. 2) depicts the four levels of work in which every living system must continually engage to increase its vitality, viability and capacity for evolution [3]. It is applied here to introduce a ‘reactive’ and ‘proactive’ approach to building retrofits. The below-the-line concepts of operating and maintaining deal only with what is in existence whilst the above-the-line concepts of improving and regenerating explore the creativity and potential in relationship to the larger system [3]. Current approaches to retrofitting with a focus on efficiency and performance standards are therefore below-the-line as they are simply ‘reacting’ to negative events or outcomes. Although this is fundamental to achieving a high performing or green building, it does not tell the whole story. A ‘proactive’ building retrofit seeks to integrate net-positive, restorative and regenerative concepts by interacting with its surrounding human and natural systems. However, what is crucial to a system’s ongoing health and capacity for evolution is its ability to work at all four levels [5]. To achieve proactive outcomes for building retrofits therefore requires not only an awareness of a building’s components and performance, but a deep understanding of the ‘place’ in which it is situated. Consequently, this research proposes a regenerative design model to explore the potential interactions an existing building can have within its larger system.

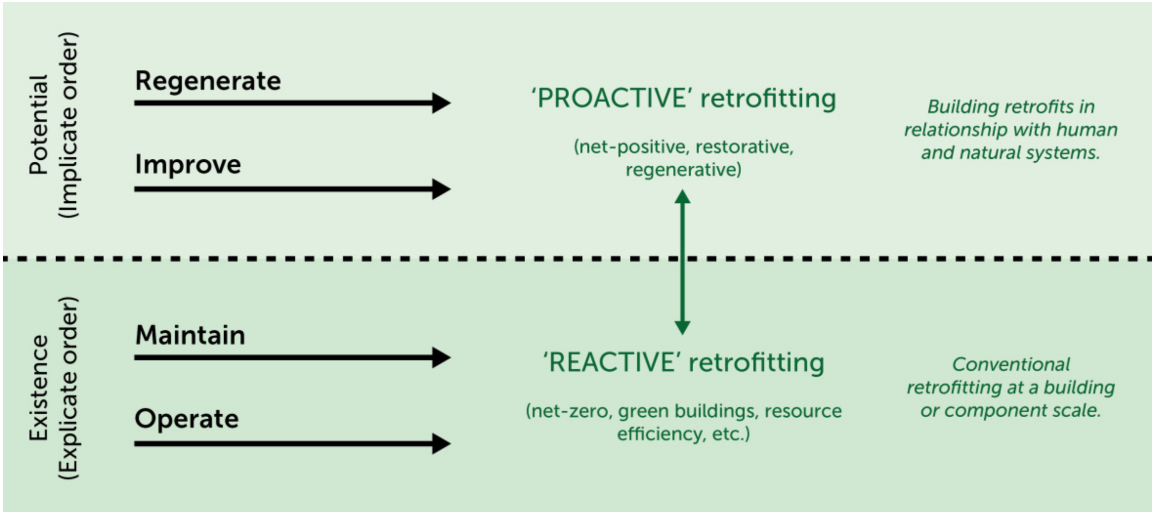

Fig. 2. 'Levels of Work' used as a conceptual framework for regenerative building retrofits. (Developed from original by Charles Krone, in Mang and Reed, 2012 [3])

3.1.1. Measuring proactive outcomes

At the core of this challenge to transition towards net-positive, restorative and regenerative design is "the need to reconcile the widely different interpretations of value and value-adding [4]." The fundamental question is then what constitutes as a 'proactive' building retrofit and how can it be measured? Svec et al. suggest that attempts to use metrics, indicators, or other devices to measure the impact of strategies to achieve these outcomes is fairly weak and unresolved [7]. Despite this, Janis Birkeland's 'Positive Development' highlights how existing models, methods and metrics can be reversed and converted from negative to positive [1]. Furthermore, the LENSES framework positions project outcomes on a scale ranging from degenerative to regenerative. This scale moves away from prescriptive metrics towards descriptive metrics to allow for flexibility and contextual or 'place' based design solutions [8]. As this research is further developed, a similar metric to those mentioned above could be incorporated into the following preliminary regenerative design model. This will enable designers to prioritise and implement appropriate retrofit strategies to achieve 'proactive' outcomes.

3.2. Preliminary regenerative design model

Achieving proactive retrofit outcomes requires an understanding of the physical built environment so as to improve resource efficiency, and an exploration of how this can enhance social connections and strengthen a connection to nature. More specifically, the preliminary regenerative design model developed in this research (Fig. 3) will consider how an energy efficient building retrofit could also improve occupant health and wellbeing, and restore and enhance local ecosystems. The cost-benefit of this approach to retrofitting is an important factor but as it is heavily influenced by project specific factors it has been left out of the model at this stage. Identifying the potential interacting components between these three dimensions and extracting the key interactions will facilitate the development of a set of regenerative design principles for building retrofits.

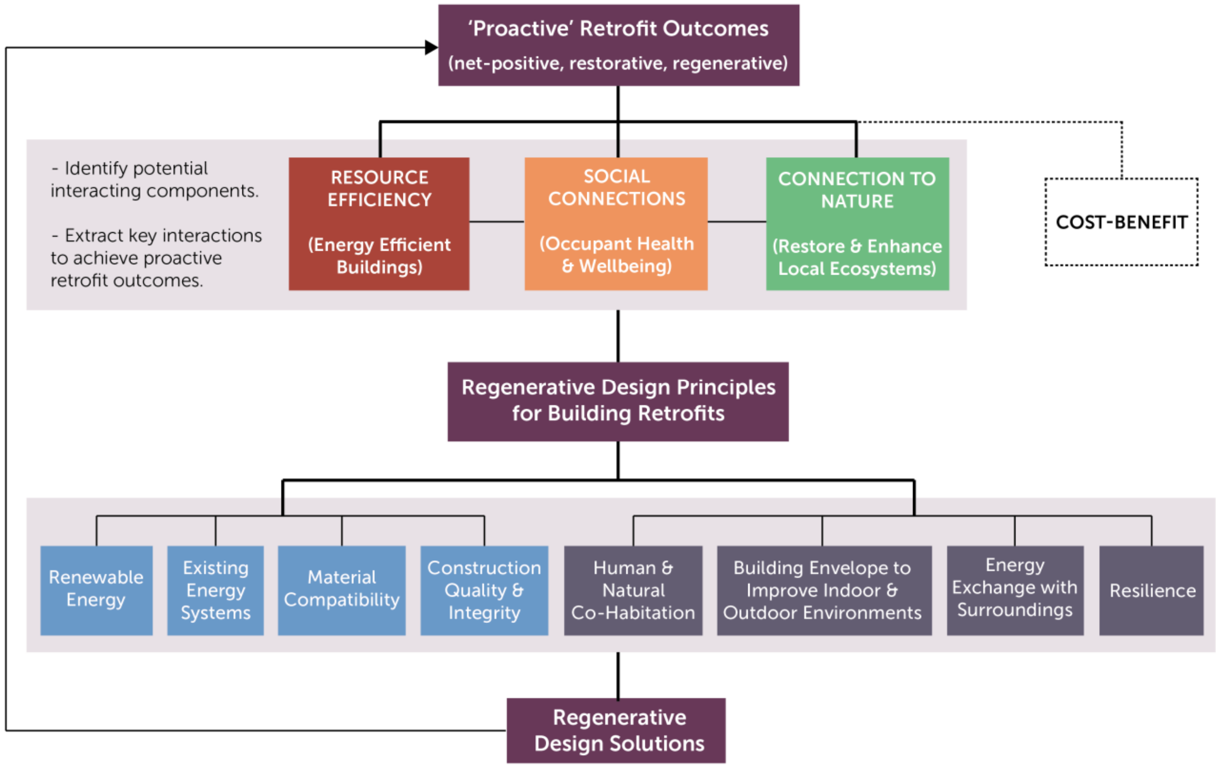

Fig. 3. Preliminary regenerative design model for building retrofits.

3.3. Identifying and extracting key interactions

Figure 4 highlights the potential interacting components for building retrofits between the physical environment, human systems and surrounding natural systems in the proposed model (shown in red, orange and green respectively). Although improving energy efficiency and occupant health and wellbeing remains at a building scale, it is restoration and enhancement of a building's local ecosystem that enables the retrofit focus to expand beyond its site boundaries. In this way, the identification and extraction of the key interactions must cross all three dimensions to ensure a proactive retrofit outcome. Each dimension can spin on a central pivot to explore the potential interactions between each of the components (developed from [8]). This provides a framework for designers or decision makers to question the interconnectedness of the different components of each dimension, for example, to consider how a material choice could improve indoor environmental quality but also mitigate the surrounding urban microclimate. This process of identifying and extracting the key interactions between physical, human and natural systems provides a strong foundation on which to develop a set of design principles to shift building retrofits towards regeneration.

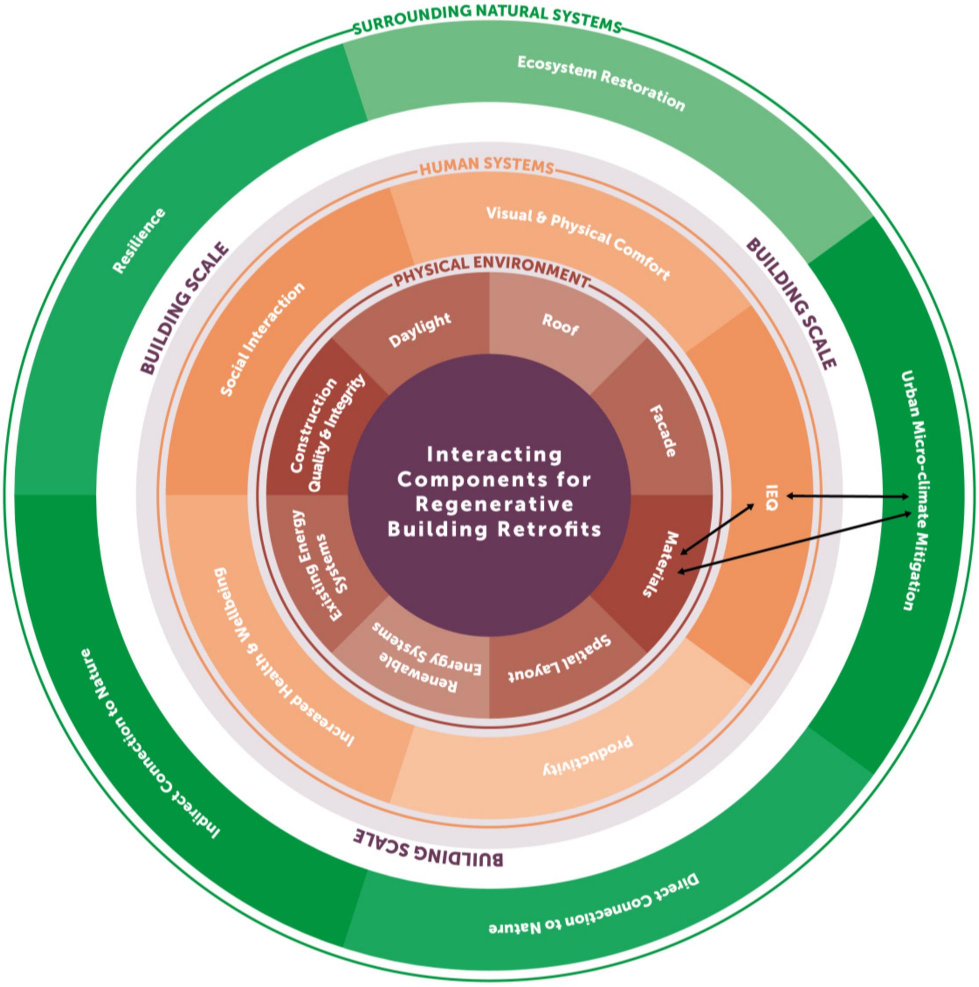

Fig. 4. Potential interacting components for regenerative building retrofits.

4. Development of Regenerative Design Principles for Building Retrofits

4.1. Importance of place

The first step to achieving a regenerative building retrofit is to develop a deeper understanding of not only an existing building but the ‘place’ in which it is situated. A regenerative definition of ‘place’ goes further than the contextual factors of topography, climate, light and tectonic form [5]. It is a concept that emerges from the whole network of systems and the complex interactions between these systems within a geographical area. Before specifying any positives an existing building can generate, a deeper understanding of its place is required by asking:

- What patterns, dynamics and relationships between physical, human and natural systems characterize this specific place? Do they add positive value to the whole system?
- What is the existing role of this building? Does it enable or diminish the ability of others to play their role? Does it need to change [4]?
- What are the major issues preventing the building from improving its own performance and its ability to add positive value to its occupants and the local ecosystem?

4.2. Regenerative design principles for building retrofits

It is only from this deeper understanding of place that one can identify the issues preventing an existing building from shifting towards regeneration. As these regenerative design principles for building retrofits (Fig. 5) are developed from the interactions between physical, human and natural systems, it is the identification of these 'place-specific' issues that will ultimately determine the appropriate selection and application of principles. Although these principles are still under development, they seek to shift the building retrofit design process towards regeneration by considering the larger system. The 'proactive' retrofit approach incorporates principles that enable a building to add positive value to its surroundings, while the 'reactive' retrofit approach focuses on principles of more conventional building retrofits. Despite the 'proactive' approach being the focus of this research, it is important to note that a 'reactive' approach provides the foundation on which to expand potential intervention options.

Fig. 5. Regenerative design principles for building retrofits (under development).

Supporting human and natural co-habitation involves providing intervention strategies that increase a human's visual and physical connection to nature. This includes the provision or alteration of shared spaces to incorporate nature and facilitate opportunities for social interaction. This principle would actively retrofit either vertical or horizontal spaces to support local food production and provide indigenous wildlife habitats in order to increase biodiversity. Numerous ecosystem benefits could be seen as a result of this principle, but of equal importance is its potential to (re)connect building occupants to nature so as to co-evolve as one.

The building envelope improving not only the indoor environment but restoring the local ecosystem enables an existing building to have multiple health benefits for human and natural systems. Integrating nature and natural systems into the retrofit of a building envelope (roof or façade) drastically improves the internal environment with regards to thermal comfort, natural ventilation, air quality, daylighting and can also reduce the building's heating and cooling loads. This building envelope would also enhance the external environment by mitigating the surrounding urban microclimate and supporting wildlife habitat connectivity.

A positive energy exchange with the surrounding built environment requires the effective management and storage of excess renewable energy produced. In addition to a two-way exchange with the grid, this would allow an existing building to implement energy sharing strategies and initiatives with surrounding buildings and infrastructure.

Retrofitting for resilient buildings will enable building or building components to be adaptable, demountable, reversible and durable where possible. This allows the building to evolve and account for future changes in technology or climatic conditions. Figure 6 illustrates these principles for a 'proactive' retrofit approach and highlights the potential for an existing building to improve its own performance and interact with its surroundings.

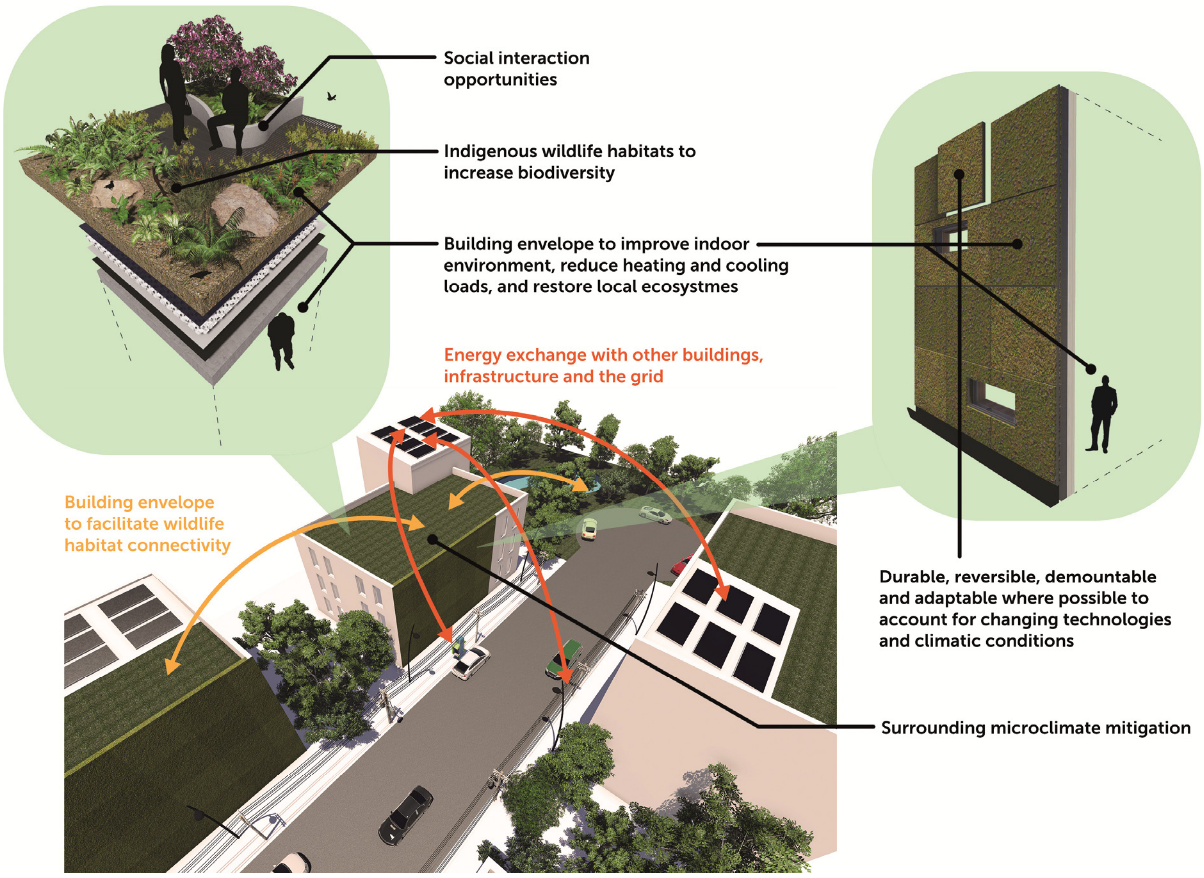

Fig. 6. Illustration of the regenerative design principles for building retrofits.

5. Application of Regenerative Design Principles for Building Retrofits

5.1. Building context and issues

The chemical science building at the University of New South Wales was selected as an example to demonstrate the potential of these design principles. The building was added to in 2007 but the 10 storey tower itself has remained since the mid-late 1960s. As mentioned previously, before these principles can be applied to a building retrofit a designer must understand the building's place in order to identify the potential issues.

Currently the chemical science building is not inviting to its occupants due to its dominant size and outdated design, and as a result may have a detrimental effect on the health of staff and students even before entering the building. It has a high energy demand and the building footprint and placement of mechanical equipment offer very little opportunities to counteract this simply with PV energy generation. As an educational building, there is a strong relationship between the physical building and the health and productivity of its occupants. Currently, this building does provide the facilities for a learning environment but there are minimal spaces to encourage social interaction and improve its occupant's health and connection to nature. In addition to this, the chemical science building does not actively engage with its surrounding environment as it visually and physically separates university occupants, both human and wildlife. Given more time, a deeper understanding of this building's place would be acquired to determine the appropriate selection and application of design principles, which would result in a more comprehensive design solution.

5.2. Preliminary retrofit design concept

Ensuring that the building's materials are compatible with the surrounding environment has the ability to reduce the heating and cooling loads. The addition of high performance glazing on the south and north facades of the building is one strategy implemented to achieve this principle. Improving the construction quality and integrity provides the opportunities to expand potential retrofit options. Balconies on the north façade were added to the building through the provision of additional columns and slab strengthening (Fig. 7). Although these two design principles and strategies are not directly addressing the issues identified above, they do provide the foundation on which to implement the other principles.

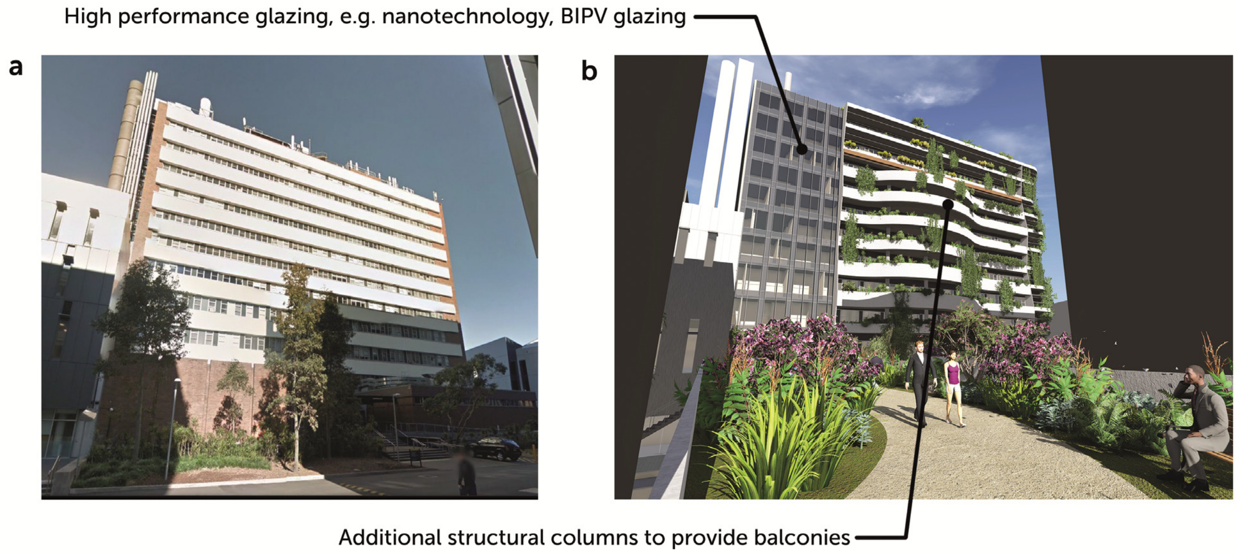

Fig. 7. (a) Existing building's north façade; (b) Retrofitted building's north façade.

Supporting human and natural co-habitation was identified to address the issue of social interaction and to improve an occupant's health and connection to nature. This involved creating a visually engaging entrance to the building from the university main walkway. This entrance integrates natural elements with social interaction spaces in order to strengthen an occupant's connection to nature and to improve their health and wellbeing upon entering the building (Fig. 8). The retrofitted tower façade enables the building to engage with its surrounding natural system by providing indigenous wildlife habitats to increase biodiversity. In this way the building can support all university occupants, both human and wildlife, as the façade acts as a vertical ecosystem.

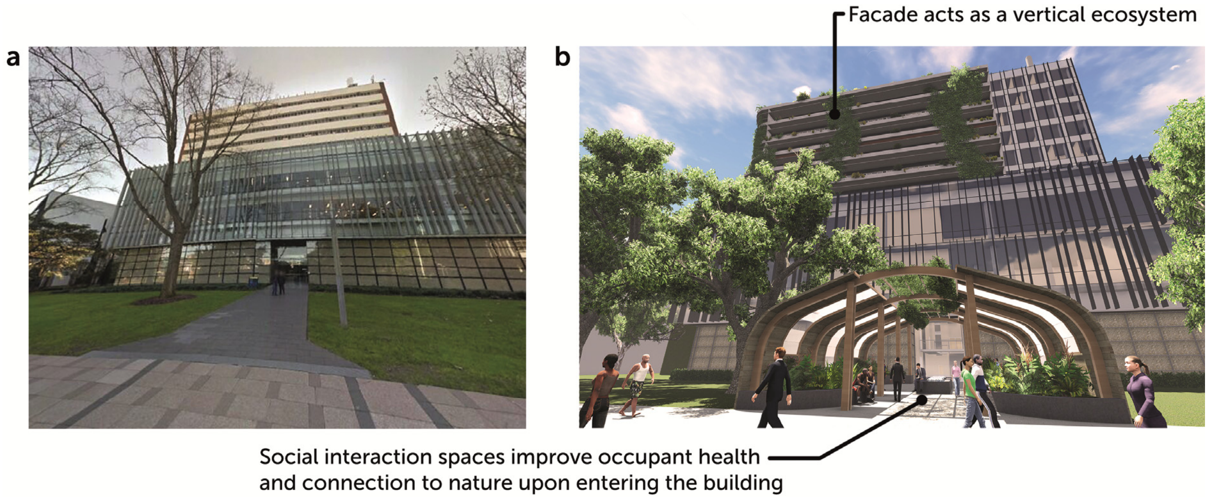

Fig. 8. (a) Existing building from university main walkway; (b) Retrofitted building from university main walkway.

Retrofitting the building envelope to improve the indoor environment and restore the local ecosystem allowed the building to improve not only its performance but the health of the surrounding natural systems. The retrofitted façade extends to integrate planter boxes which not only naturally shades the building for reduced heating and cooling loads, but assists with mitigating the urban heat island (UHI) effect (Fig. 9). The provision of balconies on the north façade with planter boxes also has the potential to improve the building occupant's health and productivity by strengthening their connection to nature. To address the issue of visual and physical separation for wildlife and university occupants, a raised green roof platform is proposed over the street on the northern side of the building. In addition to providing a space for social interaction, this platform also facilitates wildlife connectivity through the careful selection and placement of vegetation.

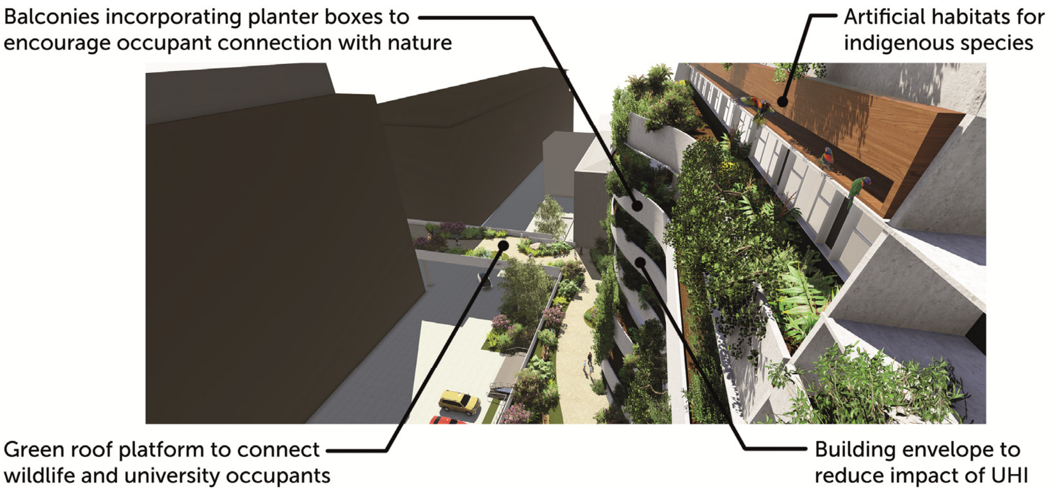

Fig. 9. Detailed view of retrofitted building's north façade.

While this building retrofit example is only a preliminary design concept, this idea of a building envelope to improve indoor quality and restore the surrounding environment is clearly evident in the work of eco-architect Ken Yeang. His 'Solaris' building in Singapore emphasises an ecological approach to building design with a 1500m perimeter 'green ramp' which wraps around the façade of the building (Fig. 10). This ramp allows for "fluid movement of organisms and plant species between all vegetated areas within the building, enhancing biodiversity and contributing to the overall health of these ecosystems [11].” Furthermore, the green areas of this building not only reduce its overall energy consumption, but provide social and interactive natural environments for occupants, as well as mitigate urban heat island effects. Therefore, the success of this building lies in its ability to link energy efficiency and occupant health to the restoration of a previously damaged ecosystem. Solaris is briefly introduced in this paper to demonstrate that we currently have the means and technology to explore these complex interactions in the built environment to achieve ‘proactive’ outcomes.

Fig. 10. An extensive ‘green ramp’ wraps around the building’s façade. (T. R. Hamzah & Yeang Sdn. Bhd.)

6. Discussion and Future Work

By introducing a ‘proactive’ approach to building retrofits, this paper has touched on the importance of ‘place’ in achieving regenerative outcomes. As discussed previously, the idea of place is about looking at the whole network of systems and the complex interactions between these systems. So designing from place within this regenerative worldview requires not only a focus on the individual building but also on its surrounding social and natural context. As the nature of retrofitting means there are already many of these systems in existence, it is crucial that a designer can identify and address the issues with a building within this larger context. Ultimately, it is the ability to simultaneously work at and transition between the individual building scale and its ‘place’ that will enable building retrofits to make this shift towards regeneration.

This research will continue to explore how this idea of place can be effectively integrated into the retrofit design process. The regenerative design principles will need to be further developed and refined to emphasise how a building retrofit can not only improve individual performance, but also the health of its surrounding systems. This will involve further investigation into the emerging retrofitting approaches, techniques and technologies, to ensure these principles are adaptable for different building types.

Acknowledgements

I would like to thank the CRC for Low Carbon Living Australia for this post graduate research scholarship and Facilities Management at the University of New South Wales for access to building plans.

References

[1] J. L. Birkeland, Positive development and assessment, Smart and Sustainable Built Environment 3 (1) (2014) 4-22.
[2] C. du Plessis, Towards a regenerative paradigm for the built environment, Building Research & Information 40 (1) (2012) 7-22.
[3] P. Mang, B. Reed, Designing from place: a regenerative framework and methodology, Building Research & Information 40 (1) (2012) 23-38.
[4] P. Mang, B. Reed, The nature of positive, Building Research & Information 43 (1) (2014) 7-10.
[5] D. Hes, C. du Plessis, Designing for hope: pathways to regenerative sustainability, Routledge, New York, 2015.
[6] R.J. Cole, et al., A regenerative design framework: setting new aspirations and initiating new discussions, Building Research & Information, 40 (1) (2012) 95-111.
[7] P. Svec, R. Berkebile, J.A. Todd, REGEN: toward a tool for regenerative thinking, Building Research & Information 40 (1) (2012) 81-94.
[8] J.M. Plaut et al., Regenerative design: the LENSES Framework for buildings and communities, Building Research & Information 40 (1) (2012) 112-122.
[9] United Nations Environment Programme, Buildings and Climate Change: Summary for Decision-Makers, 2009.
[10] B. Reed, Shifting from 'sustainability' to regeneration, Building Research & Information 35 (6) (2007) 674-680.
[11] A. Welch, Solaris Singapore Development, <http://www.e-architect.co.uk/singapore/solaris-singapore>, 2016 (accessed 26 September 2016).