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STUDY ON THE IMPLEMENTATIONS OF SUSTAINABLE ARCHITECTURE STRATEGIES IN INNOVATION PRECINCT DESIGN

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ABSTRACT

The increase in carbon emissions and energy consumption due to the development of high-tech infrastructure has made the implementation of sustainable architecture strategies arise as a solution to reduce environmental impact. One of which raising this concern includes Melbourne Connect that has achieved numerous sustainability awards. This research explores two main questions: (1) What are the sustainable design strategies implemented at Melbourne Connect? and (2) How do these strategies contribute to sustainability? This research uses a qualitative approach and thematic analysis based on Sassi's Strategies for sustainable architecture theory, using data sources from literature study, video recording, and field observations. The results show that Melbourne Connect has implemented all components within Sassi's theory, represented by sustainable design strategies such as brownfield site utilization, porosity principle, natural elements, waste & rain water collection system, solar panel usage, and energy efficient façade design. These strategies are proven to not only reduce overall energy consumption by 40-50% compared to conventional buildings, but also create collaborative and healthy community. Therefore, Melbourne Connect can serve as an appropriate exemplar for the design of future sustainable innovation precincts.

Keywords: Sustainable Architecture, Innovation Precinct, Melbourne Connect.

1. Introduction

Industry 4.0, characterized by technological advances such as artificial intelligence, Internet of Things (IoT) and robotic automation, has changed the way production processes are executed through autonomous networks and real-time responses. These changes require workers to continuously update their skills to support rapid economic growth [1], [2], [3]. To this end, lifelong learning is becoming increasingly important for workers to adapt and upskill in dynamic work environments [4]. Innovation precincts are essential to this transformation, linking industry, education and research sectors to create high-skilled jobs and diversify the economy [5], [6], [7]. Innovation precincts provides an environment that supports workforce competencies while fostering innovation for Industry 4.0 through physical and digital infrastructure that enables high-tech-based economic activities [3]. However, viewed from another perspective, the rapid development of these technologies also has the potential to cause significant environmental impacts. The use of advanced technologies, while improving efficiency, often leads to pollution, increased waste and excessive energy consumption [8], [9]. Infrastructure based on high-tech innovation, such as innovation precincts, often produces a large carbon footprint and contributes to unsustainable energy use, which may be detrimental towards environmental sustainability.

Sustainability issues in infrastructure development, especially in high-tech buildings that has the potential to consume excessive energy, are crucial given that the building and construction sector already accounts for more than 35% of global energy use and nearly 40% of energy-related CO_2 emissions, most of

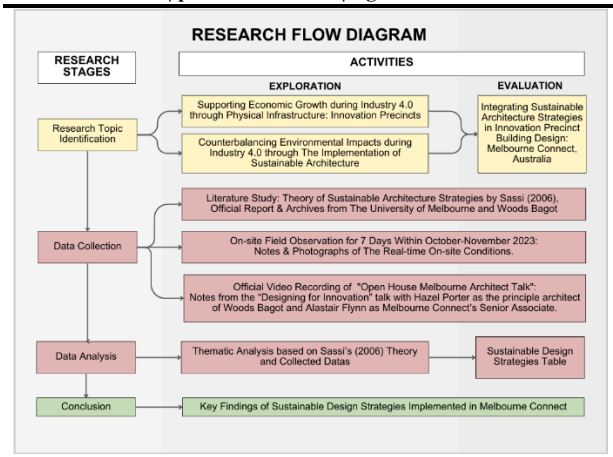
which are still dependent on fossil fuels [10], [11]. The huge environmental impacts generated by this sector not only have the potential to damage global ecosystems, but also threaten long-term environmental resilience that can exacerbate climate change issues. Therefore, the concept of ideal development globally is now shifting towards development that is more responsive to environmental issues, with the aim of protecting nature from the threat of human-induced degradation [12]. For this reason, it is important for future infrastructure development to apply sustainable architecture principles that emphasize the efficiency of resources such as energy, water, and materials, and reduce emissions and other environmental impacts [13]. The concept of sustainability, outlined in the 1987 Brundtland report, emphasizes the importance of meeting the needs of the present without compromising the ability of future generations to meet their needs [14]. Sustainable architecture itself aims to reduce negative impacts on ecosystems and minimize excessive resource use [15], [16]. Through energy efficiency, renewable energy sources, eco-friendly design, and a lot of other design considerations, sustainable architecture creates harmony between humans and nature and represents as a blueprint for a more sustainable future that supports innovation and long-term economic growth without neglecting environmental sustainability [17].

To strike a balance between economic development and environmental sustainability, several innovation precincts around the world are beginning to implement sustainable architecture strategies to reduce environmental impact while still supporting innovation and economic growth. One prominent example is Melbourne Connect, an innovation precinct in Australia that has implemented sustainable design strategies in its design. Melbourne Connect, operated by the University of Melbourne with Lendlease as the contractor and Woods Bagot as the architect, consists of five connected buildings that serve as collaboration hubs for a variety of parties, including students, university staff, scholars, researchers, startups, artists and business leaders. The precinct has comprehensive facilities, such as office space, laboratories, student dormitories, and public spaces for various activities. The Green Star ratings Melbourne Connect received include Green Star 6 for the commercial buildings and student accommodation, and Green Star 6 for the interior design of the Faculty of Engineering and Information Technology. Melbourne Connect has demonstrated its dedication to sustainability by being recognized by the Green Building Council of Australia for its implementation of sustainable design strategies.

The aforementioned background demonstrates the growing demand for innovation precincts that implements sustainable architecture strategies to minimize environmental impacts. Melbourne Connect, as a leading innovation precinct with numerous sustainability awards, is a relevant object of study for further investigation into the implementation of sustainable architecture strategies within it. Therefore, this research is directed to answer the following questions: first, what are the sustainable design strategies implemented in Melbourne Connect; and second, how does the sustainable design strategies contribute to sustainability? By assessing the overall implementation and impact of sustainable design strategies within Melbourne Connects, this research is expected to contribute in providing new insights in designing future sustainable innovation precincts as well as to enrich understandings on the impacts of sustainable architecture implementations in high-tech innovation-based infrastructure. The novelty of this research lies in its holistic approach in identifying and analyzing the implementation of all components of sustainable architecture strategies in Melbourne Connect. In contrast to previous studies, which have only focused on specific aspects, such as the key elements for success in the development of innovation precincts with Melbourne Connect as one of the case study object [18], the contribution of innovation precincts as smart city initiatives to sustainable city resilience in Melbourne [19], or a magazine article analyzing specifically only the design of the Faculty of Engineering and Information Technology (FEIT) in Melbourne Connect [20], this study provides a complete picture of the implementation of sustainable design strategies within the precinct, taking more of an architectural approach to maintain environmental sustainability.

2. Material and Methods

This research used a qualitative approach with thematic analysis method to analyze the implementation of sustainable design strategies in Melbourne Connect, a sustainable innovation precinct that has been recognized as a sustainable building by the Green Building Council Australia through a high Green Star rating. Research flow diagram is as illustrated in Figure 1 below.



Source: (Author, 2024)
Figure 1: Research Flow Diagram

During the data collection stage, several research materials are gathered, including archives and reports from the University of Melbourne as the main institution that supports the innovation precinct with additional data obtained from Woods Bagot as the main designer of the Melbourne Connect building. Video recording data collection was conducted by referencing to the "Open House Melbourne Architect Talk" session which can be accessed via YouTube on the official Melbourne Connect channel. The video of the talk is titled “Designing for Innovation” which provides an insight into the design process of Melbourne Connect from the perspective of Hazel Porter as the Principal Architect of Woods Bagot and Alastair Flynn as the Senior Associate to convey the vision in creating Melbourne Connect. Field observations were conducted on-site in working hours for seven days within October to November 2023 to experience peak user’s productivity at the location as well as to utilize the facilities at the site firsthand. The purpose of the field observations was to identify real-time conditions and activities at the site, collect notes, as well as photo documentations that can support the analysis of sustainable design strategies applied in the precinct.

A qualitative approach was then chosen to gain an in-depth understanding in the form and impacts of sustainable design strategies implemented in Melbourne Connect as a case study object. The data collection stage is carried using three main sources: literature study, video recording, and field observation. The literature study was conducted to review relevant theory on sustainable architecture, referring to Sassi's [16] theory of sustainable architecture strategies.

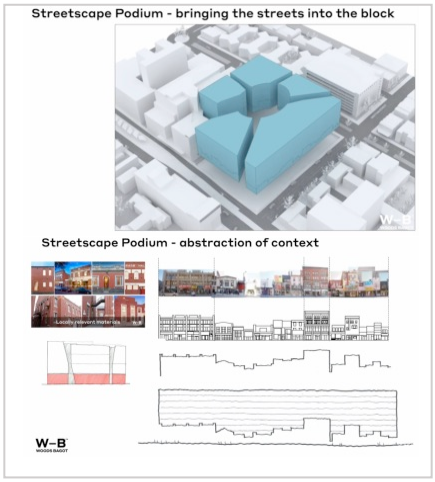
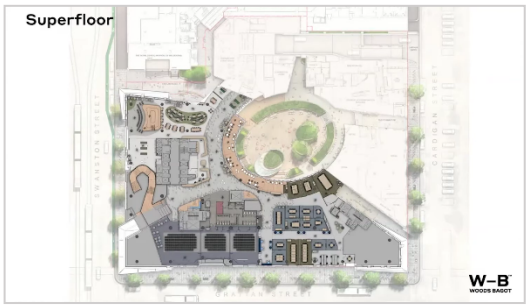
The collected data will then be analyzed using thematic analysis. The researcher will organize the data into relevant categories based on the theory by Sassi [16], namely site planning, community, health & well-being, water, material, and energy category. This analysis will integrate the data collections to build a thorough understanding in each category of sustainable design strategies implemented at Melbourne Connect. To ensure data validity, this research utilizes findings from three different data sources that aims to provide a more comprehensive and objective picture in the implementation of sustainable design strategies in Melbourne Connect. After data analysis stage, this research will compile a final report and conclusion that consists of key findings in sustainable design strategies implemented within Melbourne Connect and how each strategy contributes to sustainability.

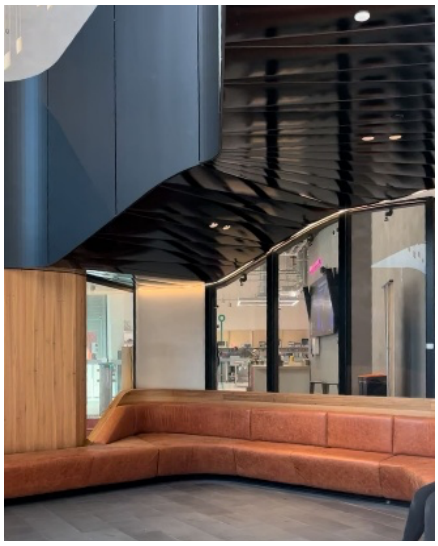
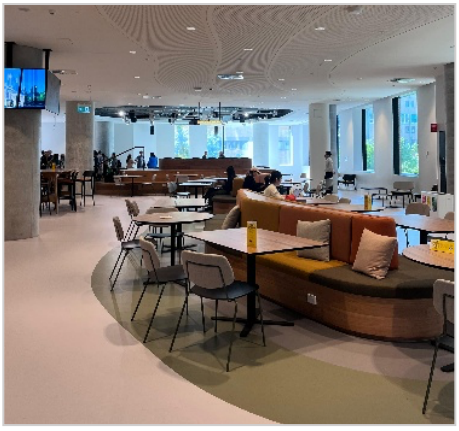
3. Results and Discussions

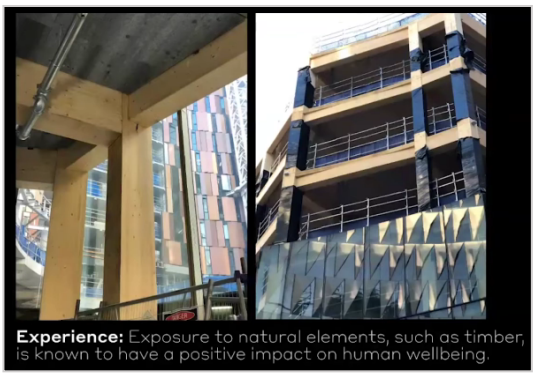
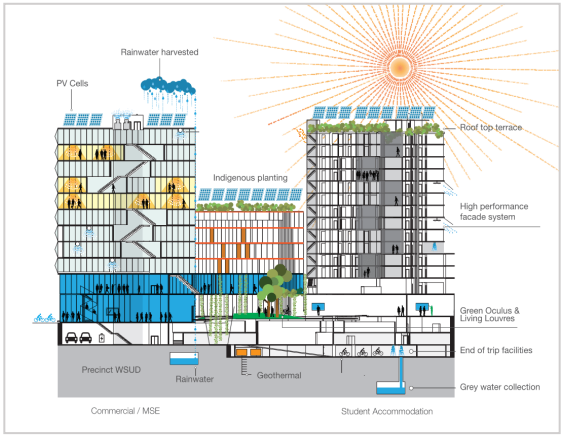
This research explores the application of sustainable design strategies within Melbourne Connect using a thematic analysis that highlights key elements based on Paola Sassi's [16] theory of sustainable architecture strategies. The analysis thoroughly identifies and classifies Melbourne Connect's sustainability strategies through six core components: site planning, community, health and well-being, water, materials and energy. Each of these components plays a significant role in creating an environment that is sustainable, resource-efficient and supports long-term sustainability.

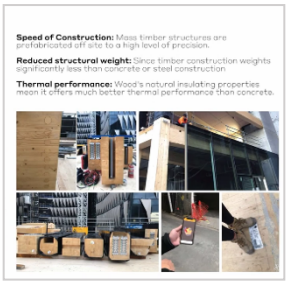
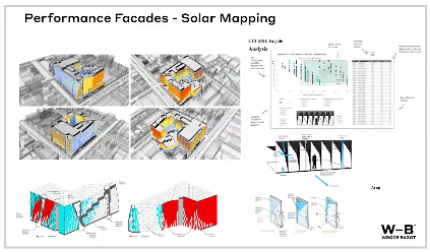
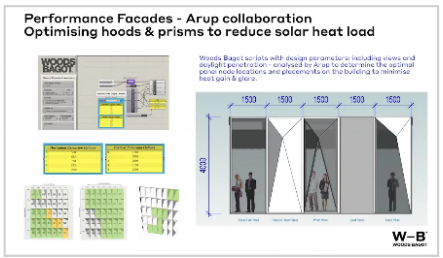
The site planning component, for instance, evaluates how brownfield site management and the integration with regional context impacts the surrounding environment. In the community component, design efforts to support social interaction, collaboration and connectedness among users to create a vibrant environment is examined. Health and well-being component highlights design approaches that support the comfort, productivity, and mental and physical well-being of building occupants. Water efficiency is examined through the use of wastewater rainwater harvesting systems, while the materials component observed sustainable material choices. Lastly, the energy component highlights the building's operational efficiency, such as the use of solar panels or facade to maintain thermal comfort as well as energy efficiency. Through this comprehensive approach, this analysis aims to deepen the understanding about each component of sustainable design strategies and elaborate its impact on environmental sustainability in Melbourne Connect. These sustainable design strategies will be outlined further in Table 1.

Table 1. Sustainable Design Strategies Analysis

Components	Theory of Sustainable Architecture Strategies by Sassi	Sustainable Design Strategies Applied in Melbourne Connect
Site Planning	Site planning involves managing an area for various development needs and transforming the natural environment into an artificial space that considers both environmental and socio-cultural impacts. Sassi's [16] theory in sustainable site planning strategies highlights seven important aspects, such as the reuse of existing buildings, investment in landscaping, public transport priority, pedestrian friendly environment, microclimate impacts, appropriate density, and utilization of brownfield sites.	Melbourne Connect was built on a brownfield site, the former Royal Women's Hospital, which fits with Sassi's sustainable land use strategy that recommends to utilize abandoned land to increase development efficiency and density. Despite initially considering retaining the old building, Woods Bagot decided to demolish it as it impeded physical and visual access [21]. Materials from the demolition, such as bricks, were reused for road paving. The new design divides the site into several buildings with a pathway leading to an open space in the center, creating a connection to the main intersection [21]. The concept of a streetscape podium (Fig. 2) was used to unite the building with its low-rise surroundings, with historical elements such as reused bricks, integrated into the design. Two large portals at Grattan and Swanston Street provide the main access, with special bricks creating a visual connection to the surrounding street. Three passageways and plazas connect the open spaces at the center of the project, creating a collaborative area called the 'oculus'.  Source: (Melbourne Connect, 2021) Figure 2: Streetscape Podium Concept
Community	The community component in sustainable architecture embodies the application of sustainability in a social context. In addition to green technology, social impacts are also considered, including community education to support sustainable lifestyles. According to Sassi's [16] theory, sustainable buildings should include several aspects: mixed development, local amenities for daily needs, collaborative environment, supporting economic & social well-being, and	Melbourne Connect is designed as a collaborative ecosystem that brings together researchers, industry partners, startups and students in an environment that accelerates innovation. The complex comprises research, commercial and residential spaces integrated across three buildings, emphasizing "porosity" to support planned and unplanned community collaboration [21]. The superfloor (Fig. 3) provides co-working areas and collaborative facilities, such as The Forum, The Studio and The Launch Pad for meetings, workshops and innovative activities.  Source: (Melbourne Connect, 2021) Figure 3: Superfloor of Melbourne Connect

	community involvement in the design process.	The principle of porosity is applied consistently throughout, connecting spaces visually and physically [21]. A large central flowing staircase connects the lower and upper floors (Fig. 4), increasing interaction between residents and maximizing opportunities for knowledge exchange. This design is also applied in the student residential areas with social staircases that encourage interaction between residents. By taking principle of porosity as an approach, Melbourne Connect has succeeded in creating spaces that interact with each other, facilitating collaboration between residents [22]  Source: (Author, 2023) Figure 4: Central Social Staircase
Health & Well-being	Health & well-being is an important component of sustainable architecture, encompassing physical, mental and social health. According to Sassi [16], elements such as natural lighting, natural ventilation, use of hazard-free materials, ergonomic design, green spaces and access to health facilities important to support users' health and well-being.	Eduard Hovy, Executive Director of Melbourne Connect, stated that Melbourne Connect is a 'living laboratory' that prioritizes sustainability and innovation [23]. The building's architectural design aims to improve the health, well-being and productivity of its occupants, by prioritizing the selection of eco-friendly natural materials and the utilization of natural light that could be seen in the interior setting of the building (Fig. 5).  Source: (Author, 2023) Figure 5: Interior Setting in Melbourne Connect Superfloor The relationship between building user and nature can be created through the establishment of visual, non-visual relationships, natural systems, and the selection of nature-related materials [24]. Melbourne Connect utilizes exposed timber (Fig. 6) to create a visually appealing and calming environment, which has a positive impact on users' health [21]. The use of wood is known to reduce stress, increase productivity, help students learn more effectively, and speed recovery for patients [25]. The building also meets Passive House airtightness standards and features climate sensors to monitor and control energy use optimally [26]. This sensor

		technology enables a 33 percent reduction in energy consumption while improving thermal comfort within the building. In addition, a wellness area facility on the seventh floor that includes a relaxation room, yoga studio, and health consultation room supports the physical and mental well-being of residents, creating a well-rounded environment that supports a healthy lifestyle.  Source: (Melbourne Connect, 2021) Figure 6: Natural Element Timber Structure
Water	Water management is an important aspect of sustainable architecture, especially in the midst of a water crisis due to unsustainable development. Sassi [16] suggests building designs that manages rainwater, uses recycled water, and increases water efficiency through rainwater harvesting systems, permeable pavements, and optimization of water use to support the preservation and sustainability of water resources.	Melbourne Connect has achieved a 4.5 Star NABERS Water Rating, demonstrating outstanding water efficiency (Fig. 7). Water conservation efforts include the use of wastewater collection systems and rainwater utilization for non-potable needs, saving up to 20% of the building's potable water consumption [21]. Advanced pipe systems such as Geberit SuperTube are used to optimize wastewater discharge while minimizing space and material usage (Green Building Council of Australia, 2023). In addition, wastewater treatment throughout the precinct enables recycling of water for non-potable purposes. Melbourne Connects design also prioritizes water conservation to increase resilience to drought, a climate issue Australia often faces, reflecting climate change awareness [21].  Source: (Melbourne Connect, 2021) Figure 7: Melbourne Connect Sustainable Water & Energy System
Material	The use of materials in sustainable architecture focuses on renewable, efficient and environmentally friendly materials, prioritizing recycled, ozone-free and low carbon footprint materials. Sassi's [16] theory emphasizes the	Melbourne Connect integrates sustainable materials and reuse approaches to improve the environmental performance of the building. Approximately 22,000 reclaimed bricks from the previous building were used for sidewalk paving, as well as reused elements such as signage and surgical lights [21]. The building also uses extensive engineered wood, including glulam beams and CLT slabs, which reduces the carbon footprint compared to concrete and steel (Fig. 8). The seven-story mass timber structure made from renewable materials sequester carbon, reduce VOCs, and allow the use of wood chips as fuel [21]. Off-site production of mass timber enables faster installation (30% faster) with less labor and equipment requirements, and lower impact on communities. These wooden structures are also fire and earthquake resistant, and have better thermal performance, improving energy efficiency [21].

	importance of conserving resources through the selection of durable materials as well as the reuse of materials to reduce waste and in line with circular economy principles.	 Source: (Melbourne Connect, 2021) Figure 8: Glulam Beams & CLT Slabs
Energy	The energy component in sustainable architecture emphasizes efficiency and reduction of greenhouse gas emissions. According to Sassi [16], Sustainable buildings are designed to reduce energy consumption over their lifetime through the use of renewable energy, natural ventilation, maximized lighting and ground temperature control. In addition, shading systems and proper building placement enable passive energy utilization, such as solar heating in winter and natural cooling in summer, thus the buildings meet high energy efficiency standards to support sustainability.	Melbourne Connect implements a range of sustainable energy solutions to support energy efficiency. Rooftop solar panels account for approximately 10% of energy consumption, reducing reliance on non-renewable energy and keeping operating costs down [26]. In addition, geothermal-based heating and cooling systems optimize energy from stable ground temperatures, resulting in significant energy savings over conventional HVAC systems [21]. Facade design is a key element in reducing energy consumption and improving occupant comfort. The building facade was designed by utilizing computer simulation to map the solar heat load, which supports the development of a facade appearance that is not only functional but also aesthetically pleasing (Fig. 9).  Source: (Melbourne Connect, 2021) Figure 9: Simulation & Solar Mapping The western façade was designed to maximize views of downtown Melbourne, while the façade facing Oculus is lower to reduce direct sunlight and maintain occupant privacy. The prism panels and shading hoods (Fig. 10) on the FEIT facades are designed to maintain a balance between daylighting and heat control, supporting energy efficiency in an expressive way. On the Swanston Street side, the facade with a triangular pattern and opaque color elements regulates the intensity of incoming daylight, while the facade facing Cardigan Street uses a panel design with a neutral rectangular shape, giving it a subtle yet harmonious feel with the surroundings. The colored facades are designed to maximize natural light and reduce the need for artificial lighting and cooling, which saves up to 40-50% energy compared to conventional buildings. Climate sensors integrated into the facade allow interior lighting to be optimally adjusted, ensuring occupant comfort while maintaining energy efficiency [23].  Source: (Melbourne Connect, 2021) Figure 10: Prism Panels & Shading Hoods

Source: (Author, 2024)

4. Conclusion

The result of this research show that Melbourne Connect has successfully implemented all of the components within Paola Sassi's sustainable architecture strategy. The key findings of each component, consequently starting from site planning, community, health & well-being, water, material, to energy, are summarized in the following sustainable design strategies: brownfield site utilization and usage of podium streetscape concept to integrate with the surrounding environment; use of porosity principles to create a collaborative community; use of natural elements such as wood and natural light for maintaining user's well-being; application of wastewater collection & rainwater harvesting system for increasing water efficiency; use of engineered wood materials, such as glulam beams and CLT slabs, to reduce carbon footprint; and use of solar panels and simulated facade for increasing energy efficiency.

Several components of the sustainable design strategy are also proven in contributing to sustainability by minimizing energy use and optimizing the building's operations, such as the use of rooftop solar panels that provides approximately 10% of the precincts power; greywater collection, water treatment system and reuse of rainwater saves up to 20% of the precinct's potable water consumption; and overall, the energy-saving design features contributes to a 40-50 per cent reduction in energy consumption, compared to conventional buildings. Through spatial arrangements that supports social interaction and collaboration, Melbourne Connect also is proven to successfully establishing a healthy and collaborative community, which encourages innovation and knowledge exchange. The sustainable design strategies implemented within Melbourne Connect not only reduces the environmental footprint but also creates a more productive, healthy and connected environment for its residents. To conclude, Melbourne Connect is therefore an appropriate exemplar of an innovation precinct that not only prioritizes economic development and high-tech use, but also maintains a balance between environmental and social sustainability.

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