



Article

The Uncommon Nightingale: Sustainable Housing Innovation in Australia

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Abstract: There is a need to deliver more environmentally and socially sustainable housing if we are to achieve a transition to a low carbon future. There are examples of innovative and sustainable housing emerging around the world which challenge the deeper structures of the existing housing regime. This paper uses the analysis of socio-technical dimensions of eco-housing presented by Smith to explore the development of an emerging sustainable housing model known as Nightingale Housing in Australia within a sustainability transitions framing. While there were several similarities to Smith's analysis (e.g., establishment of guiding principles, learning by doing), there were also some key differences, including the scaling up of sustainable housing while using tried and tested design principles, materials and technologies, and creating changes to user relations, policy, and culture. Smith's dimensions remain a good framework for understanding sustainable housing development, but they must be located within a scaling up sustainable housing agenda. What is required now is to develop a better understanding of the processes and opportunities that such housing models offer policy makers, housing researchers, and building industry stakeholders to achieve a broader scale uptake of sustainable housing both in Australia and globally.

Keywords: sustainable housing; nightingale; apartments; affordable housing; socio-technical transitions

1. Introduction

Sustainable housing has been identified as a critical element in the transition to a low carbon and equitable future within the UN's Sustainable Development Goals [1], the Intergovernmental Panel on Climate Change's assessment reports [2] and other key research [3,4]. Increasingly, sustainable housing is about more than reducing resource consumption; it is also about broader social and financial benefits delivered for households and society, such as reducing fuel poverty and improving health and wellbeing outcomes [5–10]. Despite the benefits of sustainable housing, most new and existing housing around the world falls short of what is required for a low carbon future [2,11].

Experimentation is crucial to support systemic change towards sustainable housing and the transition to a low carbon future, and there has been an emphasis on bottom-up innovations and interventions (see [12–15] etc.). For example, Smith [14] states that innovations in housing can be identified as niches or experiments able to “inform possibilities for developing more sustainable regimes”. In his analysis, Smith explored how eco-housing differs across socio-technical dimensions compared to mainstream housing, highlighting challenges for sustainable housing uptake with regulation and a building regime resistant to change. The importance of supporting niche sustainable housing developments (or experiments) through policy developments or other approaches has been identified by other researchers [16–23].

As with many countries, the provision of housing in Australia falls below the requirements for low carbon/energy sustainable housing [24,25]. Extrapolating data from Newton and Tucker [25] finds that a detached house in Melbourne built to minimum performance standards is predicted to emit 8556 kg/year CO₂-e. There are examples of innovative sustainable housing developments emerging in Australia which go beyond minimum energy and water performance requirements and embrace wider considerations of sustainable housing, such as social elements that challenge deeper structures of the existing regime. This includes structures such as improving processes, supply, affordability and quality to deliver housing which better matches consumers' requirements. One such example is Nightingale Housing, which has emerged over the past decade as one of Australia's leading examples of sustainable higher density housing. This paper uses this sustainable housing model to ask 'how is the Nightingale Housing model developing in relation to Smith's identification of eco-housing transitions?' The paper does not seek to evaluate the actual technical performance of the individual buildings, as the first completed development within the Nightingale Housing model was only occupied in late 2017 and there has not been sufficient data collected to report upon actual performance. That analysis will be forthcoming.

It is timely to review Smith's eco-housing analysis as there have been changes in the larger built environment system over the past decade [21,26]. For instance, at the landscape level, events such as the Paris Agreement, more serious and frequent climate change related disasters, and increased energy security challenges have changed both the narrative around sustainability and the urgency with which we must act [27]. Regime-level changes include incremental improvements to minimum standards and continued resistance from key building regime stakeholders against future regulatory changes towards low carbon building [24,28]. At the niche level, the rapid cost reduction in sustainable technology such as photovoltaics have impacted the building industry [29]. We argue that is it therefore pertinent to revisit the socio-technical dimensions Smith [14] discussed considering these changes. In addition, Smith's analysis investigated sustainable eco-housing more broadly, so contains generalizations, whereas this research focuses on a specific case study, the Nightingale Housing model.

Progress towards improving the sustainability of housing in Australia has broadly followed international approaches, with the setting of minimum building standards [30]. However, there has been limited advancement of these standards in relation to delivering low-carbon housing performance since their introduction in the early 2000s [24,25,28]. In fact, Berry and Marker [27] find that house energy standards in Australia lag behind leading practice in the UK, European Union, and North America by up to 15 years. Highlighting this is research by Horne and Hayles [31] who found in 2005 that housing in compatible climate zones in North America and Europe was 55% more efficient for heating and cooling energy compared to minimum standard housing in Australia; when adjusted to account for an increase to minimum standards in 2011, the housing in those locations would still be 40% more efficient. This places Australian housing stock behind international best practice [11,31].

The current minimum housing standards in Australia have several limitations, including what they cover, and the assumptions around how housing is used [24]. The standards also assume a business-as-usual delivery, where the focus is to tweak dwelling design and include new technologies as 'bolt on' to achieve improved sustainability outcomes. This approach is supported by key building industry stakeholders, who resist any push for more substantial improvements to building performance. Such an approach fails to consider deeper structural changes to housing that will be required for a transition to a low-carbon housing future [14,32].

In Australia, the minimum standards are set nationally through the National Construction Code (NCC). The NCC is developed by the federated Australian Building Codes Board, which is a Council of Australian Governments (COAG) standards writing body. COAG is tasked with setting nationally consistent policy which includes addressing minimum performance requirements in buildings. The last substantial improvement to minimum performance requirements was introduced in 2010, with the next opportunity for substantial changes not expected to be any earlier than 2022 [24].

Rather than wait for a national response to improve minimum building regulations, there are examples of lower levels of government trialing and delivering more sustainable housing options. The State Government of South Australia, through their land development authority Renewal SA, developed Lochiel Park Green Village, an award winning low-carbon development with 103 dwellings in Adelaide [33]. Niche developments, such as Lochiel Park, challenge “industry experts and policy makers to set objectives, performance targets and regulatory guidelines outside existing institutional and professional norms” [19]. Such developments are also important for demonstrating the capacity of the Australian building sector to design and build homes that operate at or near zero energy performance [34]. In Victoria, the State Government, through their land development authority Places Victoria, developed the Nicholson—an innovative mixed tenure, mixed-use apartment development that emphasized affordable living, environmental sustainability features, and utilized modular construction [35]. In their analysis of the influence of the Nicholson, Moore and Higgins [36] found some evidence of demonstration projects influencing future urban developments in Melbourne.

While the above examples involved significant direct government interventions, there are building industry stakeholders working without such support who are providing more innovative and sustainable housing options that go significantly beyond minimum standards. There are community-lead developments such as WestWyck EcoVillage in Melbourne [37] and Bull Street Terraces in Castlemaine (rural Victoria) [38], and developer-led examples like Yarra Bend in Melbourne [39]. The Nightingale Housing model is another example of a non-government led approach. The Nightingale Housing model is interesting because it has elements of a bottom-up community led project and an industry-insider development. In addition, rather than see each building as a separate project or development, the Nightingale Housing model is challenging the broader housing regime with a movement to radically innovate housing delivery, and even the idea of a housing, in Australia. This is why the aim of this paper is to investigate the Nightingale Housing model as a niche trying to challenge and change the housing regime.

2. Materials and Methods

To address the research question, this paper explores the case study of the Nightingale Housing model and compares it with Smith’s analysis of eco-housing socio-technical dimensions and current mainstream house building characteristics in Australia. Table 1 presents Smith’s identification of seven key social-technical dimensions for housing transitions and niche development.

Table 1. Contrasting socio-technical practices in niche and regime [14].

Socio-Technical Dimension	Mainstream House Building	Sustainable (Eco) Housing
1. Guiding principles	Profit and loss; high external inputs.	Ecology; autonomous housing; minimize ecological footprint within cost constraints.
2. Technologies	Tried and tested; grid services; routine; bulk purchasing; listed suppliers.	Small-scale; off-grid services; natural/reclaimed materials; green supplies.
3. Industrial structure	Speculative; volume building; subcontracted labour; construction costs; profit from contracted price; one fault on many dwellings—large liabilities; larger estates.	Bespoke building; specialist builders; lifecycle costs; premium for sustainable features; learn from correcting faults; single dwellings or small groups.
4. User relations and markets	Passive and conservative consumers.	Active commitment to a green lifestyle; high-user involvement or self-build.
5. Policy and regulations	Land use planning and building regulations are followed; lobby to control the pace of environmental standards.	Land use planning and building regulations can be a constraint; lobby to accelerate the pace of environmental standards.
6. Knowledge	Knowledge relevant to existing competencies and business practice; standard designs of developers choosing.	Knowledge relevant to reducing the ecological footprint of homes; site-specifics count, e.g., solar orientation, waste water treatment and recycling.
7. Culture	Markets and regulations.	Sustainable housing.

While there has been limited academic research into the Nightingale Housing model to date, there has been a significant amount of public discussion about the housing model in the media (print, online, and radio) and other outlets (e.g., industry conferences). Such public discussion can play an important role in the collection of data for case study research [40]. To understand how the Nightingale Housing model was developed a qualitative content analysis was undertaken based upon publicly available information [41]. The content analysis process categorizes qualitative textual data into clusters to identify consistent patterns and relationships [41,42]. The qualitative approach emphasizes the meanings and understandings of the content across a range of outputs, rather than the frequency of particular words. A limitation of this approach is that the analysis relies upon the interpretation of the researchers to determine context and meaning [41], however the setting of clearly defined categories for analysis, that is, Smith's socio-technical dimensions, helped address this along with a triangulation of different data sources (e.g., reported interviews over time with the lead architect).

As stated in the introduction, there are several reasons for the use of Smith's framework. Smith's paper remains an important paper within the transitions literature. While "there is not one right way to investigate socio-technical transitions" [43] it is a highly cited paper, with more than 600 citations, and is a key paper which many housing transition researchers have drawn upon [11,18,44]. Despite the importance of this paper there has been limited revision of the framework, especially in light of changes to the niche, regime, and landscape level for housing and sustainability more broadly.

A systematic search for reports, project documentation, and public discourse (media) was undertaken. The search started with the main website for the Nightingale Housing model (<http://nightingalehousing.org/>) with key documents and information collated about the model, and individual projects. This website also identified key stakeholders involved in the development of the Nightingale Housing model. A general Google search using words 'Nightingale', 'Nightingale housing', 'Nightingale model', in addition to the names of key stakeholders involved, for example, 'Breathe Architecture' and 'Jeremy McLeod', were used to identify other information relating to the Nightingale Housing model. While only secondary data, one of the benefits of this content analysis approach is it has allowed the analysis of multiple reports, blogs, and interviews across a period of

almost 10 years, whereas a primary data collection approach (e.g., interviews conducted by the authors) would have only provided information at a point in time. The following section provides an overview of the base study, before it is analyzed in more detail against Smith's socio-technical dimensions.

The Nightingale Housing model has emerged over the past 10 years in Melbourne, starting with the initial development, The Commons, the precursor to Nightingale Housing. The model was pioneered by architect Jeremy McLeod of Breathe Architecture, in conjunction with a collection of local architects who shared a similar goal: to provide higher density housing which properly, and equally, addresses the triple bottom line of sustainability and affordability outcomes. The Nightingale Housing model aims to create liveable apartments, as many new higher density developments in Melbourne were becoming critically small and had lost usability (e.g., lack of storage) [45]. Recognizing that there were fundamental issues with the way housing was being provided in Melbourne, the architects wanted to influence the market by showing what could be done. McLeod states '... we thought that we would build a precedent, Australia's flagship sustainable apartment building, that was simultaneously affordable, liveable, and sustainable.' [46]. Around 2007, McLeod and six other architects found a suitable piece of land and planned to use their own money to build such a development. The block of land was in Brunswick, in the City of Moreland (in Metropolitan Melbourne), and was located next to a train station. This location was ideal for several reasons, including that the local council had increasingly embraced green idealism, and were more accepting of what they wanted to do. However, the land was zoned as industrial and needed to go through a planning scheme amendment to allow a residential development, although this also helped to reduce the cost of the land.

Unfortunately, after much of the design work was completed and planning permits had been obtained, the global financial crisis hit. In 2012, when they were ready to proceed with the development, the architects could not obtain an offer of finance (i.e., loan) from the banks, reflecting the reduced liquidity in the credit market that was one of the effects of the global financial crisis. The inability to obtain finance for development and the holding costs of the land meant the architects were forced to sell the project. Small Giants, a B Corp company interested in sustainability purchased the land and intellectual property on the condition that the original design was kept and Breathe Architects were retained as the architects.

The development, called The Commons, was completed in 2013 (Figure 1). It contains 24 one and two-bedroom apartments across five stories. The Commons also includes a ground floor café, yoga studio, and work space for Breathe Architecture. It has a gross floor area of almost 3500 m². To ensure improved sustainability, affordability (through reduced construction costs and ongoing living costs), and social outcomes, the design team used a reduction design approach to remove things found in typical apartment developments. This approach meant that onsite car parking spaces, second bathrooms, and individual laundries were removed, while a shared laundry was located on the roof of the development. The aim of this approach was to not only save internal space in the apartments, along with associated costs and resources, but was a deliberate plan to help foster community by providing a place for residents to engage with each other. The development also included several other elements including:

- 7.5 star Nationwide House Energy Rating Scheme (NatHERS) rating. This equates to a predicted thermal energy load of 68 MJ/m²/year which is 40% lower than the minimum 6 star NatHERS requirement for new housing of 114 MJ/m²/year.
- Shared 5 kW solar photovoltaic array, solar hot water system and hydronic heating boiler,
- No air conditioning, plasterboard ceilings, chrome, tiles, toxic finishes or imported timbers,
- Undercover parking for more than 70 bikes,
- Car share located in front of the building,
- Passive design, double glazed windows and timber doors, exposed thermal mass (concrete), locally manufactured and recycled materials, rain water collection,
- Provision of communal spaces including rooftop garden and laundry.

The Commons has been recognized across the industry for being a leading exemplar of sustainable design that reduces ongoing living costs (e.g., through lower energy consumption), not just for Melbourne but across Australia. The building and design team have won numerous national and international awards. Despite the amount of industry recognition and high resident satisfaction, the architect is more critical of the process, in particular with relation to having to bring a developer in to fund the project [46]. However, what The Commons allowed the design team to do was to test what worked and learn how to improve design, technology, and occupant experiences for their next development; Nightingale 1, the first from the Nightingale Housing model (See Figure 2). In addition, the failure of The Commons to deliver affordable housing (in relation to purchase price) led to the establishment Nightingale Housing Pty Ltd. as a not-for-profit in 2016 to help develop and support other Nightingale Housing projects. Through this organization, architects can apply for Nightingale licenses to develop similar projects and receive access to the IP and the waiting list of people wanting to buy a unit.

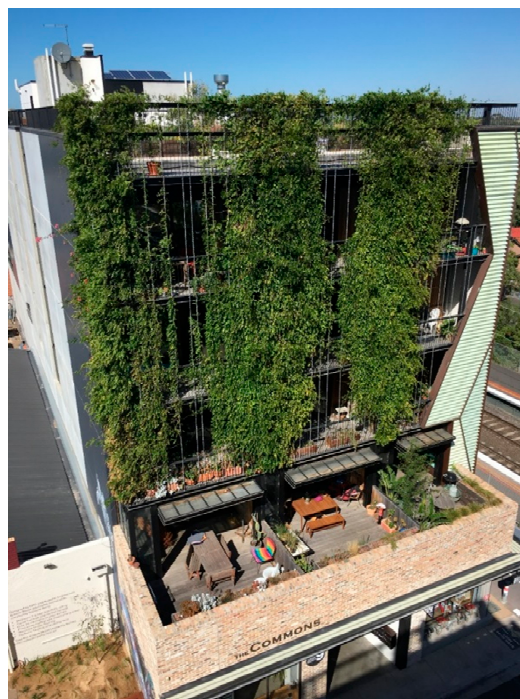


Figure 1. The Commons (Author).

Nightingale 1 is located across the road from The Commons, but has had a different journey to completion. Breathe Architects were again the lead architect on the development. Whereas The Commons had little issue in proceeding through local planning approval, a minority in the local community were not satisfied that Nightingale 1 was being proposed without any onsite car parking. A planning approval provided by the council was revoked when an objection was lodged through the Victorian Civil and Administrative Tribunal (VCAT). In Victoria there is a formal process allowing for development approval decisions to be appealed to a court or tribunal. VCAT through its Planning and Environment List provides a merits-based review of a council's decision to grant, impose conditions or refuse planning permits. Depending on the type of appeal lodged, a VCAT hearing will generally involve the permit applicant, the relevant Council and any third party joined to the proceeding. The hearing is overseen by VCAT members, with each party provided the opportunity to present their argument as to their preferred outcome. Ultimately VCAT sided with the objector and revoked the planning approval. The design team went away and incorporated onsite car parking for 3 cars and was re-granted planning approval. This pushed back the development by 12 months.

Nightingale 1, completed in 2017, includes 20 one and two-bedroom apartments across five storeys with ground floor retail. Prices for the apartments started at around \$415,000 (AUD). In addition to many of the design elements demonstrated in The Commons, Nightingale 1 included:

- An average NatHERS rating of 8.2 stars (this equates to a predicted thermal energy load of 48 MJ/m²/year),
- 18 kW solar photovoltaic system,
- Improved rooftop design for better rooftop gardens,
- Covenant applied to building capping sale price of apartments tied to average price rise of area.



Figure 2. Nightingale 1 (Breath Architecture).

The Nightingale 1 has also received significant positive discussion within the building industry regarding its achievements. The success of The Commons and Nightingale 1 has seen more than 14 licensed developments at various stages of design and construction utilizing the Nightingale model (Table 2), each being led by different coalitions of architects. The developments have spread outside of Victoria, and are now being planned other parts of Australia and even in New Zealand [47].

Table 2. Current Nightingale Housing model projects [48].

Projects in Development	Status	Location	Lead/Architect	Year	Size
The Commons	Completed	7 Florence St, Brunswick (Victoria)	Breath Architecture	2007–2013	24 units, 4 storeys, ground floor retail/commercial
Nightingale I	Completed	6 Florence St, Brunswick (Victoria)	Breath Architecture	2014–2017	20 units, 5 storeys, ground floor retail/commercial
Nightingale II	Under construction	72a Station St, Fairfield (Victoria)	Six Degrees Architects	2017–	20 units, 5 storeys, ground floor retail
Nightingale III	Planning	209 Sydney Rd, Brunswick (Victoria)	Austin Maynard Architects	2017–	20 units, 7 storeys, ground floor retail
Nightingale Brunswick East	Under construction	55–63 Nicholson St, Brunswick East (Victoria)	ClarkeHopkinsClarke & Breath Architecture	2017–2019	38 units, 6 storeys, ground floor retail
EHDO Nightingale Fremantle	Planning	29 Wood St, Fremantle (Western Australia)	EHDO Architecture	2017–2019	12 units + mixed use
Nightingale Village	Land purchased, pre-planning	Duckett Street in Brunswick (Victoria)	Architecture Architecture, Austin Maynard Architects, Breathe Architecture, Clare Cousins Architects, Hayball Kennedy Nolan, WOWOWA Architecture	2017–current	7 different buildings on same development site, specific details of each not yet determined

3. Results

This section of the paper presents the Nightingale Housing model in further detail against the seven socio-technical dimensions identified by Smith [14]: guiding principles, technologies, industrial structure, user relations and markets, policy and regulations, knowledge and culture—which are described previously in Table 1. Each dimension is discussed with similarities and differences to Smith’s eco-housing analysis highlighted.

3.1. Guiding Principles

In Smith’s study, he identified that eco-housing had core guiding principles around improving sustainability (towards autonomous performance) within cost-constraints. While this is very much the aim of the Nightingale Housing model, Nightingale Housing Pty Ltd. have developed a set of broader guiding principles. The principles address design and technology requirements in each development, a focus on creating community in and around the building, and the way the model itself operates. The Nightingale Housing model is centered around five core principles of affordability, transparency, sustainability, deliberative design, and community contribution (Table 3). Under each of these principles are targets and guidance about what they mean. A number of these will be discussed further in the other dimensions.

Table 3. The Nightingale Housing model guiding principles [48].

Affordability	Transparency	Sustainability	Deliberative Design	Community Contribution
Project profit capped at 15%	Transparent project costs to investors and purchasers	100% fossil fuel free building operations, e.g., via an embedded energy network	Meaningful and informed participation from future home owners across the project, from design through to settlement	Contribution back to the local urban community through the creation of connected communities, active street frontages, fine-grain and tactile pedestrian experience for passers-by, and engagement with tenants who can provide ‘third’ spaces’
Designed to reduce operating and maintenance costs	Transparent governance and decision-making processes	Minimum 7.5 star NatHERS thermal rating	Purchasers given real cost information during the design process to support informed decisions	
Removal of unnecessary inputs, e.g., marketing activities and display suits		Water harvesting and productive gardens		
Covenant on resale to ensure affordability is passed on				

These guiding principles of the Nightingale Housing model were not formalized in such a structured way to begin with. The key stakeholders’ initial plan, as demonstrated through The Commons and Nightingale 1, was to try and influence the market by demonstrating what was possible and to significantly challenging the current housing regime’s idea of apartment design, performance, and delivery. The initial coalition of architects started with ideas similar to the above core principles, but it has been through their journey over the past decade, and in particular learnings from the initial developments, that has helped them to more clearly articulate the principles are and how to achieve them.

While affordability and sustainability are seen in Smith’s analysis, information, transparency, deliberative design, and community collaboration are the key principles that differ. As will be discussed below, these really emerged from a recognition from key stakeholders about the limitations of the current regime. Furthermore, the Nightingale Housing model has more specificity around certain principles, especially around technical performance (e.g., minimum 7.5 star NatHERS thermal rating) compared to Smith’s guiding principles. However, Smith was writing about sustainable housing more broadly and developing an analysis that could be applied in different locations—meaning that specific performance outputs would not have been appropriate.

3.2. Technologies (and Design)

In relation to technologies, Smith defined eco-housing as small-scale, off grid developments that use sustainable materials. Development of (deep) sustainable housing in Australia has typically been characterized by Smith’s analysis. The challenge is that this type of housing has previously only been

delivered in low numbers in comparison to standard housing. Since Smith's analysis there have been some changes at the landscape and regime level to some degree in relation to sustainability in housing. In Australia, there has been a rapid uptake of residential solar photovoltaics driven by a price drop in global manufacturing of the technology, in conjunction with increased (but fragmented) financial support by governments [29]. Around 25% of housing now has solar panels installed, which changes the narrative around sustainable housing and technologies [49,50]. However, this change has been driven by occupants, and not the regime (building industry) who are fundamentally delivering standard housing through the tried and tested, mainstream bulk building approach identified by Smith.

The Nightingale Housing model challenges the mainstream approach on several fronts. Firstly, it is looking to deliver sustainable housing at larger scales. It has recently announced plans to deliver a precinct of seven buildings, which they hope will demonstrate even greater benefits through scale. Secondly, while the Nightingale Housing model is heading towards potential off-grid zero energy outcomes, it has recognized significant benefits to still using some existing infrastructure (e.g., energy networks). Thirdly, the model does not require placing the development or performance at risk by requiring untested materials, technologies, or designs. Key people involved in the Nightingale Housing model freely admit that they are drawing upon elements that have worked elsewhere. When speaking about The Commons, the lead architect says, "all this building is, is a series of research pieces done from buildings in Germany, Barcelona, Copenhagen, Sweden, you know, we just found great buildings, great precedents around the world and kind of bought them all together here" [46]. Therefore, this reduces the risk to all involved, while pushing sustainability innovation.

There is however a key focus on sustainable materials in the Nightingale Housing model, as Smith has highlighted. The Commons achieved an above-minimum thermal energy performance due to a focus on sustainable materials which enhanced elements such as thermal mass. As the lead architect states "I find it very difficult to imagine why anyone wouldn't be hitting 7.5 star [NatHERS] average across an apartment building" [51]. The design team also constantly ask themselves (and prospective occupants) what must be included, and what can be removed from designs to ensure there is no waste, and that the model continues to evolve. This has resulted in key design differences to typical 'standard' housing, as well as other sustainable housing examples previously developed in Australia. For example, the removal of onsite car parking, second bathrooms, individual laundries, and air conditioners resulted in better internal space and layouts, and significant cost savings (see Tables 4 and 5).

3.3. Industrial Structure

Smith identified characteristics around bespoke buildings, requiring specialist builders, sustainability being a premium product, learning-by-doing, and delivering buildings at a small-scale. This is perhaps the dimension where the largest difference is seen with the Nightingale Housing model. Nightingale Housing wants to be a model that can to be replicable on other sites in Melbourne and around Australia. This is evidenced by the 20 Nightingale Housing model developments at various stages of planning, design, construction and occupation across Australia and New Zealand. While each building has differences, the core principles, design ideas, and features are incorporated into each. Furthermore, while the Nightingale Housing model has some differences to standard housing in terms of construction techniques, materials, and finishes, it is designed to be suitable for all builders if they wish to take it on. To date, the developments underway have gravitated towards those who had some engagement with sustainability previously, but the model does not preclude others from taking on the building. This is important if such housing is to scale up.

Lifecycle costs are a key consideration in the Nightingale Housing model, as identified by Smith. But unlike Smith's finding of premiums for sustainability, the Nightingale Housing model puts forward a framework of transparent affordability within the context of delivering a premium product without the premium price tag through the design process. Using the example of Nightingale 1, a AUD \$9 million development, the model demonstrates how savings per apartment of over AUD \$110,000 were

achieved for purchasers (Tables 4 and 5) [52]. This was done through: (1) a cap on profit for investors (set at no more than 15% compared to a more traditional 30% profit)—what they term the ethical lender model; and (2) removal of non-essential elements. The breakdown is as follows:

Table 4. The Nightingale Housing model profit cap (AUD\$) [52].

	Standard Developer Model	Nightingale 1
Profit on cost	\$1,800,000	\$810,000
Saving for development		\$990,000
Saving per apartment (20 apartments)		\$49,500

Table 5. The Nightingale Housing model design elements (AUD\$) [52].

Element Compared to Traditional Development	Saving
No marketing team or advertising fees	\$50,000
No display suites	\$100,000
No real estate agent	\$250,000
Removal of 20 × second bathrooms	\$200,000
Removal of 450 sqm car parking	\$500,000
Removal of air conditioning	\$150,000
Savings for development	\$1,250,000
Savings per apartment (20 apartments)	\$62,500

While 20 apartments might still be considered small scale, for sustainable housing in Australia it is considered larger scale. The speed at which the model is being replicated around Australia also demonstrates that it is scaling up both in total numbers and geographic spread.

While there have been identified challenges throughout the design and development of initial buildings, the open source and collaborative approach between different design teams lends itself to learning-by-doing and addressing faults as they arise, which then feed into future developments, similar to that identified by Smith. Part of this learning process has been around the funding of developments. To date, the developments have relied on ethical investors to help fund the projects. But, the aim of the design team was always for this to be a self-funded and self-sustaining process. Nightingale Housing have recently announced plans to use the Baugruppen financial structure where the apartment purchasers will be the ‘investors’ in the development [53]. This means they will co-own the land with the other purchasers, avoiding the need for third party investors and further reducing the cost for the project, by avoiding the 15% profit margin and paying less property tax.

3.4. User Relations and Market

Smith identifies that eco-housing requires active commitment to a green lifestyle and high-user involvement or self-build. This is the same for the Nightingale Housing model, as they have targeted occupants who are more aligned with their guiding principles, especially around sustainable living. Part of the guiding principles for the Nightingale Housing model are about community development and engagement within the building and into the local community. In Nightingale 1, the architects wanted the building to be occupied by owners rather than renters in the hope that this would foster a more stable community and avoid property speculation. This was addressed through a selection process (e.g., interviews/surveys with prospective occupants) to ensure an understanding of what occupants wanted and their financial capacity to afford the property, and through creation of a covenant on the building restricting apartments from being on-sold for more than the average price rise of the local area for 20 years, therefore locking in affordability gains for future owners [52]. This second method was about discouraging investors who may not have shared the same values, or owners who might be looking to take advantage of the popularity of the building to make a quick profit. However, it is not yet clear if this approach has produced different outcomes to The Commons (which includes renters and no covenant).

Further, as discussed previously, the design process for Nightingale 1 and subsequent Nightingale Housing model developments involves a significant level of engagement and input from those who will be living in the apartments. This ensures that occupants have a level of control over the final product they end up with, but also helps to identify areas of cost and resource efficiency. The Baugruppen financial model is not quite a self-build outcome, but it is one where owners (and therefore occupants) have a much stronger stake in the development from the planning and design phase.

3.5. Policy and Regulations

Smith identifies that land use planning and building regulations can be a substantial constraint for sustainable housing. However, he also identifies that there is a significant opportunity to lobby for the accelerated pace of improving environmental standards, presumably drawing upon examples of sustainable housing in practice to inform such developments. The Nightingale Housing model has also come up against challenges with land use planning and building regulations. The main challenge has been through land use planning, which typically requires a certain number of onsite car parking (generally in the range of 1–2 parking spots per apartment in Melbourne). The Nightingale Housing model typically selects development sites located in close proximity to public transport as a way to encourage public transport use and avoid the need for costly onsite car parking. The Commons development, without any onsite car parking, was granted a planning permit by the local government as the responsible authority and was not subject to appeal. However, Nightingale 1, which is located across the street, received a single objection from the developer next door for having no onsite car parking. The challenge remains ongoing with each new development site continuing to push innovations. In this way, the Nightingale Housing model has been critical for challenging established notions of developments, particularly higher density developments, within local planning schemes. While seemingly not wanting to do this to be political, the developments are having demonstrated impacts on the planning system.

The building regulations have not (at least publicly) created any significant challenges for the development, as the design, construction approach, and materials/technologies selected are generally tried and tested. The Nightingale Housing model is just delivering them at a higher sustainability performance outcome. If anything, the building regulations through the energy rating design and evaluation tools have given the development an edge in demonstrating improved performance and occupant outcomes. However, the Nightingale Housing model is demonstrating another form of regulation; through building-specific regulation. The covenant around sale price is not something typically seen in Australia but bounds the occupants to rules around selling for two decades.

3.6. Knowledge

Smith identifies that knowledge is important for eco-housing, especially in terms of identifying site specific design and technology outcomes. Similarly, the Nightingale Housing model prides itself on its transparency and knowledge sharing. They established the Nightingale Housing Pty. Ltd., a not-for-profit organization to help deliver the knowledge of developments to other interested designers, developers, and the public. It is through a lens of transparency that the model can learn and improve. As the lead architect of Nightingale 1 says

“... we waste resources all the time redoing what’s been done before. Shouldn’t we be spending our time finding better, newer solutions to things rather than redoing someone else’s work? If you are generous with your IP—it forces you to go and find new solutions, it encourages you not to rest on your laurels, but to know that there’s some other better way to do it. It also encourages generosity with our colleagues—people return the favour ... the best way we can have that impact is to make it as easy as possible for other architects to be able to take what we know and improve on that.”. [51]

But it is not just the knowledge of how to deliver such a project, but also in sharing the actual performance and residents' experiences. For example, the residents have reported how their apartments stay comfortable during heatwaves even without air conditioning [54], something the authors of this paper also identified in a recent tour of the building. This is confirmation of the impact the Nightingale Housing model is seeking to have on broader housing, thermal comfort, and energy practices. Further to this, McLeod (the lead architect of The Commons and Nightingale 1) and his wife bought into the Commons with the aim of living there for a year to experience how it was performing; but liked it so much they stayed living there beyond the first year [54]. In addition, one of the project managers from Nightingale Housing Pty Ltd. bought an apartment in Nightingale 1 and lives and works in the building.

While the Nightingale Housing model contains key principles and design/technology requirements, each new development builds upon the previous developments. By standing on the shoulders of others, the newer developments push boundaries even further. The coalition of architects involved in the Nightingale Housing model recognize the broader influence their developments could have. As a stakeholder involved in one of the proposed developments says, "if we build this building well and people live in it and enjoy it, the next time someone plans a building, even if we're not involved, and they use our building as a measure for what can be achieved, then our project has been successful" [55].

3.7. Culture

Smith identifies that the shift to sustainable housing relates to culture. The Nightingale Housing model is not just an architectural solution, but a financial model, and a model which attempts to deliver improved social outcomes—therefore delivering sustainable housing outcomes across a number of perspectives [52]. McLeod believes that "our housing system is absolutely broken and we've just been incredibly frustrated with the development market for the last 10 years. So we want to be part of that solution, which is why we are pushing for Nightingale" [56]. The Nightingale Housing model funding approach is now gaining traction and is seen as a reliable way to deliver sustainable higher density housing. As an architect based in Sydney says, "that's why I love Nightingale—because it doesn't rely on an individual policy or council; it's a robust model that fits into the current land development paradigm. By cutting the development profit, the cost of marketing and a display unit you're already delivering product at 20–30 per cent below developer margins" [47].

One of the Nightingale's guiding principles is about communities; deliberate strategies for fostering community include strategies such as the lack of individual laundries, a communal laundry instead being located on the roof next to a rooftop garden and entertaining space. As McLeod states, "when you are doing your washing on the rooftop you quickly meet all your neighbours. Meeting people over washing laundry is a good way to break down barriers pretty fast. After that happens a few times, there are no awkward silences!" [54].

What is clear is that the Nightingale Housing model has some very lofty ambitions about what it can deliver compared to standard housing provision in Australia; not only in terms of technical performance, but also in terms of shifting the culture of the building industry from one that is happy to deliver a low quality product, to one that takes care and delivers a carefully considered and constructed development which will continue to thrive into the future.

4. Discussion

Despite inconsistent policy development for sustainable housing around the world, there are key examples of innovative sustainable housing which have been developed over recent decades. For example, at the individual or small building scale there is the Vale's Autonomous House in Nottinghamshire in the East Midlands of England [57], BedZED in Hackbridge, London [58], zHome in Washington, USA [59] and at a larger precinct or city scale Masdar City in Abu Dhabi [60]. These examples show that housing which has low environmental impact is achievable and that we

have the design understanding, materials, technologies, and labor skills to deliver them. The examples also show that it is pertinent to revisit Smith's socio-technical dimensions of eco-housing, and apply the dimensions to a newer sustainable housing model.

The above analysis clearly highlights some similarities and differences between the Nightingale Housing model and the socio-technical dimensions identified by Smith. These are summarized in Table 6.

Table 6. Similarities and differences in the socio-technical dimensions in comparison to Smith's [14] analysis.

Socio-Technical Dimension	Similarities to Smith	Differences to Smith
Guiding principles	Established guiding principles.	More specific guiding principles which specify performance and process requirements. Also covers broader elements of delivering housing.
Technology (and design)	Delivering significantly improved sustainability outcomes across all elements of design and occupation.	Delivering sustainable housing at a larger scale but still using existing infrastructure where beneficial and tried and tested technologies, materials and design approaches.
Industrial structures	Focused on learning by doing and addressing lifecycle considerations.	Larger scale outcomes with no financial premiums for improved performance and design, capping profits, the use of ethical investors and moving to the Baugruppen financing model.
User relations	Require a high active commitment to green lifestyles and input into designs.	Not strictly a self-build, sets financial return restrictions via covenant for 20 years.
Policy and regulations	Significant constraints and challenges, especially through local planning requirements but are also about challenging these and local community perceptions.	Includes building specific regulations i.e., covenant on sale.
Knowledge	Sharing knowledge so as not to have to reinvent each time.	Developed a formal process for knowledge sharing with other developments, provides significant open source information.
Culture	About delivering more sustainable housing as outcome.	Delivering a model which challenges financial, social and community elements of housing.

What these similarities and differences suggest, is that there has been a shift in terms of what sustainable housing is, how it is being developed, and the actors involved. For instance, the rapid uptake and normalization of residential solar photovoltaics, not only in Australia but in many parts of the world, has shifted the discussion around energy consumption and generation in housing. Households in Australia are increasingly concerned with rising energy costs and recognize that solar photovoltaics offer a way to reduce and control these costs. This means that the benchmark for sustainable housing is different to what it was a decade ago, and will likely be different in another decade as battery storage and other technologies/materials enter the market and become cost efficient. This shift around sustainable housing outcomes is also evident in the fact that Smith talks about one off dwellings, whereas the focus around the world is now on how we can develop sustainable housing developments, precincts, and even cities; in this regard it is not just the performance benchmark that has changed but also the scale [19]. In addition, the actors involved in the delivery of sustainable housing are shifting from boutique builders to include a broader range of actors. This evolution of actors and their roles has been noted elsewhere in the sustainability transitions literature [61].

The rapid change in technology in the housing sector is not just challenging notions and definitions of sustainable housing, but also the policies and regulations which determine housing performance as identified by Smith. As we move towards more houses being part or wholly energy self-sufficient, this will need to be reflected in how housing is designed (e.g., ensuring enough optimal roof

space for solar photovoltaic generation) or considered within minimum standards. Currently in Australia the inclusion of solar photovoltaics is not considered when meeting minimum building performance requirements [24]. There are some examples where energy generation is being regulated for inclusion and/or required as part of minimum performance requirements, but there will be ongoing challenges around how to design flexibility into regulation to more rapidly take advantage of emerging technology developments. The challenge remains that housing is delivered to the minimum regulated requirements—which fall significantly below those required for a low carbon future, and with entrenched building regimes that are reluctant to change [28].

The Nightingale Housing model also demonstrates that there has been a shift in the language and focus around sustainable housing [62]. While there remain efforts to improve the environmental performance, as is the focus in Smith's analysis, the Nightingale Housing model is broadening this to include other benefits. As the evidence continues to emerge, benefits relating to through-life affordability, occupant health, and broader societal benefits (e.g., reduced energy network infrastructure), these may become more of a focus for housing outcomes, especially as our climate continues to change. The Nightingale Housing model is also striving to not only change housing, but also our cities. Nightingale licensed architects, according to McLeod, "are really interested in . . . sustainable urbanization and how [we can] make that happen . . . " and believe "that architects, through collaboration, can drive real positive change in our changing cities" [48]; in essence ground up innovation such as this is being driven by concerned stakeholders to address policy and practice failures at a local, state, and federal government level in Australia [26].

Another important shift is that the Nightingale Housing model is about scaling up the delivery of sustainable housing in recognition that we need to be delivering higher number of sustainable dwellings; but also that in so doing, this results in a higher quality housing outcome with significant benefits across environmental, economic, and social considerations. In this way, discussions in Australia and globally are about how we go beyond one-off sustainable housing developments to delivering such housing as a standard offering, and how do we continue to bring these broader benefits into policy discussions.

Interestingly, the Nightingale Housing model to date has been focused on a set type of dwelling; that of new-build medium density apartments in well located areas in larger cities. This is just one part of the housing sector in Australia, and globally, and the model is untested for lower density detached housing, higher density apartments, and retrofitting of existing dwellings. We may know within a few years if it is suitable for other housing types or locations with the announcement of a possible development in Bendigo, which is a regional city (with an approximate population of 113,000) in Victoria. While no firm proposals have been put forward, there is a suggestion that the development may include lower density housing. Addressing sustainability across all density types and having access to such housing in a range of locations is going to be critical if we are to transition to a low carbon housing future. We also need to start to think about how such sustainable housing models might be applied to existing housing stock which offers significant opportunities for improvement [63].

In a similar regard, questions will remain over the Nightingale Housing models suitability for broader scale uptake as the housing model requires changes to the way occupants engage with, and use, their dwellings. For example, the shared laundry is both a cost saving measure but also about generating opportunities for residents to engage with each other. While research is required to explore this in more detail (and including if the actual sustainability performance measures are being achieved), earlier adopters to the Nightingale Housing model seem to embrace these differences to traditional housing, but this may not be the case for less sustainability minded occupants, as challenges of taking previous non-sustainable practices into more sustainable housing have been identified elsewhere [64,65].

The analysis finds that overall the research by Smith remains mostly relevant when explored through this case study. The socio-technical dimensions provide a good framework for understanding sustainable and traditional housing development. However, there have been a number of changes

at the landscape, regime, and niche level over the past decade which mean that the way we view and evaluate sustainable housing has shifted. What is required now though is to develop a better understanding of the processes and opportunities that such housing models offer policy makers, housing researchers, and building industry stakeholders, in order to achieve a broader scale uptake of sustainable housing. In this way, housing transitions research should start to focus on the uptake phase of the transition.

5. Conclusions

The current provision of housing in Australia falls below the requirement for a low carbon and equitable future. Previous research by Smith identified several key socio-technical practices across seven dimensions for sustainable housing in comparison to mainstream housing. This paper applies these dimensions to the Nightingale Housing model, an emerging sustainable housing model in Australia. The analysis highlights a number of similarities to the practices identified by Smith, but also a number of differences, including a shift from the focus on individual dwellings to larger numbers, and a step back from bespoke design and technology towards more standardized approaches. In this way the Nightingale Housing model opens itself up to replicability across the industry. While it is too early to know how much it will challenge the existing housing regime, the initial evidence suggests that occupants in these dwellings are realizing benefits (social, economic and environmental) and that some in the broader housing industry are starting to take up various elements of the Nightingale Housing model. While Smith's research provides relevant framing for sustainable housing analysis, further research is required to understand how such housing models can be scaled up. While this paper explores the socio-technical dimensions of Nightingale Housing, further research is required to see assess how the developments are performing in reality, and if design intent is being achieved.

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