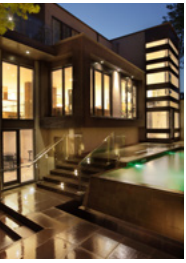
bankwest

Curtin University




BANKWEST CURTIN ECONOMICS CENTRE

PERTH'S INFILL HOUSING FUTURE

Delivering innovative and sustainable housing

Edited by Steven Rowley, Rachel Ong and Amity James

BANKWEST CURTIN ECONOMICS CENTRE

PERTH'S INFILL HOUSING FUTURE

Delivering innovative and sustainable housing

Edited by
Steven Rowley, Rachel Ong and Amity James

ISBN: 978-1-9250836-13

This book was edited by:
Steven Rowley, School of Economics and Finance, Curtin University
Rachel Ong, Bankwest Curtin Economics Centre, Curtin University
Amity James, School of Economics and Finance, Curtin University

It can be cited as: Rowley S, Ong R and James A (2017), *Perth's infill housing future: delivering innovative and sustainable housing*, Curtin University, Perth.

ABOUT THE CENTRE

The Bankwest Curtin Economics Centre is an independent economic and social research organisation located within the Curtin Business School at Curtin University. The centre was established in 2012 through the generous support of Bankwest (a division of the Commonwealth Bank of Australia), with a core mission to examine the key economic and social policy issues that contribute to the sustainability of Western Australia and the wellbeing of WA households.

The Bankwest Curtin Economics Centre is the first research organisation of its kind in Western Australia, and draws great strength and credibility from its partnership with Bankwest, Curtin University and the Government of Western Australia.

The centre brings a unique philosophy to research on the major economic issues facing the state. By bringing together experts from the research, policy and business communities at all stages of the process – from framing and conceptualising research questions, through the conduct of research, to the communication and implementation of research findings – we ensure that our research is relevant, fit for purpose, and makes a genuine difference to the lives of Australians, both in WA and nationally.

The centre is able to capitalise on Curtin University's reputation for excellence in economic modelling, forecasting, public policy research, trade and industrial economics and spatial sciences. Centre researchers have specific expertise in economic forecasting, quantitative modelling, micro-data analysis and economic and social policy evaluation. The centre also derives great value from its close association with experts from the corporate, business, public and not-for-profit sectors.

CONTRIBUTORS

Courtney Babb is a lecturer in urban and regional planning in the School of Built Environment, Curtin University. His teaching and research interests include: transport and land use relations in cities; planning systems, governance and processes; and the relationship between urban development and wellbeing.

Samba Datta is Professor of Architecture in the School of Built Environment, Curtin University. His research focuses on computational representation and reasoning, and analysis of building and urban typologies. He is currently an International Visiting Professor at the Indian Institute of Technology, Kharagpur, and Academic Fellow at the Australia India Institute. He serves as Corresponding Editor (Asia-Pacific) of the *Nexus Network Journal* on architecture and mathematics.

Keith Hampson is Professor of Construction Innovation, Curtin University. He serves as CEO of the Sustainable Built Environment National Research Centre (SBEnrc), successor to the CRC for Construction Innovation, for which he led the bid team and served as CEO from its establishment in 2001. Keith holds a Bachelor of Civil Engineering with Honours (Queensland Institute of Technology), MBA (Queensland University of Technology) and a PhD (Stanford University).

Amity James is a Senior Research Officer and lecturer within the School of Economics and Finance, Curtin University. Her research interests focus on housing affordability and housing aspirations in both the ownership and private rental market, with an emphasis on the experiences and expectations of those in later life.

Shohreh Nematollahi is an architect, urban designer and lecturer in the Department of Planning and Geography, Curtin University. She has undertaken extensive research on understanding community resistance to redevelopments around train stations in Perth. Shohreh has worked in architecture and urban design fields for more than 12 years. She has been teaching in architecture and urban planning departments for more than 10 years.

Peter Newman AO is Professor of Sustainability at Curtin University. Peter has written 19 books and more than 300 papers on sustainable cities. In 2014 he was awarded an Order of Australia for his contributions to urban design and sustainable transport. Peter has worked in local government as an elected councillor, in state government as an adviser to three premiers and in the Australian Government on the Board of Infrastructure Australia and the Prime Minister's Cities Reference Group.

CONTRIBUTORS

Rachel Ong is Professor of Economics at the Curtin Business School and Deputy Director of the Bankwest Curtin Economics Centre, Curtin University. Rachel is a member of the Steering Committee for the Asia-Pacific Network for Housing Research. Her research addresses a range of important housing issues including housing affordability, intergenerational housing concerns, and the links between housing and the economy.

Steven Rowley is Director of the Australian Housing and Urban Research Institute's (AHURI) Curtin Research Centre, Chair of the WA Housing Industry Forecasting Group and Associate Professor in the School of Economics and Finance, Curtin University. He has spent more than 20 years delivering research on housing affordability and affordable housing, securing funding from both government and industry.

Dr Giles Thomson is a lecturer at the Curtin University Sustainability Policy Institute. He is an urban designer who completed his PhD on regenerative urbanism, and is currently researching regenerative cities and regions. Giles has previous industry and government experience working on urban regeneration projects in the UK and Australia, most recently as Research Leader for the Government of South Australia's Integrated Design Strategy.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOREWORD

Perth's infill housing future is the first edited book in Bankwest Curtin Economics Centre's rich collection of publications, targeted at informing issues of economic and social policy importance within Western Australia. This book brings together a wealth of data, analysis and commentary on the state of Perth's infill housing sector, a sector vital in delivering a significant proportion of the housing required to meet future population growth.

The book offers thoughtful perspectives on how housing demand, diversity and affordability have changed in recent years and the resulting need for more diverse housing delivery. It discusses the roles of the planning system, community engagement, infrastructure investment and design-led innovations in delivering infill development both now and in the future. Using a number of case studies from across Perth, the book highlights examples of innovative thinking and delivery, providing exemplars for those working in the sector.

A critical feature of the book is its forward-looking perspective. It makes an important contribution to the evidence base by offering a narrative on the future of the infill housing sector, including the benefits that it yields for environmental sustainability. It sets a roadmap for industry and government, necessary to increase rates of infill development to meet the ambitious targets set within strategic planning documents.

Perth's infill housing future constitutes an authoritative yet accessible guide to the latest developments in infill housing, useful for academics and practitioners alike. We have made extensive efforts to capture perspectives from highly respected Curtin University researchers, delivering a comprehensive compilation of perspectives cutting across the disciplines of architecture, economics, geography, engineering and urban planning. These perspectives are drawn from academics from Curtin's School of Economics and Finance, School of Built Environment, Curtin University Sustainability Policy Institute, Sustainable Built Environment National Research Centre and the Bankwest Curtin Economics Centre. Moreover, the book represents a collaborative effort with the WA housing industry. Senior representatives from the industry were given the opportunity to comment on each chapter to help shape its overall direction. Hence, the book delivers practical and policy-relevant research informing government and industry.

It is with great pleasure that I commend the editors and authors on their accomplishment. This book is truly a high-quality multidisciplinary collaboration. I would also like to express my thanks to the key industry representatives who contributed their valuable comments. It is my sincere hope that *Perth's infill housing future* will enhance the ongoing development of the infill sector, delivering sustainable and innovative ways to meet Perth's future housing needs.

Professor Alan Duncan
Director, Bankwest Curtin Economics Centre
Curtin Business School, Curtin University

1

INTRODUCTION

Steven Rowley*
Rachel Ong
Amity James

*Corresponding author: Steven Rowley, School of Economics and Finance, Curtin University, GPO Box U1987, Perth WA 6845. Email: steven.rowley@cbs.curtin.edu.au Tel: +61 8 9266 7721

WHAT IS INFILL HOUSING?

The 2016 Census revealed a Western Australian population of 2.47 million accommodated in just over one million dwellings, with 78 per cent located in Greater Perth[1]. Despite the recent slowdown in population growth, the state government is predicting the population to rise to over three million by 2024, four million by 2035 and out to five million by 2060, based on medium-level growth projections (Department of Planning 2015a; 2015b). The Australian Bureau of Statistics (ABS) is projecting WA to increase in its share of Australia's population, from 10.7 per cent in 2012 to 15.4 per cent in 2061.

As Western Australia continues to grow, it is Greater Perth which is under increasing pressure to accommodate an expanding and demographically ageing population while delivering a diverse supply of new housing affordable to households across the income spectrum. The Census revealed 74.5 per cent of the current dwelling stock is made up of separate houses, a fall from 76.7 per cent in 2011 indicating a small increase in housing diversity, but the state is still dominated by a single form of housing. This lack of housing diversity is important because diversity delivers a range of housing options suitable for different household types across a variety of price points. Diversity delivers options for first home buyers through to older Australians looking to downsize, while tenure diversity delivers a range of products from ownership, private rental, shared ownership and social housing to meet the needs of households across the income spectrum. While greenfield development can deliver some of this diversity, it is our existing urban areas where there is need for the greatest change. Opportunities exist to increase housing choices in these areas, and delivering such diverse 'infill' housing is the subject of this book.

Infill development is defined as housing development that occurs in existing urban areas, in contrast to greenfield sites which are previously undeveloped (National Housing Supply Council 2010). Infill development takes place on

1 Greater Perth is the old Perth Metropolitan region plus Mandurah and Pinjarra. Perth's Greater Capital City Statistical Area reflects the functional extent of the city. The definition is designed to include those within the urban area of the city as well as people who regularly socialise, shop or work within the city, but live in small towns and rural areas surrounding the city (ABS 2012).

brownfield and greyfield sites. Brownfield sites are typically publicly owned land that has previously been developed, perhaps as industrial land. On the other hand, greyfield sites are defined as under-utilised property assets within ageing but occupied areas in inner and middle ring suburbs.

Infill housing is distinctly different from the traditional three/four-bedroom, two-bathroom detached houses that typically occupy greenfield sites and can include high-density apartment blocks, medium-density apartment blocks, three-storey walk-up apartments, townhouses, villas on battleaxe subdivisions, ancillary dwellings, granny flats and student housing. Hence, infill developments can offer diverse housing choices to consumers (Rowley & Phibbs 2012). Encouragingly, recent innovations within Greater Perth have started to deliver more diverse housing forms including medium-density options in new greenfield suburbs. Metronet has the potential to accelerate infill development by facilitating large-scale development around new and existing transport hubs.

Infill development is currently dominated by two types: build and replace, where a single dwelling is replaced with two dwellings (sometimes three depending on the zoning), resulting in a net gain of one dwelling. These dwellings are often separate houses. While important, it does little to alter local amenity and puts pressure on the local transport network, as infrastructure is not upgraded. The second type is high-density apartment development. What is missing is the middle – precinct level, medium-density development delivering a range of different housing types while contributing to the upgrade of local amenities.

Infill development has the potential to increase housing diversity and improve housing affordability for WA's expanding population, while at the same time promoting quality design and sustainability. The state government, through LandCorp and the Department of Communities – Housing (formerly the Housing Authority) have taken the lead in delivering innovative and sustainable housing options, but they are not alone. This book refers to a number of innovative infill examples across Greater Perth to illustrate best practice.

While it is important to remember that greenfield housing development plays an important role in delivering housing supply and remains the preference of many households, WA does not have a problem delivering this type of housing

at scale. However, it does have a problem delivering infill housing, hence the motivation behind this book.

KEY ISSUES

Perth's infill housing future is an edited collection of book chapters on issues relating to the state's infill housing sector. While focusing on examples from Greater Perth, the book is relevant to the whole state. It has a particular focus on disseminating practical and policy-relevant research to industry and government. The book will shed light on the following key questions:

- How has housing demand, diversity and affordability changed in recent years and what are the resulting implications for the infill housing sector in WA?
- How can planning systems be exploited to support the delivery of quality infill development?
- What are some key principles of community engagement that should be employed to mitigate community resistance to infill development?
- What are the benefits of design-led innovations in the infill housing sector?
- What sort of infrastructure investments are likely to promote infill development?
- Can infill housing present opportunities for enhancing city sustainability?
- How can innovative architectural designs lead to positive infill outcomes for sustainable development?

The book draws from a unique set of multidisciplinary expertise spread across Curtin University on urban infill development. It features important perspectives from research experts in the field from Curtin's School of Economics and Finance, School of Built Environment, Curtin University Sustainability Policy Institute (CUSP), Sustainable Built Environment National Research Centre (SBEnrc) and the Bankwest Curtin Economics Centre. Each chapter received comments from relevant industry experts before being finalised.

THE CHAPTERS

Chapter 2 by Rowley and James provides important contextual background to the subsequent chapters. It presents an overview of the housing sector in WA and highlights key issues around housing demand, diversity and affordability. The chapter draws from a range of WA-specific policy and data sources, including *Directions 2031 and beyond*, the *State planning strategy 2050* and *Perth and Peel@3.5million* to shed light on key policies that encourage infill development in metropolitan Perth.

This policy context sets the scene for a discussion on the contribution of the planning system to the delivery of quality infill development in Perth, in Chapter 3, by Babb. Through its framework of statutes, standards and guidelines that control the location, form and use of development, urban planning plays a vital role in determining the type and character of infill housing in our cities. This chapter evaluates the influence of planning on infill development in three urban contexts – urban infill around rail stations, urban infill along arterial roads, and infill in suburban areas.

Community resistance is often viewed as a major barrier to the infill development process. In Chapter 4, Nematollahi reviews recent community engagement processes undertaken in relation to infill development in Greater Perth. Drawing on two case studies, the chapter highlights key principles that underpin successful community engagement strategies in infill housing.

The next two chapters investigate the role of innovation in the delivery of high-quality infill housing in WA. In Chapter 5, Thomson, Hampson and Newman offer a detailed look at the potential of new technologies and processes for promoting infill development outcomes including cost-effectiveness, timeliness, sustainability and liveability. The chapter focuses on key design-led innovations such as prefabrication or off-site manufactured building, digital design innovations that complement the prefabrication process, and innovations in governance processes that aim to maximise the quality of infill development outcomes. The discussion is aided by case studies of design-led infill processes in Perth and Melbourne.

Chapter 6, by Datta, shifts the focus to the role of innovative architecture in promoting successful infill outcomes. The chapter draws heavily on eight exemplary infill housing projects in Greater Perth suburbs and encompasses a broad range of housing typologies within its discussion. These case studies help demonstrate the role of creative planning and design strategies in mitigating negative perceptions of urban consolidation and promoting sustainable infill outcomes.

The role of infrastructure investment in promoting urban infill outcomes is the subject of Chapter 7, by Thomson and Newman. The exposition focuses on transport infrastructure, and considers infrastructure for infill at two scales. At the city-wide level, the chapter considers the interplay between infrastructure and three main urban fabric contexts – walking cities, transit cities and automobile cities. At the local geographic level, units of plot, block and precinct are considered, which represent the typical scales of infill delivery. The chapter also discusses the different urban qualities and costs resulting from different types of infrastructure, as well as implications for the town planning system.

Chapter 8, by Thomson and Newman, examines how infill decisions can help foster a more sustainable, liveable and prosperous Perth. The chapter expounds on concepts related to sustainable urban systems including the definition of the term 'sustainable', urban metabolism, and sustainable and liveable cities. It also sheds light on how higher-density infill offers a significant opportunity to promote sustainability and liveability. A Perth case study – WGV (or White Gum Valley) – is critically assessed in the context of sustainable infill development. The chapter concludes by laying out steps that are required to accelerate the mainstreaming of sustainable urbanism in Australian cities.

Finally, Chapter 9 integrates the perspectives laid out in the preceding chapters and offers a forward-looking narrative on the future of the infill housing market in Western Australia.

REFERENCES

ABS – see Australian Bureau of Statistics.

Australian Bureau of Statistics 2012, *Greater capital city statistical areas*. Statistical Geography Fact Sheet. Retrieved from http://www.abs.gov.au/websitedbs/d3310114.nsf/4a256353001af3ed4b2562bb00121564/6b6e07234c98365aca25792d0010d730/$FILE/Greater%20Capital%20City%20Statistical%20Area%20-%20Fact%20Sheet.pdf.

Department of Planning 2015a, *Western Australia Tomorrow, population report No. 9, long-term population forecasts for Western Australia, 2031 to 2061*. Western Australian Planning Commission. Retrieved from https://www.planning.wa.gov.au/publications/6194.aspx.

Department of Planning 2015b, *Western Australia Tomorrow, population report No. 10, medium-term population forecasts for Western Australia 2014-2026 and sub-regions 2016-2026*. Western Australian Planning Commission. Retrieved from https://www.planning.wa.gov.au/publications/6194.aspx.

National Housing Supply Council 2010, *National Housing Supply Council 2nd state of supply report*. Canberra: Commonwealth of Australia.

Rowley, S & Phibbs, P 2012, *Delivering diverse and affordable housing on infill development sites*. (Report No. 193 from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/__data/assets/pdf_file/0014/2066/AHURI_Final_Report_No193_Delivering_diverse_and_affordable_housing_on_infill_development_sites.pdf.

2

HOUSING DEMAND, DIVERSITY AND AFFORDABILITY

Steven Rowley*
Amity James

*Corresponding author: Steven Rowley, School of Economics and Finance, Curtin University, GPO Box U1987, Perth WA 6845. Email: steven.rowley@cbs.curtin.edu.au Tel: +61 8 9266 7721
The authors would like to thank Christopher Phelps for creating the maps used in this chapter.

INTRODUCTION

This chapter introduces the policies governing infill development in the Greater Perth[2] region. It discusses key issues around housing demand, diversity and affordability, and is designed to complement the other chapters by providing a general overview of the housing sector in the region.

The Greater Perth region extends north and south of the CBD covering some 120 km, bound by the Indian Ocean to the west and the Darling Scarp to the east. The region is characterised by low-density suburbs consisting of separate detached dwellings around an inner ring, which contains limited housing diversity. The Government of Western Australia (WA Government) and Western Australian Planning Commission (WAPC) have outlined a vision to create a more consolidated city encouraging a diverse range of housing options to deliver choice and affordability (WAPC 2010). This requires the (re)development of existing suburbs to deliver more housing and more housing choice (Rowley & Phibbs 2012). Such development is categorised as infill – "housing development sites within existing urban areas" (National Housing Supply Council 2010:223). Infill development includes brownfield and greyfield sites. Brownfield usually refers to large-scale, previously developed sites, while greyfield sites are defined as "under-utilised property assets located in the middle suburbs of large Australian cities. Greyfields are usually occupied and privately owned sites typical of urban development undertaken from the 1950s to the 1970s" (Newton et al. 2011:1-2).

CURRENT POLICIES

Three key documents form the policy context at a strategic level for the Greater Perth area: *Directions 2031 and beyond*, *State planning strategy 2050* and *Perth and Peel@3.5million*.

2 Greater Perth consists of the Perth Metropolitan Region plus the City of Mandurah and the Pinjarra Level 2 Statistical Area of the Shire of Murray.

Directions 2031 and beyond (WAPC 2010) was the first to address the issue of a consolidated city, and the need to change existing patterns of housing development in the long term through infill measures:

> *Directions 2031* recognises the benefits of a more consolidated city while working from historic patterns of urban growth. Importantly, the framework sets achievable goals that will promote housing affordability over the longer term. (WAPC 2010:iii)

Based on population projections, *Directions 2031 and beyond* estimates the need for a further 328,000 dwellings over the 20-year life of the plan. Crucially, the plan aims to accommodate 47 per cent of these dwellings within the existing urban area. This 47 per cent is now engrained in discussions about housing density at all levels and has delivered a useful target by which to gauge changing patterns of housing supply. Rates of infill development have increased in recent years, with the rate in 2015 sitting around 34 per cent, up from 28 per cent in 2013 (WAPC 2016). Multi-residential approvals are synonymous with infill development; however, they are not the only form of such development. Since early 2014, multi-residential developments have been well above their decade average of 22 per cent of all dwelling approvals, reaching 28 per cent in 2015-16 (Housing Industry Forecasting Group (HIFG) 2016) but since falling to under 20 per cent (HIFG 2017). This highlights the cyclical nature of multi-residential development, which is driven by a host of economic and demographic factors, the availability of finance and the ability of developers to make a profit commensurate with the risk associated with such development. The 47 per cent is an ambitious target; it relies on a number of economic factors aligning, along with accommodating planning policies and local communities.

By concentrating new housing development around transport hubs, and commercial and retail centres, *Directions 2031 and beyond* aims to increase housing diversity and affordability within the Greater Perth region (WAPC 2010). The strategy contends that residents will have the opportunity to live closer to work, and choose from a wider range of housing options, while simultaneously preserving the character and amenity of existing suburbs.

The *State planning strategy 2050* (the strategy), provides a strategic context for planning and development across WA (WAPC 2014). It recognises affordable living as being a component of the state's social wellbeing and economic growth. The strategy acknowledges that housing affordability in the Greater Perth region is challenged first by the mismatch between the changing demographic structures and the lack of diversity among the housing stock, and secondly, by affordable land being located on the outskirts of the metropolitan area, where travel costs can often negate any initial cost savings associated with dwelling purchase.

The primary housing objective of the strategy is to create affordable living through housing diversity and compact settlements, centred on mixed-use transport hubs offering access to employment, services and amenities (WAPC 2014). The strategy argues that economies of scale for affordable living can be achieved by creating a more consolidated urban footprint, characterised by higher dwelling densities and a mix of housing types developed around transport corridors (WAPC 2014).

Designed to realise the vision of *Directions 2031 and beyond* over the next 35 to 40 years, and echoing the direction of the affordable living component of the strategy, the final planning document is *Perth and Peel@3.5million*. Consisting of four sub-regional planning frameworks, the document provides a spatial plan for the development of the Greater Perth and Peel region (WAPC 2015). The key housing strategy is to contribute to housing choice and availability. It is argued that the current pattern of development on the urban fringes is not sustainable, with calls for "a more consolidated city through greater infill and residential density and better use of existing infrastructure" (WAPC 2015:3).

The plan specifies a number of actions which are required to achieve the vision for the Greater Perth area, including:

1. Increasing the diversity of housing types by encouraging more medium-density housing; a higher proportion of low to medium-rise apartments within designated urban consolidation areas; and high-density living opportunities within the Perth city centre.

2. Encouraging developers and builders to increase supply of affordable houses[3] through the region, with a particular focus on alternative building methods and delivering high-quality, affordable housing in urban consolidation areas.

3. Facilitating the rapid response of the development and building industry to changing demographics profiles and consumer needs by removing barriers to adaptive reuse or existing housing stock and innovative use of redundant commercial spaces or vacant land (WAPC 2015:63).

Overall, the strategic direction for the Greater Perth region is on urban consolidation, increased housing diversity underpinned by the need for greater housing affordability. It is envisaged this direction will result in a shift in the current housing landscape. But to what extent does this policy direction accord with the housing demand aspirations of Greater Perth residents and, indeed, is it feasible given the many factors that drive housing supply?

HOUSING AFFORDABILITY IN PERTH

The strategic planning policy frameworks described above consistently refer to the need to provide housing which is affordable, albeit without a clear, consistent definition of affordable housing or housing affordability. The frameworks are closely tied to the state's affordable housing strategy, *Opening doors to affordable housing*, released in 2010 with the objective of increasing affordable housing opportunities. The Department of Planning, Lands and Heritage has a key role in the strategy, helping to deliver opportunities for low to moderate-income households. There are a number of reasons why a state government would prioritise affordable housing, with economic productivity being one (Maclennan et al. 2015), and social outcomes another (Stone et al. 2015).

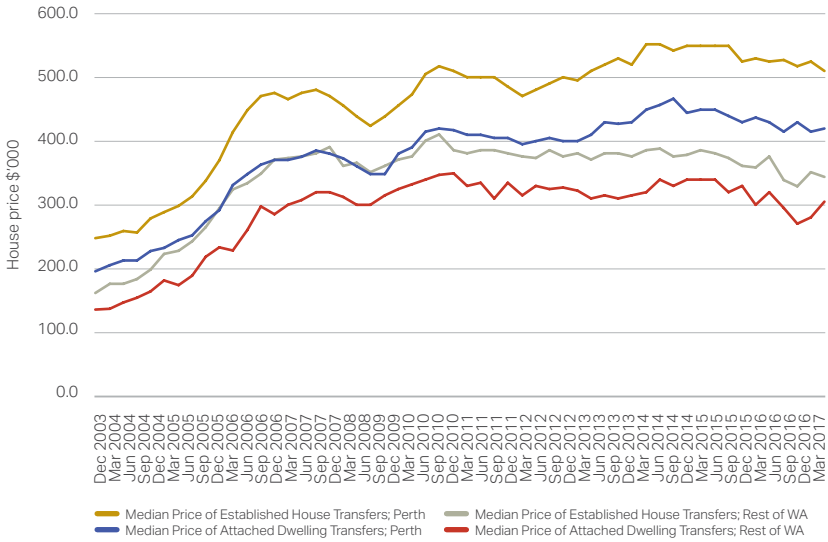
3 Here affordable housing is used as a generic term meaning housing affordable to those on low to moderate incomes, rather than subsidised housing (public and social housing) or housing with eligibility limits (typically income-based, for example: Keystart), which is a more appropriate definition and one gaining traction, at least in academic circles.

Additionally, the link between housing and health is well acknowledged (Mason et al. 2013), with design, location and affordability of housing understood to have a central impact upon wellbeing (Rowley & Ong 2012).

Figure 2.1 shows that over the last decade median house prices in Perth and the rest of WA have not changed substantially, with growth diverging from the rest of Australia since the end of 2013 (Figure 2.2). According to the Real Estate Institute of Western Australia (REIWA), during the December 2007 quarter median house prices were $475,000, with the figure now around $505,000 (June 2017), lower in real terms. The rise in house prices during 2012 and 2013 was fuelled by increases in net migration responding to employment opportunities generated directly and indirectly through growth in the resources sector. In response to this demand there was a surge in building activity in 2013 through to 2015 with record levels of dwelling commencements (HIFG 2017).

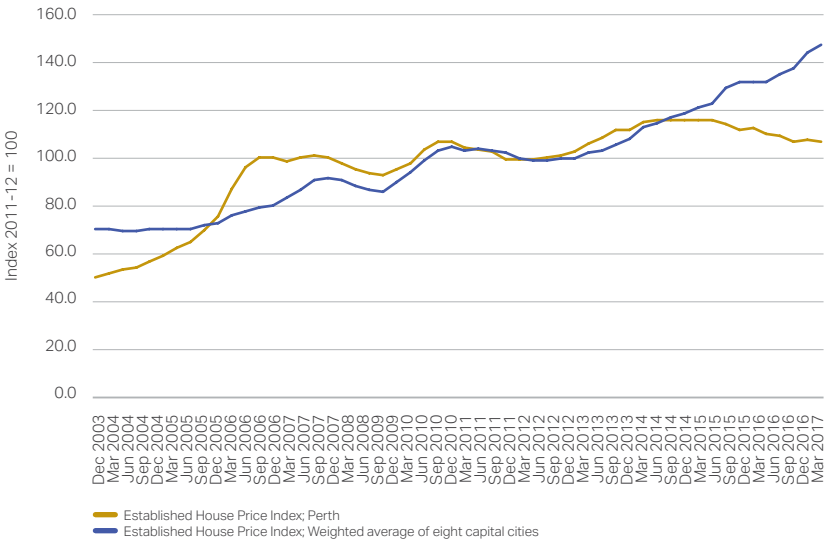
Slowing population growth and a struggling economy have resulted in the median price trending downwards in the last three years. Sales for established homes fell by 15 per cent during 2015, and activity in the land market also dropped significantly (HIFG 2017). In the private rental sector, median weekly rents for houses fell from $420 in September 2015 to $360 in June 2017, with the vacancy rate at 7.3 per cent (REIWA 2017), well above the three per cent considered 'normal' by the industry.

Figure 2.1 Median detached and attached dwelling prices, Greater Perth region and Rest of WA



Source: ABS 6416.0 Residential property price indexes: eight capital cities, Tables 4 and 5. Median price (unstratified) and number of transfers (Capital City and Rest of State).

Figure 2.2 Established house price index



Source: ABS 6416.0 Residential property price indexes: eight capital cities, Table 2. Established house price index, index numbers and percentage changes

Recent housing supply has been particularly strong in WA when compared to other states (Table 2.1). Record dwelling commencements in 2013/14 and 2014/15, on the back of strong mining investment and population growth during the preceding two years, have contributed to recent price declines when combined with soft demand. The housing industry in WA has delivered more housing per capita than any other state over the last 30 years. This has helped keep prices low in comparison to the eastern states outside of periods of exceptionally strong demand. The year 2016 saw significant falls in building approvals and dwelling commencements, bringing new supply in WA below other states, but this is a normal reaction to a period of contracting demand.

Table 2.1 Dwelling commencements per 1000 residents

	1985-2015	2005-2015	2010-2015	2016
Western Australia	10.9	10.5	10.3	8.3
Queensland	10.3	8.4	7.6	10
Australian Capital Territory	9.5	9.9	11.9	14.7
Victoria	8.2	9.1	10	11
Australia	*8.1*	*7.6*	*7.8*	*9.7*
Northern Territory	7.7	6.8	7.8	4.9
South Australia	6.6	6.7	6.2	6.5
New South Wales	6.5	5.2	5.9	9.9
Tasmania	5.8	5.3	4.8	4.1

Source: ABS Cat. No. 3101 and 8752.0

While falls in rents and prices suggest broad improvements in housing affordability, such improvements have not filtered down to lower-income households (Duncan et al. 2016). The recent Bankwest Curtin Economics Centre *Keeping a roof over our heads: BCEC housing affordability report 2016* (Duncan et al. 2016) found that while there was a diverse range of house and unit prices across the Greater Perth area, it was spatially specific resulting in a lack of affordable housing options in inner-city areas (Duncan et al. 2016). For example, price-to-income ratios for established homes – with higher ratios indicating higher levels of unaffordability – were found in those suburbs directly to the west of the Central Business District (CBD) to be 11.9 times the annual income of the residents (Duncan et al. 2016). Fremantle and the Vincent/Stirling South East region had house prices 8.8 times annual household income (Duncan et al. 2016). A similar trend was found for multi-residential units where Fremantle was the least affordable location followed by the inner-city suburbs of Belmont and South Perth/Victoria Park (Duncan et al. 2016).

Hence, despite general improvements to house prices and the private rental market, "housing affordability continues to be a significant issue for Western Australian households on low or moderate incomes" (HIFG 2017:iii). If a household on a median income was to spend only 30 per cent of their income

on mortgage costs, they would be unable to afford an entry-level dwelling at the lower quartile price of $422,000 (HIFG 2017). The reality highlights the mismatch between incomes and dwelling prices within the Greater Perth region, which is influenced in part by a lack of housing diversity. A recent study by the Department of Communities – Housing (Housing Authority 2016) found that less than one per cent of properties sold in Perth during the period 2013 to 2015 were affordable to households on under $45,000 per annum. A household on the same income could afford only three per cent of private rentals (Housing Authority 2016). Despite falls in rental costs, affordability in the private rental sector remains a major concern for households on low incomes, even those with access to Commonwealth rent assistance (HIFG 2017). It is worth noting that many households are able to adjust to service direct housing costs. To illustrate, half of all WA respondents to the Bankwest Curtin Economics Centre 2015 Housing Affordability Survey spent more than 30 per cent of their income on housing costs, with a quarter spending more than 40 per cent (Duncan et al. 2016). When asked to rate the affordability of their housing, only 20 per cent regarded their housing as unaffordable (Duncan et al. 2016). However, it is still the case that those most likely to describe their housing as being unaffordable were living in the private rental sector, on a low income and paying a high proportion of their income towards their housing costs (Duncan et al. 2016).

PERTH'S HOUSING STOCK PROFILE

Greater Perth contributes around 86 per cent of all dwelling commencements in the state (HIFG 2016). While WA may have delivered significant quantities of housing (Table 2.1), diversity is lacking, with the housing stock dominated by large detached homes (Table 2.2).

Almost three-quarters of all new development occurs as greenfield development on the urban fringe (WAPC 2015), with 75 per cent of all dwellings in Greater Perth being separate dwellings and the remainder of the stock divided between semi-detached (17 per cent) or flats, units or apartments (8 per cent) (Table 2.2). These figures are in stark contrast to Sydney, for example,

where separate dwellings consist of 55 per cent of the housing stock, with the number of flats, units or apartments much higher at 30 per cent. Although seemingly comparable on the semi-detached housing front, overall Greater Perth is characterised by a distinct lack of housing diversity, making it difficult for households to trade attributes such as house size and type to access affordable accommodation in their preferred location. Greater Perth saw the lowest drop in the percentage of separate houses in the five-year period from 2011 to 2016 but the biggest growth in semi-detached dwellings (Table 2.2).

Table 2.2 Capital city housing stock diversity, 2016 (change on 2011)

	Greater Perth	Greater Sydney	Greater Melbourne	Greater Brisbane	Greater Adelaide
Separate house	75% (-2%)	55% (-4%)	66% (-6%)	74% (-4%)	73% (-3%)
Semi-detached[4]*	17% (+5%)	14% (+1%)	17% (+5%)	10% (+1%)	18% (+5%)
Flat, unit, apartment	8% (-2%)	30% (+2%)	16% (-1%)	14% (+1%)	9% (-2%)

Source: ABS (2011, 2016)

Note: *Semi-detached, row or terrace house, townhouses with one or two storeys.

The lack of diversity in Perth is highlighted when separate houses are considered as a proportion of housing stock in each local government area (LGA) (Figure 2.3 and Table 2.3[5]). With growing distance from the city, the housing stock is increasingly dominated by detached dwellings. LGAs with the highest proportion of detached dwellings are generally to the east of the city, including Mundaring (96 per cent), Kalamunda (94 per cent) and Gosnells (90 per cent). There are some LGAs delivering housing diversity; for example, semi-detached, single-storey dwellings constitute 21.5 per cent of the housing

4 Semi-detached etc. is defined by the ABS as follows: "These dwellings have their own private grounds and no other dwelling above or below them. They are either attached in some structural way to one or more dwellings or are separated from neighbouring dwellings by less than half a metre."

5 The figures presented here are based on 2011 Census data whereas the tables have been updated to 2016 data. There seem to be significant increases in the number of semi-detached etc. dwellings between 2011 and 2016. These increases should be treated with some caution, as this may well be due to a change in the way data were collected between the two Census dates (see http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter29902016)

stock in Stirling, but such diversity needs to become the norm if Greater Perth is going to meet its infill target and deliver the type of diversity present in other cities. Overall, LGAs in the inner-central, coastal and outer-central locations have the most diverse housing stock profiles (Figure 2.3). This is for two reasons: 1) planning policy permits density in many locations, and 2) this type of development is profitable, with revenues able to support the total costs of producing such dwellings.

Table 2.3 Examples of housing diversity in selected WA LGAs, 2016 (change on 2011)

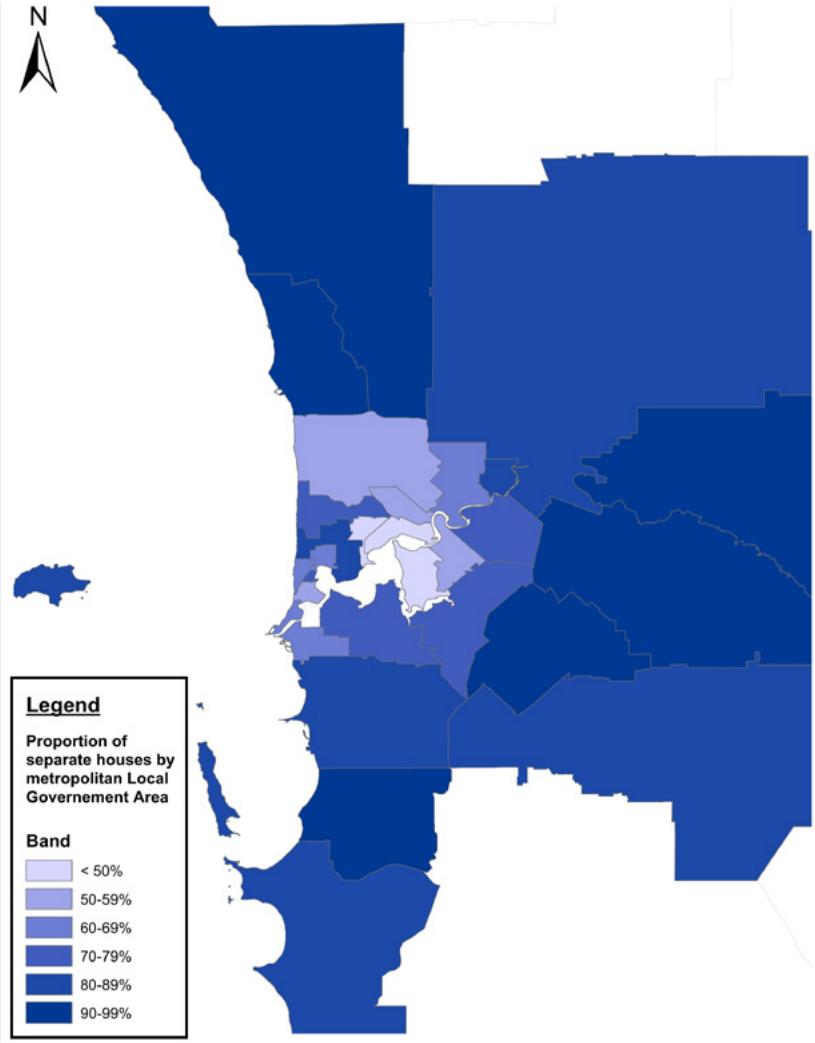
	Armadale	Belmont	Perth	South Perth	Stirling	Victoria Park
Separate house	87% (-1%)	65% (-7%)	1% (-1%)	47% (-1%)	53% (-5%)	52% (0%)
Semi-detached dwelling or terrace house	13% (+7%)	23% (+11%)	5% (+4.5%)	37% (+23%)	37 (+15%)	27% (+11%)
Flat, unit or apartment (one or two storey)	1% (-4%)	4% (-3%)	4% (+2%)	6% (-3%)	6% (-5%)	6% (-4%)
Flat, unit or apartment (three storey)	0%	4% (0%)	13% (-6%)	4% (-3%)	3% (+1%)	5% (0%)
Flat, unit or apartment (four storey)	0%	6% (+4%)	78% (+8%)	6% (-2%)	1% (0%)	9% (-2%)

Source: (ABS 2011)

Building approvals[6] offer a useful proxy for new housing supply in the absence of stock data, which is only available every five years with the Census. Unlike dwelling commencements and completions, building approvals are available at the LGA level, helping to track changing diversity over time. Total building approvals for all dwelling types have been falling since a peak in September 2014 (HIFG 2017), driven by a decline in population growth and a downturn in prices. The figures highlight patterns of separate dwelling approvals on the edges of the Greater Perth region, while other dwellings are more centrally located.

6 This analysis was conducted prior to the release of housing stock data in the 2016 Census.

Figure 2.3 Separate houses as a proportion of housing stock in Greater Perth, by LGA, 2011



Adapted from: ABS Cat. No. 8752.0

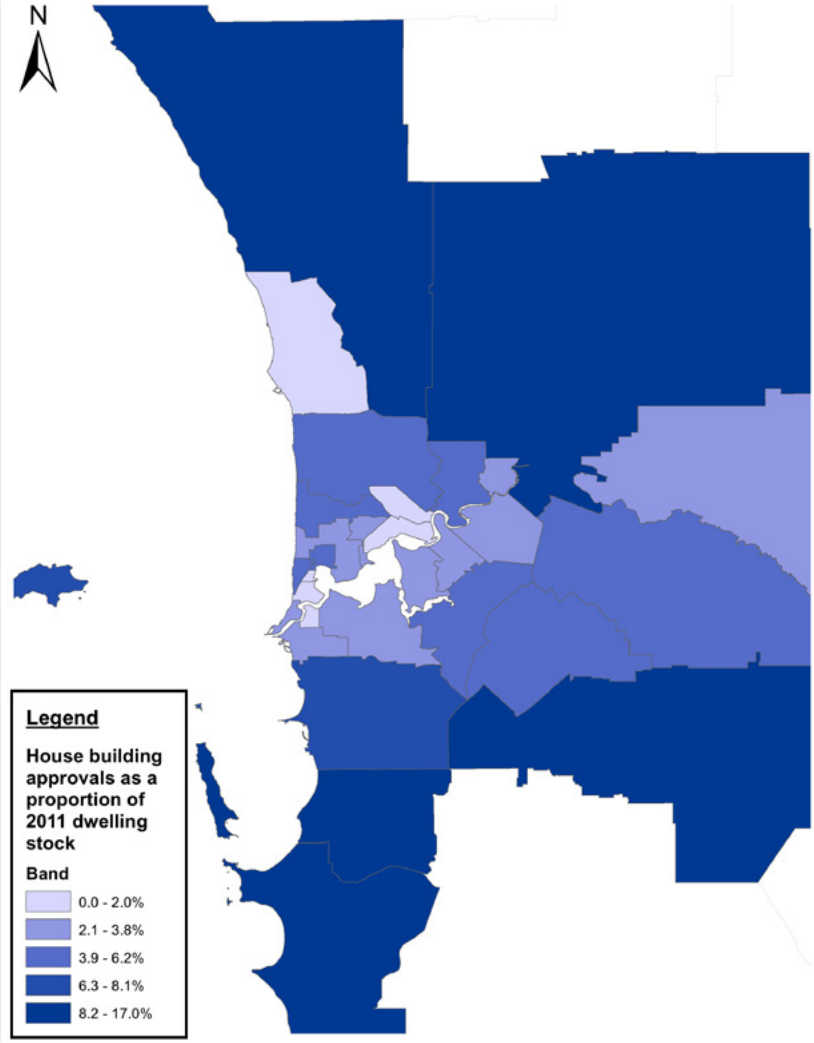
Figure 2.4 shows the sum of building approvals for separate houses during the period 2011/12 to 2013/14 as a proportion of all private dwellings recorded by the 2011 Census. This reflects the increase in supply of separate houses between 2001 and 2014 as a proportion of the housing stock in 2011. The LGAs with the greatest proportional increase in detached housing stock were Armadale (34 per cent), Kwinana (33.5 per cent) and Wanneroo (29.1 per cent). The building approvals for other dwellings, such as apartments or townhouses in the Greater Perth area, were much lower. Figure 2.5 maps the total number of 'other dwellings' approved between 2011 and 2014 to show changing spatial patterns in these dwelling types (numbers are used rather than percentages of stock because the proportions are so low in many areas). The greatest increases in other dwellings were found in the City of Perth (21.4 per cent of all stock) and City of Vincent (10.6 per cent of all stock). The figures highlight patterns of separate dwelling approvals on the edges of the Greater Perth region, while other dwellings are more centrally located.

Changes to the housing stock profile are typically driven by a mix of factors, many of which are related, including:

- planning policy
- consumer demand from owner-occupiers and investors
- development profitability
- the availability of finance
- population growth
- general economic conditions including interest rates.

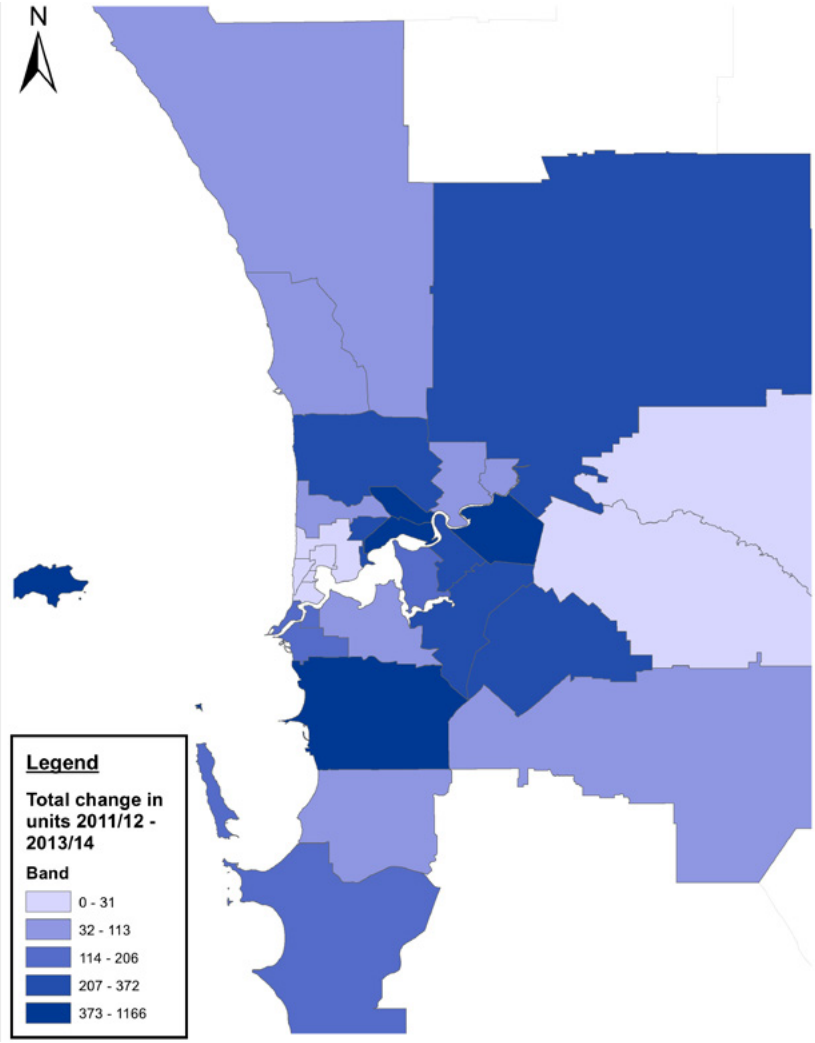
The higher cost of land closer to the city (largely a function of consumer demand) requires developers to maximise height and density to meet return requirements, resulting in higher-density dwellings closer to the CBD. The outer suburbs to the north east and south will continue to be dominated by detached dwellings unless there is some form of policy intervention, while those in the more central locations will offer more diverse housing options. Diversity in dwelling type can be achieved by including the full range of housing types comprising apartments, both large and small scale, but also terraces and townhouses and other forms of smaller scale, medium-density products. This is the missing middle – Greater Perth has a strong supply of detached

Figure 2.4 Growth in the supply of separate houses between 2011/12 and 2013/14, by LGA, per cent



Adapted from: ABS Cat. No. 8752.0

Figure 2.5 Growth in the supply of multi-residential units between 2011/12 and 2013/14, by LGA, per cent



Adapted from: ABS Cat. No. 8752.0

dwellings and a growing number of apartments but lacks the medium-density housing options for which the industry believes there is strong demand (HIFG 2017). Diversity also refers to tenure and there is scope to increase options through alternative tenure products such as shared ownership or cooperative developments.

HOUSING ASPIRATIONS

The strategic policy direction in WA focuses on consolidating development within the Greater Perth region, in part to mitigate broader housing affordability issues resulting from commuting needs and the costs of delivering greenfield infrastructure. As shown in the housing stock profile in Table 2.2, achieving greater housing diversity through infill development will require a sustained shift in development patterns. However, will this policy shift actually deliver the housing that households want? Surveys over the last four years have collected detailed evidence on what Perth residents want from their housing. The Bankwest Curtin Economics Centre Housing Affordability surveys conducted in 2013 and 2015 and the WA Department of Housing and Department of Planning, Lands and Heritage *The housing we'd choose: a study for Perth and Peel* conducted in 2013 considered households' preferred tenures, locations and dwelling characteristics. The combined outcomes of these three reports provide an insight into the housing preferences of Perth's residents.

Traditionally a nation of home owners, 67 per cent of all Australian households either own their property outright or with a mortgage (ABS 2011). Studies have shown the preference for home ownership persists (Department of Housing 2013). In 2015, over half of non-home owner survey respondents (57 per cent) stated they would prefer to live in a home that they owned, while just 24 per cent would, given their current circumstances, prefer to live in the private rental sector (Duncan et al. 2016).

Location

Housing aspirations are underpinned by location and affordability. The importance of location for Perth and Peel residents was made clear in the *Housing we'd choose* survey where respondents regarded location as being more important than the dwelling itself (Department of Housing 2013). Affordability and location are consistently identified by survey respondents as being the two most important aspects in deciding where to live (Table 2.4). The location of housing impacts significantly on the day to day access households have to work, school, public transport, entertainment and community services, and has the capacity to shape household wellbeing. Households tend to be quite flexible about the dwelling itself, if the dwelling delivers affordability in a desired location.

Table 2.4 Decision-making factors in housing choice, WA respondents, 2015 relative ranking

Distance of alternative location	Relative ranking
Location (for example, easy access to work, schools, friends, family)	1.00
Affordability	0.83
Neighbourhood characteristics (e.g. amenities, safety and security)	0.38
It was the best option available at short notice	0.24
Size (number of bedrooms, for example)	0.13
Space (large rural lot, for example)	0.09
Specific features (such as appearance or energy efficiency)	0.08
Other (please specify)	0.07

(Duncan et al. 2016:82)

A unique element to the *Housing we'd choose* study was its capacity to collect data on respondents' current and preferred location of residence. Nine regions were identified throughout the Perth and Peel area (Figure 2.6). It was found that, regardless of age group, twice as many respondents wanted to live in the inner-city region than are currently living there (Department of Housing 2013). The study also found that, once constrained by financial capacity, only half those who expressed a preference to live in this region could actually afford to do so (Department of Housing 2013). The only solution here is to deliver more diverse and affordable housing options in inner locations.

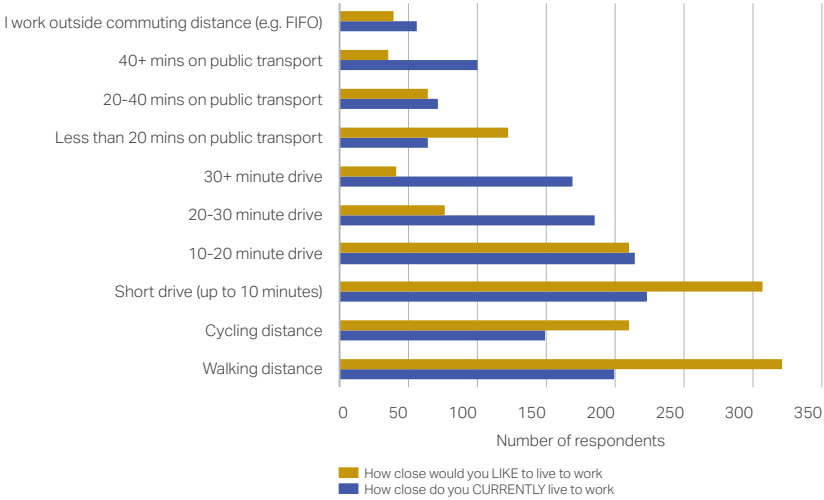
Figure 2.6 Perth and Peel region map

Source: Department of Housing (2013:23)

The 2013 Bankwest Curtin Economics Centre Housing Affordability Survey found that those households most likely to have secured their first-choice location were currently in the north west, coastal, inner central, north east and river/coastal areas, compared with less than half of those in the south and east (Cassells et al. 2014). Those households in the private rental sector were less likely to have secured their preferred location when compared to purchasers, reflecting the very tight rental market at the time. Almost half the respondents to the 2013 survey living outside their first-choice location reported they had to move between 5 km and 10 km away to afford a suitable dwelling and, in the 2015 survey, a fifth of both owners and private renters reported they were forced to locate more than 10 km away from their preferred location to access housing which was affordable to them (Duncan et al. 2016). It is clear location trade-offs are being made because suitable housing options are not available. This is hardly new, but the distances between preferred and selected locations are growing. Again, an increase in diverse housing options would offer households more choice in their preferred location and a greater chance of accessing the housing market in the area they want to live.

Housing affordability is influenced by housing type and location, particularly in regard to commuting and running costs (Duncan et al. 2016). As households make location trade-offs to secure housing, they often increase their commuting costs, which further affects housing affordability pressures. WA respondents to the 2015 Bankwest Curtin Economics Centre Housing Affordability Survey indicated, unsurprisingly, that overall they would like to spend less time commuting and, given the option, would prefer to walk (Duncan et al. 2016). As shown in Figure 2.7, most survey respondents reside within a 10 to 30-minute drive from work, but a significant proportion live more than 30 minutes away (Duncan et al. 2016). Commuting preferences of WA households provide support for a more compact city, which would enable people to live affordably within those regions with the most employment opportunities.

Figure 2.7 Commuting patterns and references, WA residents, December 2015



Source: Duncan et al. (2016:86)

Findings from these studies demonstrate evidence of unmet need, particularly in the inner central, north west, coastal, north east and river/coastal regions of Perth (generally the older, more established suburbs) and a need to increase the diversity of housing supply in these regions to accommodate the location preferences of Perth residents (Department of Housing 2013).

Dwelling type

The *Housing we'd choose* study found that the housing aspirations of Perth residents showed a strong preference for detached houses. Separate detached homes were favoured by 78 per cent of respondents (Department of Housing 2013) and at first glance appear to match the current housing stock profile. However, once respondents selected a preferred dwelling from a range dwelling types in a variety of locations affordable to them given their income, those who preferred detached dwellings dropped to 56 per cent. Respondents indicated they would trade-off house type for location, largely opting for semi-

detached homes where possible and, for many, apartments in the absence of an alternative. The study highlighted a considerable mismatch between housing stock and preferences. Similar to the preference shifts in Melbourne and Sydney reported by the Grattan Institute (Kelly et al. 2011), new housing supply in Perth needs to find a more appropriate balance between traditional detached dwellings and more diverse housing options, such as semi-detached houses.

Households in all studies demonstrated they are realistic about the trade-offs that have to be made to access their preferred locations (Cassells et al. 2014; Department of Housing 2013; Duncan et al. 2016). These trade-offs include, for example, buying a smaller house or paying higher housing costs. Households residing outside their preferred location are willing to compromise on housing attributes such as lot size, construction type, proportion of outdoor space (Duncan et al. 2016) or the number of bedrooms (Department of Housing 2013) to access a preferred location. Location is key, with the dwelling type secondary for many.

The research indicates that the housing preferences of Perth residents would "support a shift in focus from urban fringe development of detached four-bedroom homes to a wider range of housing types in the inner and central regions" (Department of Housing 2013:5), particularly semi-detached dwellings. There remains a role for detached dwellings in outer suburbs, and it is important to note not all employment opportunities are located in the inner regions. However, respondents to the surveys conveyed a strong desire to live within more established suburbs, notably those in the inner central and surrounding regions. In all studies, the importance of location as a decision-making factor was underpinned by affordability, as it determines where a household can live, as well as the type and size of dwellings affordable in those locations.

CONCLUSION

The Greater Perth region is characterised by a low-density, sprawling housing landscape. Changes to the demographic structure of the population and the need for more affordable housing have generated a shift in demand for

housing in Perth. There is a desire by residents to live closer to the central regions, which offer access to employment opportunities and other amenities. Many households are excluded from these regions because of housing costs. Housing affordability has, subsequently, created a mismatch between what Perth households want to achieve from their housing and what is available for purchase or rent. Recent research has found that location is so important households are willing to make trade-offs regarding housing design, size and land area.

The state is aiming to create a more consolidated metropolitan region, characterised by greater housing diversity where development is focused on key transport nodes. Encouragingly, the housing aspirations of the population support this current strategic direction. Rates of infill development have increased in recent years, with the rate in 2015 sitting around 34 per cent, up from 28 per cent in 2013 (WAPC 2016), a long way short of the 47 per cent target but demonstrating much greater activity in multi-residential development. However, this activity has been dominated by high-density, multi-residential development which is highly cyclical, and recent data shows a sharp decline in the number of approvals (HIFG 2017).

There remains a gap in the medium-density space – small-scale apartment developments and alternative house types including terraces and semi-detached options which can significantly increase the yield from a single lot and are less prone to community opposition. To provide a better match between the types of dwellings supplied and housing preferences, the state government needs to encourage more medium-density development in established suburbs. This was the type of product favoured over high-density apartments in the *Housing we'd choose* study and, as the rest of this book will show, it is possible to deliver sustainable, well-designed and high-quality developments the community will support, and which will deliver the type of housing diversity we need to supplement traditional forms of development.

REFERENCES

ABS – see Australian Bureau of Statistics.

Australian Bureau of Statistics 2011, Census of Population and Housing. Canberra: Australian Bureau of Statistics.

Australian Bureau of Statistics 2016, Census of Population and Housing. Canberra: Australian Bureau of Statistics.

Cassells, R, Duncan, A, Gao, G, James, A, Leong, K, Markkanen, S & Rowley, S 2014, *Housing affordability: the real costs of housing in WA*. Bankwest Curtin Economics Centre, Focus on Western Australia Series, No. 2, April 2014. Perth: Bankwest Curtin Economics Centre and Curtin Business School.

Department of Housing 2013, *The housing we'd choose: a study for Perth and Peel*. Perth: State of Western Australia.

Duncan, A, James, A, Leong, K, Ong, R & Rowley, S 2016, *Keeping a roof over our heads: BCEC housing affordability report 2016*. Focus on Western Australia report series No. 7. Perth, WA: Bankwest Curtin Economics Centre.

HIFG – see Housing Industry Forecasting Group.

Housing Authority 2016, *Housing affordability: a study for the Perth Metropolitan area*. Perth: Government of Western Australia, Housing Authority. Retrieved from http://www.housing.wa.gov.au/HousingDocuments/Housing_Affordability_Report_2016_Perth_Metro_Area.pdf.

Housing Industry Forecasting Group 2016. *Forecast dwelling commencements in Western Australia: April 2016 update*. Perth, WA: Housing Industry Forecasting Group.

Housing Industry Forecasting Group 2017, *Forecast dwelling commencements in Western Australia: April 2017 update*. Perth, WA: Housing Industry Forecasting Group.

Kelly, JF, Weidmann, B & Walsh, M 2011, *The housing we'd choose*. Melbourne: Grattan Institute.

Mason, K, Baker, E, Blakely, E & Bentley, R 2013, 'Housing affordability and mental health: does the relationship differ for renters and home purchasers?' *Social Science & Medicine*, 94, 91-97.

Maclennan, D, Wood, G & Ong, R 2015, *Making connections: Housing, productivity and economic development*, Final Report No. 251, Melbourne, Victoria: Australian Housing and Urban Research Institute.

National Housing Supply Council 2010, *2nd state of supply report*. Canberra: Commonwealth of Australia.

Newton, P, Murray, S, Wakefield, R, Murphy, C, Khor, L & Morgan, T 2011, *Towards a new development model for housing regeneration in greyfield residential precincts*, AHURI Final Report No. 171. Melbourne, Victoria: Australian Housing and Urban Research Institute.

Real Estate Institute of Western Australia 2017, *Perth metro market snapshot*. Real Estate Institute of WA. Retrieved from https://reiwa.com.au/the-wa-market/perth-metro/.

REIWA – see Real Estate Institute of Western Australia.

Rowley, S & Ong, R 2012, *Housing stress: housing affordability and household wellbeing in Australia*. AHURI Final Report No. 193. Melbourne, Victoria: Australian Housing and Urban Research Institute.

Rowley, S & Phibbs, P 2012, *Delivering diverse and affordable housing on infill development sites*. AHURI Final Report No. 193. Melbourne, Victoria: Australian Housing and Urban Research Institute.

Stone, W, Sharam, A, Wiesel, I, Ralston, L, Markkanen, S & James, A 2015, *Accessing and sustaining private rental tenancies: critical life events, housing shocks and insurances*, Final Report No. 259. Melbourne, Victoria: Australian Housing and Urban Research Institute.

WAPC – see Western Australian Planning Commission.

Western Australian Planning Commission 2010, *Directions 2031 and beyond: metropolitan planning beyond the horizon*. Perth: Western Australian Planning Commission.

Western Australian Planning Commission 2014, *State planning strategy 2050*. Perth: Government of Western Australia.

Western Australian Planning Commission 2015, *Perth and Peel @3.5 million: summary*. Perth: Western Australian Planning Commission.

Western Australian Planning Commission 2016, *Urban growth monitor: Perth metropolitan, Peel and Greater Bunbury regions*. Retrieved from https://www.planning.wa.gov.au/publications/6182.aspx.

3

DELIVERING QUALITY INFILL DEVELOPMENT IN PERTH

The contribution of the planning system

Courtney Babb*

*Corresponding author: Courtney Babb, School of Built Environment, Curtin University, GPO Box U1987, Perth WA 6845. Email: c.babb@curtin.edu.au Tel: +61 8 9266 7259

INTRODUCTION

Urban planning plays a fundamental role in determining the type and character of infill development by providing a framework of statutes, standards and guidelines that control the location, form and use of development. By doing this, the planning system shapes the physical form, social quality and ecological functioning of cities. This chapter focuses on how the planning system shapes the quality of infill development in Perth. The quality of infill development can be evaluated from a number of perspectives including architectural design, construction materials and energy efficiency. From an urban planning perspective, which considers the form, function and potential impacts within the context of the city, quality infill needs to balance social, environmental and economic impacts across different spatial and temporal scales.

At a spatial scale, both the regional and local contexts of development are important. These encompass the relationship between development and the surrounding environment – the street, businesses, residences and nearby amenities – as well as the location of development in relation to employment, services and recreational activities across the Greater Perth region. At a temporal scale, important factors are how development meets the needs of present generations and provides for future generations, while also responding to cultural heritage and protecting environmental assets. Achieving a balance between these factors across spatial and temporal scales is difficult, and it is arguable whether any development can adequately meet all these criteria. Infill development frequently occurs at spatially constrained sites, and despite the best efforts of planners, trade-offs between different criteria are necessary. In Perth there are examples, however, that highlight positive steps forward that planners and others involved in shaping cities can draw on to deliver a higher quality form of urban infill.

This chapter begins by providing a brief overview of the planning system in Perth, focusing on how recent reform of the system has been instigated to influence the rate and quality of infill development being delivered. The next section uses examples to draw attention to the positive steps towards achieving good-quality infill in three urban contexts. The first of these is urban infill around rail stations, which affords access to the wider urban region by

intensifying development near to high-frequency public transport connections. The second focuses on urban infill along arterial roads, and the particular ways planners are meeting the challenges of providing quality urban environments in car-dominated environments. The third example looks at infill in suburban areas and outlines how using strategies to retrofit existing low-density areas can provide new housing opportunities without undermining the elements that make suburban living attractive.

THE PLANNING SYSTEM REFORMS AND INFILL IN PERTH

To address sprawling low-density urban development and accommodate rapid population growth, Australian state governments have responded by setting targets for urban infill in most capital cities. The 2010 metropolitan strategic plan for Perth, *Directions 2031 and beyond* (Western Australian Planning Commission (WAPC) 2010a) and the recent draft *Perth and Peel@3.5million* plan (WAPC 2015) outline that 47 per cent of future dwellings in Perth are planned to occur within the existing urban boundary. This equates to approximately 328,000 additional dwellings being provided in local government authorities (LGAs) within the central and outer sub-regions of Perth by 2031. The target is modest in comparison to other metropolitan areas, with strategic metropolitan plans in Melbourne, Adelaide and, until recently, Sydney having targets of up to 70 per cent infill. Despite comparatively conservative targets, progress in the Perth and Peel regions has been slow. By 2014, only two out of the 32 LGAs were ahead of their targets and half were in the early planning phase for addressing these targets (WAPC 2014).

To achieve infill targets the planning system deploys a range of mechanisms to guide developers, decision-makers, stakeholders and community interests within the urban development process. Since 2009, the Western Australian planning system has been subject to a comprehensive reform of its legal, policy and governance frameworks (WAPC 2014), largely based on increasing the rate of infill development. The scope of the reforms encompasses legislation and policy concerning the zoning of land uses, and the control of urban form and design.

The introduction of Development Assessment Panels (DAPs) is one element of the reforms. The role of DAPs is to assess proposed developments within mandatory and opt-in development cost thresholds against relevant planning policies, local planning schemes or regional planning schemes. The rationale for their introduction was to reduce complexity and ensure planning expertise was safeguarded when proposals for development were assessed (Maginn & Foley 2014). Panels consist of two representatives, nominated by the relevant local government, and three specialist members, nominated by the Minister for Planning, representing different professional affiliations. The response to the inclusion of DAPs in WA's planning system has been mixed, with the main contention due primarily to the centralisation of decision-making power. A review of DAPs in 2013 (Department of Planning 2013) highlighted that panels were received very positively by the development industry, with more qualified support overall from local government. Ongoing concerns about the centralisation of decision-making powers led to several local governments passing motions to oppose DAPs in 2016. It is important to remember that decision-making by DAPs, albeit discretionary, is framed within the parameters defined by local planning frameworks. One potential outcome of the introduction of DAPs into the WA planning system is that there will be more political support at state and local government level for updating planning schemes, formulating policies and undertaking structure planning to ensure that future decisions relating to infill development produce outcomes that support urban quality.

Another facet of the reform of the planning system relevant to delivering infill development is the Multi-Unit Housing Code (MUHC). The code was introduced in 2010 (WAPC 2010b) as an addition to the Residential Design Codes, (R-Codes). These are the primary planning tools for guiding the design of development: the code has the objective of ensuring diversity and flexibility in the housing market by introducing new controls for new multi-unit housing, or apartments. The MUHC introduced new parking standards and removed a requirement for a minimum lot size for new residential development, including regulating the bulk and mass of development with plot-ratios, boundary setbacks and maximum heights. This effectively increased the capacity of dwellings permitted on lots within areas zoned R30 and above. The implementation of the initial code was met with substantial criticism from local

government and sections of the community, based on poor amenity of the development being produced and increased traffic in local streets. In 2015, the Department of Planning amended the policy to allow local governments to place tighter restrictions on multi-unit housing in areas zoned R30 and R35.

Although DAPs and the MUHC have arguably facilitated an increase in the rate of infill development, it is important to recognise it is not the density of urban areas alone that leads to an improvement in urban quality. Although there are potentially significant benefits to increasing density within existing urban areas, such as an increased consumer and land tax base to pay for infrastructure and services, and increased opportunities for economic and social interactions, dense cities also increase potential conflicts due to more impacts of development in spatially constrained urban places. To ensure quality infill occurs, development planning must move beyond a simple assumption that infill development will inevitably improve people's quality of life.

Design is a critical factor in determining the overall quality of infill development. Good design encompasses both tangible and intangible factors that emerge in response to the 'genius loci' or spirit of place, including adapting the design of development to be consistent with the local character of the existing neighbourhood context, designing apartments to provide passive surveillance of the street and discourage crime, and carefully responding to natural features of the site to protect environmental assets and ecological functions. Ensuring better design for infill development requires both an overall legislative framework and the mechanisms to embed design considerations in the ongoing assessment of proposals in situ.

At the local government scale, design advisory committees have emerged as one solution to ensure that design is addressed and delivered for infill development. The City of Fremantle Design Advisory Committee, whose role is to review developments against a series of design principles, is an example. Another initiative is *Diverse city by design*, a collection of fact sheets produced by the WAPC and the Department of Planning in 2015 that provide a useful educational tool to increase knowledge of the diversity of, and issues related to, infill development (Department of Planning 2015). In late 2016, a suite of planning initiatives concerned with strengthening the design outcomes of infill

development, branded Design WA, was released for comment. This included a state planning policy focused on design, apartment design guidelines and protocols for design review panels. These initiatives reflect design policy in other states, including the well-considered *State environment planning policy No. 65* in New South Wales (NSW) (Parliament of Western Australia 2014). Although it is too early to evaluate the impact of Design WA, embedding design principles, expertise and evaluation in the assessment of infill development is an important step in improving the quality of the built environment within the existing urban boundary.

Planning policy has increasingly sought to target infill development towards specific urban contexts in the Greater Perth area. The next sections highlight some examples of how infill is progressing in Perth in three different contexts. These examples illustrate how, through appropriate consideration of siting and design, the planning system can improve the quality of infill development being delivered in Perth.

INFILL AT RAIL STATIONS

Strategic planning in Perth has sought to direct substantial future infill development within 'activity centres', planned hubs of commercial, residential and recreational activity located to take advantage of existing transport connections. *State planning policy 4.2* (WAPC 2010c) identifies areas of Perth within a hierarchy of activity centres, and sets out planning consideration for these centres. The accessibility of rail stations and the transport options they afford have accordingly resulted in many stations in the Perth region being identified as future activity centres or Transit Oriented Developments (TODs). TODs are models of urban development that leverage the accessibility of stations, locating jobs and housing near to the station and providing a high-quality, walkable urban realm (Cervero et al. 2002).

Since the early 1990s the WA Government has made significant investment in new, heavy rail infrastructure in Perth, pragmatically located within the freeway median reserves. The Joondalup and Mandurah rail lines have provided a raft of

new stations and created new opportunities for activity centres. The decision to locate a new hospital at Murdoch station reflects the importance of co-locating major employment centres close to high-quality transit links. The challenge for developing activity centres at these freeway median stations is to provide a good-quality public realm to support increased population growth. Many of these stations are surrounded by greyfield urban areas, which have evolved to accommodate car-based mobility, dominated by road infrastructure, parking spaces and low-density urban development. The station precinct at Cockburn Central is illustrative of this challenge. Planned as a TOD due to large state government land holdings, the area west of the station has slowly transformed into a town centre, and future housing development and recreational facilities will ensure steady population growth in the precinct. However, balancing the need to be a place to live, and the need to function as a park-and-ride and bus interchange for commuters in the broader region, has proven difficult. The major arterial roads on the periphery of the station precinct are busy and often congested, impacting the quality of the overall urban area (Babb et al. 2015a).

Research conducted by the Planning and Transport Research Centre in 2015 investigated the potential for different rail stations to develop as activity centres (Babb et al. 2015b). This research showed that while stations located in the freeway median have much potential to develop as effective nodes for secondary transport connections demonstrated by the existing feeder bus network or potentially by future bus rapid transit or light rail, it was stations located away from freeway medians that had the most potential to develop as good-quality places for people to live. The urban fabric surrounding stations located on the heritage railway lines in Perth – the Fremantle, Midland and Armadale lines – has largely evolved separate from major road infrastructure. Unlike freeway median stations, many stations on the heritage lines have features that provide a better framework to support the quality of life of residents, such as permeable and walkable street networks, character housing contributing to higher urban amenity, and established street trees that contribute to lower ambient temperatures.

The Midland railway line provides an example of a corridor with potential for the development of several activity centres to accommodate quality infill development at rail stations. The planned Forrestfield–Airport Link, which will

link the eastern hills and airport with the Midland line near Bayswater station, will deliver accessibility gains to many of the stations on the line and therefore provide more advantages to increasing infill within station precincts (City of Perth 2015). The station precinct at Midland has been identified as a strategic regional centre. With the planning controls of the Metropolitan Redevelopment Authority (MRA), along with ongoing state government investment, and the addition of the new Midland campus of the Curtin University Medical School and health facilities, the area will continue to attract significant interest by developers seeking to capitalise on the existing accessibility and the amenity.

Rail stations closer to Perth, such as Maylands and Bassendean, have seen recent increases in infill development, and other stations, like Bayswater, have the potential to provide more opportunities for infill in the future. The Maymont development in the Maylands town centre is indicative of the type of infill development possible in rail precincts in older suburbs. The Maymont development (see Figure 3.1), which provides apartments above the commercial shops, maintains the historical facade of the main street and is a good example of how heritage built form can be integrated into new infill development. Planning studies such as the *Maylands activity centre urban design framework* (City of Bayswater 2009) and appropriate structure planning provide important blueprints to inform statutory mechanisms and guide future development that is responsive to the local heritage context of these precincts. Some infill development has progressed outside of the main street precinct since the release of the Maylands urban design framework, with Unison on Tenth taking advantage of a larger lot remnant of the area's industrial history, close to the train station. However, opportunities on larger lots, with the exception of the busy Guildford Road corridor, will be constrained and future development will need innovative design approaches to make strategic use of smaller lots.

The challenge for these areas will be to balance the need to service the broader urban catchment as activities and services around the station attract more people, and maintain the quality of the activity centre and protect character areas. Delivering quality infill in these heritage precincts in the future will both require robust planning frameworks, along with a series of planning 'tools', to ensure that as individual developments are proposed, they respond to the local

Figure 3.1 Maymont, Maylands

Source: Photo © C. Babb (2017)

context and their own set of unique design requirements. The use of design advisory committees by an increasing number of local governments to provide expert advice on design issues is an example of how a higher quality of infill development is being achieved.

INFILL WITHIN ROAD CORRIDORS

Arterial roads provide further synergies between infill development and transport infrastructure by providing housing that can be co-located with high-frequency bus routes or light rail. Infill within transport corridors was first articulated in urban policy in WA in the 2004 Network City metropolitan strategy, in the form of 'activity corridors' and remains a feature of current planning policy. A methodology used by architect Rob Adams in Melbourne was applied to Perth to give a rudimentary indication of the capacity of arterial road corridors to accommodate infill development (Property Planning Council et al. 2013).

It found a medium-density development scenario along just seven road corridors in Perth had the capacity to deliver the *Directions 2031* housing targets.

Road corridors are, however, challenging environments to deliver high-quality infill, as they are often noisy, polluted and inhospitable – and dangerous for pedestrians and cyclists. Beaufort Street, which links the major activity centre of Morley to the city, is one road corridor attracting increased infill development. The neighbouring suburban area has high amenity and established retail and commercial businesses, and a high frequency bus service and bus priority lanes support intra-regional access. Traffic management areas like the modified slow speeds in the Mount Lawley area also mitigate some of the impacts of heavy traffic. However, there are conflicts between the traffic function and the corridor as a place for living. Many properties immediately adjacent to Beaufort Street are subject to reservations for future transport corridors, restricting future development from delivering a human environment with consistent frontage to the street and providing a challenge for street activation that is commonly an objective of such activity corridors.

Other emerging activity corridors have been more successful in integrating infill development within main road environments. One example is Cambridge Street, linking the Leederville and Northbridge area to the garden suburbs of Floreat and City Beach. The *West Leederville activity centre plan 2011* and associated Cambridge 'High Street' project (Town of Cambridge 2014) illustrate the type of urban design intervention that can be used to improve the streetscape, minimise the impact of traffic on residences adjacent to the road, and provide a safer environment for pedestrian movement. The project used a 'road diet' approach, meaning that two traffic lanes in each direction were reduced to one, with the removed lane replaced with turning lanes or increased space for pedestrians in the road median. By reducing capacity of the roadway strategically, at a number of key points in the road, and by increasing the capacity of pedestrian space at key nodes in a street, road diets reduce the overall speed of traffic in an area and therefore provide a safe and more generous street environment for pedestrians (Thomas 2013). The improvements in the quality of the street environment that result from a road diet can moderate the impacts of intensive forms of development along urban corridors with limited or no setback from the street (see Figure 3.2 for an example of such a development).

Figure 3.2 Development on Cambridge Street in the road-diet area

Source: Photo © C. Babb (2016)

The combination of higher-density apartments directly adjacent to the arterial road and the redesign of the road space to improve safety and quality for pedestrian movement provides a good example of the type of public realm design intervention needed to support infill in main road areas.

RETROFITTING SUBURBIA

Many rail station precincts and road corridors have the capacity for increased infill development that can make use of existing urban infrastructure. However, Perth is a largely suburban city and vast areas of the metropolitan area lie outside accessible rail station precincts and transport corridors, many of which are characterised by low-density, single-lot dwellings. Although the inherent car dependence and fragmented, small lot land holdings in these areas limit their capacity to sustain significant urban consolidation relative to activity

centres and activity corridors, there are opportunities for infill development through subdivision of lots. The recent reforms to the planning system have accelerated the rate of change in many of these areas. However, much of this infill development is single storey, grouped housing on battleaxe blocks (Duckworth-Smith 2015), and by effectively removing space for gardens and increasing paved surfaces, roofs and driveways, many of the benefits and amenity of suburban development are disappearing (Brunner & Cozens 2013).

There are several ways to ensure a higher quality of infill in these suburban areas than the planning system is currently producing. One is to allow greater flexibility in site design. Greater flexibility in built form design requirements increases opportunities for innovative built form that is responsive to the qualities of the site and needs of people who live there. Preservation and creation of gardens and communal spaces is possible, balanced with opportunities for increasing the dwelling yield of sites. Two examples in Lathlain by developers The Green Swing (2016) illustrate the type of infill development that can be delivered which provides greater density and diversity of housing while limiting the factors that result from maximising site coverage. The planning for the first of the developments, Genesis, was lodged prior to the introduction of the MUHC in 2010, meaning that the development was subject to more rigid mechanisms in the pre-reform development assessment process. Despite this, the outcome was: two grouped houses and two apartments on an 837 m^2 lot, with 60 per cent of the lot containing a mix of private and common open space. The second development, The Siding (see Figure 3.3), which was assessed after the introduction of the MUHC, provides a more substantial dwelling yield on the lot, with two townhouses and seven apartments. The dwellings are provided with private garden spaces and there is a common area with a food garden supporting the sustainability of the development. Both developments offer an indication of how the design of sites and the configuration of housing can protect valuable resources like gardens, privacy, common areas and solar access while still increasing the number of dwellings.

A further means of delivering a higher quality form of suburban infill development is to support enhancements to the quality of local streets. The traditional function of suburban local streets as a place for people has gradually eroded and is now superseded by a space for cars. If suburban areas are to

Figure 3.3 The Siding, Lathlain

Source: Photo © L. Brookes-Kenworthy (2016)

accommodate more dwellings, then the balance of function of streets must be shifted back towards human activity rather than mobility for cars. There are international examples of how streets can be redesigned to address this balance, both to reduce the impact of increased demand for travel resulting from more infill development and to enhance the human activity through walking, cycling, social interaction and play (Karndacharuk et al. 2014). A local example of how streets can be redesigned in this way is the application of the concept of 'self-explaining roads' in Innaloo, by the City of Stirling. The area is within the catchment of the Stirling activity centre but characterised by predominantly low-density suburban housing. Self-explaining roads employ design interventions, such as landscaping or the installation of public art, to provide drivers with visual cues signalling that the function of the road has changed and to reduce speed. The combination of such innovative street-based design interventions with increased infill development has the potential to deliver a more resilient and equitable form of urban growth, allowing planning authorities to meet their infill targets without compromising the quality of life of existing and future urban populations.

CONCLUSION

The examples presented in this chapter demonstrate a range of tools that planners are using to improve the quality of infill development occurring in the Greater Perth area. There is a broad range of contexts where infill development is occurring and this chapter has highlighted three of these areas. Rail station precincts offer opportunities for higher-density infill in proximity to public transit services that afford accessibility to the broader urban area. Road corridors often provide difficult contexts to deliver quality infill, although with careful design of the adjacent road environment the impacts of heavy traffic can be minimised. Finally, existing suburban areas have the capacity to provide some proportion of the projected infill targets; however, planning in these areas must proceed by paying attention to the benefits that suburban areas afford to residents – private open space, safe streets and affordability.

Three common themes link the examples in this chapter and point to the main factors that determine the quality of infill that can be produced to meet the population challenges in Perth. Firstly, location relative to regional accessibility is important. Secondly, the quality of design and the responsiveness of the development to the site and neighbourhood context is key. Essentially, quality infill should rest lightly in its urban context. Finally, the quality infill needs to be supported by quality streets and public realm. It should also enhance the function of the area, and because more people will be living there, the function of the place should be one that supports good quality of life.

REFERENCES

Babb, C, Duckworth-Smith, A, Falconer, R, Isted, R, Olaru, D & Biermann, S 2015a, 'The performance and potential of rail stations in and outside freeway medians: the application of a node/place model to Perth'. Paper Presented at Australasian Transport Research Forum, 2015, Sydney, New South Wales.

Babb, C, Duckworth-Smith, A, Falconer, R, Isted, R, Moniruzzaman, M, Olaru, D & Biermann, S 2015b, 'Activity centres: making land use and transport work: phase 1: stations in or near freeway medians: reconciling node/place conflict'. Presented at Planning and Transport Research Centre. Retrieved from http://www.patrec.uwa.edu.au/__data/assets/pdf_file/0006/2798466/Activity_Centres_September2015.pdf.

Brunner, J & Cozens, P 2013, 'Where have all the trees gone? Urban consolidation and the demise of urban vegetation: a case study from Western Australia'. *Planning Practice & Research*, 28(2), 231-255.

Cervero, R, Ferrell, S & Murphy, S 2002, 'Transit-oriented development and joint development in the United States: a literature review'. *Transit Cooperative Research Program Research Results Digest*, 52. Retrieved from http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_52.pdf.

City of Bayswater 2009, *Maylands activity centre urban design framework*. City of Bayswater website. Retrieved from http://www.bayswater.wa.gov.au/development/policies-and-legislation/maylands-activity-centre-zone.

City of Perth 2015, *Spatial network analysis of multimodal urban transport systems – City of Perth public transport accessibility study*. City of Perth website. Retrieved from http://engage.perth.wa.gov.au/transport/documents/34659/.

Department of Planning (DAP) 2013, *Review of the Development Assessment Panels*. Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/daps_review_final.pdf.

Department of Planning (DAP) 2015, *Diverse city by design fact sheet*. Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/Diverse_City_by_Design_Fact_Sheets.pdf.

Duckworth-Smith, A 2015, 'Backyard bonanza: improving the quality of "popular" suburban infill'. *Australian Planner*, 52(4), 297-313.

Karndacharuk, A, Wilson, D & Dunn, R 2014, 'A review of the evolution of shared (street) space concepts in urban environments'. *Transport Reviews*, 34(2), 190-220.

Maginn, P & Foley, N 2014, 'From a centralised to a "diffused centralised" planning system: planning reforms in Western Australia'. *Australian Planner*, 51(2) 151-162.

Parliament of Western Australia 2014, *Extract from Hansard 22nd May 2014*. Retrieved from http://www.parliament.wa.gov.au/Hansard/hansard.nsf/0/c84784b5c0e9569c48257cf30013bdda/$FILE/A39+S1+20140522+p590b-595a.pdf.

Property Council of Australia, The Greens & Australian Urban Design Research Centre 2013, *Transforming Perth: regenerating transport corridors as a network of High Street precincts*. Retrieved from http://greens.org.au/sites/greens.org.au/files/TransformingPerth.pdf.

The Green Swing 2016, 30 June, Decision-making for sustainability/greening-the-city. The Green Swing: towards a sustainable community website. Retrieved from http://thegreenswing.net/decision-making-in-the-name-of-sustainability/greening-the-city.

Thomas, L 2013, Road diet conversions: a synthesis of safety research. White Paper Series. Retrieved from http://www.pedbikeinfo.org/cms/downloads/WhitePaper_RoadDiets_PBIC.pdf.

Town of Cambridge 2014, Cambridge Street 'High Street' Precinct. Retrieved from https://www.cambridge.wa.gov.au/Develop-Build/Planning/Planning-projects/West-Leederville-Activity-Centre.

WAPC – see Western Australian Planning Commission.

Western Australian Planning Commission 2010a, *Directions 2031 and beyond*. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/plan_directions2031_Part1.pdf.

Western Australian Planning Commission 2010b, *Multi-Unit Housing Code: discussion paper*. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/Discussion_Paper_MUHC.pdf.

Western Australian Planning Commission 2010c, S*tate planning policy 4.2: activity centres for Perth and Peel (No. 166).* Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/activity_centres_policy_2.pdf.

Western Australian Planning Commission 2014, *Delivering direction 2031: annual report card 2014*. Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/Directions_2014_Report_Card.pdf.

Western Australian Planning Commission 2015, *Perth and Peel@3.5 million*. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/pp_summary.pdf.

4

COMMUNITY ENGAGEMENT

A multifaceted process

Shohreh Nematollahi*

*Corresponding author: Shohreh Nematollahi, Department of Planning and Geography, School of Built Environment, Curtin University, GPO Box U1987, Perth WA 6845. Email: shohreh.nematollahi@curtin.edu.au Tel: +61 8 9266 3866

"There is no logic that can be superimposed on the city; people make it, and it is to them, not buildings, that we must fit our plans."

Jane Jacobs ('Downtown is for people' in *Fortune Classic* 1958)

INTRODUCTION[7]

The goal of community engagement for infill development is to reach a final proposal which incorporates various governmental and non-governmental stakeholders' views. Therefore it is a complex process. This chapter uses two case studies to discuss community engagement, comparing recent processes in Canning Bridge and Subiaco. The chapter highlights the key principles that should be adopted when developing a genuine and effective community engagement strategy and avoiding the escalation of community resistance – a major obstacle in the infill development process.

WHAT IS COMMUNITY ENGAGEMENT?

Community engagement is an important, though complex process to ensure proposals for urban change respect and respond to community opinion. In the urban planning system, it is seen as a democratic way to involve a community and to initiate a dialogue regarding the development process (Healey 1997; Day 1997; Flyvbjerg 1998; Leitch et al. 2008). There is a common perception that involving local people extends to merely inviting them to several meetings and talking to them about a development project (Rifkin & Pridmore 2001). Such a limited process offers no assurance that citizen concerns and ideas will be taken into account, which Pierson (2008) refers to as 'bogus empowerment'. Such a bogus process can leave residents feeling 'used' for believing in inflated claims and undelivered promises, while project leaders are left with undermined

7 The author would like to thank Professor Dave Hedgcock for his valuable comments and extend her gratitude to interviewees Warren Giddens, Scott Davis and Juliette Hammah for their time.

credibility and respect (Pierson 2008). Community engagement is, in essence, a social process, built on an understanding of existing social values and social relations (Tiwari & Pandya 2014). Moral concepts such as responsibility, trust, respect and loyalty between those leading the process and those being empowered are seen as prerequisites for successful community engagement (Ciulla 2004 cited in Pierson 2008).

WHY DOES RESISTANCE OCCUR?

Infill development proposals, like other planning development proposals, require community consultation for approval. Depending on the nature of development and its location, various stakeholders are involved such as residents, business owners, schools, minority groups, youth, senior groups and government agencies. Such proposals often become the focus of local community resistance as stakeholders see their interests affected or threatened by proposed development outcomes (Leitch et al. 2008; Pierson 2008). This is a familiar challenge facing state agencies and local councils in Australian cities (Rice 2009; Rowley & Phibbs 2012; Cook et al. 2012; Davison et al. 2013; Weller & Bolleter 2013; Ruming 2014; Hedgcock & Brunner 2015).

These studies show that community concerns vary depending on the nature of each project. Generally, concerns revolve around land-use changes, movement networks such as road design, speed limit, number of parking bays, and issues around urban form such as building heights and dwelling types. While all of these matters are crucial to the broader consolidation debate, this chapter will focus on an analysis of built form (density) responses. Resistance to proposed density changes can delay the development process, adds uncertainty and creates a decision-making environment that reduces the ability of the planning system to deliver on its housing location and density targets (Rowley & Phibbs 2012; Cook, et al. 2012).

While community opposition is seen as a natural part of a community engagement process, engaging the community from early on in the development process, communicating effectively and acting on feedback are a

few important initial steps towards a genuine community engagement process that can avoid the escalation of resistance.

DENSITY AS THE CORE SOURCE OF COMMUNITY OPPOSITION

> "People do not perceive, understand, or relate to the environment in the same way, nor do they necessarily do so in the way a planner does or intends that they should."
>
> Churchman (2002, p. 198)

One of the major community concerns associated with infill development projects is the increase in residential density. The broader community often perceives density to be a source of noise and nuisance, loss of privacy and social incompatibility or heterogeneity between existing and incoming residents (Urban Futures Research Program 1996; Rice 2009). By contrast, policymakers and planners believe in a need for future living options in socially vibrant, cost-effective neighbourhoods that support regional economic growth and enhance housing affordability (Calthorpe 1993).

While planning and related disciplines use the term 'density' to define the number of dwellings per hectare or acre (Rapoport 1975; Forsyth 2003), the community perceives[8] and evaluates it differently (Rapoport 1975; Alexander 1993; Churchman 1999; Forsyth 2003; Argent 2008). Planners' and residents' views of density are different; they have a 'difference of outlook' (Davison 2010, p. 304) and this can create major challenges during an engagement process. Residents typically criticise form, scale and height of buildings and the different lifestyles that high-density infill developments may bring to suburban neighbourhoods as being 'out of character' (Dovey & Woodcock 2010), as they reference the perceived undesired psychological impact.

8 'Perceived density' refers to physical character and social character of a dense development (Rapoport 1975; Nematollahi et al. 2015).

Other issues include a cynical belief that development is about developers' profit[9] at the community's expense (Rice 2009) or that development may result in creating 'rental' apartments which may 'boganise' an area (Nematollahi et al. 2015).

OVERCOMING DENSITY OPPOSITION: TWO DESIGN APPROACHES FROM PERTH

In community forums, which form a key part of a community engagement process, the biggest concerns often tend to emerge when building height maps are discussed. Proposed design scenarios (future building height maps) that are at odds with the community's dominant view of acceptable and understood urban form usually escalate resistance, particularly from those living in higher socio-economic areas (Cook et al. 2012).

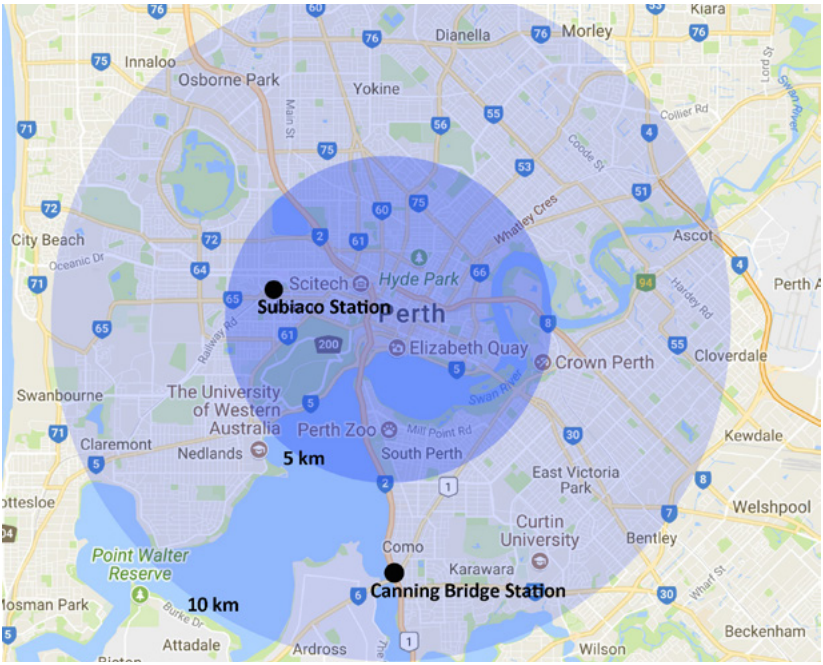
The following sections discuss two approaches undertaken in engaging the community early on in the infill redevelopment process within community forums in two affluent areas: Canning Bridge and Subiaco (Figure 4.1), both established areas designated as activity centres in strategic and local planning (Western Australian Planning Commission (WAPC) 2010).

Canning Bridge

The Canning Bridge activity centre is 800 metres from a modern train station and consists of two districts under the control of two local governments: City of Melville and City of South Perth. The Swan River separates the two districts. Canning Bridge is an established and affluent area with a high proportion of households comprising couples without children and lone persons (City of Melville, 48.7 per cent and City of South Perth, 53.8 per cent). It has also a high proportion of people over 50 years of age (City of Melville, 38.4 per cent and City of South Perth, 34.1 per cent) (ABS 2016).

9 A Canning Bridge resident also wrote in survey questionnaires: "I can appreciate that we need urban infill, but it must be done in a way that is of benefit to all concerned, not just to need to develop for huge financial gain."

Figure 4.1 Canning Bridge and Subiaco TOD areas



Source: Snapshot of map prepared by S. Nematollahi (2017)

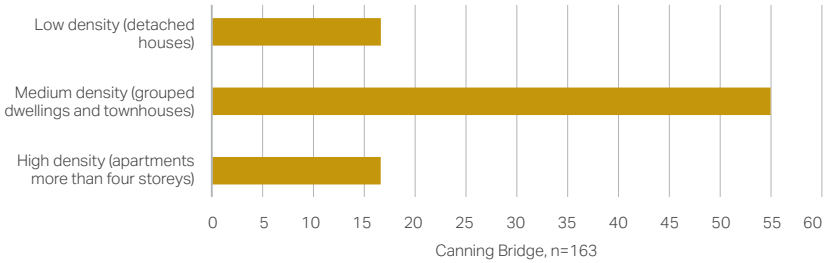
Canning Bridge is located 7 km south of the Perth CBD and has been assigned as a 'district centre' in *State planning policy 4.2: activity centres for Perth and Peel* (SPP 4.2), with a recommended density of 30 dwellings per gross hectare representing a net density of R90 – 90 dwellings per hectare.

An independent survey[10] was conducted in the Canning Bridge area to find out residents' dwelling-type preferences (Nematollahi et al. 2015). When residents

10 The survey was part of the author's PhD thesis and was conducted in 2012, a few years after the councils' 2006 and 2007 community consultation process.

were asked to select a dwelling-type option they would like to see for future density/infill development, more than half of the respondents (55 per cent) selected medium density, including townhouses and grouped dwellings, while only 16 per cent opted for apartments – the same proportion as detached houses (Figure 4.2).

Figure 4.2 Dwelling-type preferences, Canning Bridge



Source: Nematollahi, et al. (2015)

Survey respondents viewed medium-density housing options as a 'separate dwelling' which contributes to housing density, and being more likely to be owner-occupied in comparison to apartments. Townhouses were seen as the best compromise between detached houses and apartments; apartments being viewed as traffic generators, while detached housing being regarded as 'wasting land'. Respondents highlighted other advantages of townhouses including design, population density, the socio-economic characteristics of potential residents, and family-orientated dwellings. Opposition to apartments surrounded the perceived characteristics of residents of apartment properties, which were seen as being dominated by transient rental occupiers.

Similar results were found by Estill & Associates Pty Ltd (2006, 2007)[11], which conducted the initial community consultation for the Canning Bridge activity

11 A total of 2221 stakeholders participated in the community consultation process (Estill & Associates, 2006).

centre plan. Their reports indicated that the community generally associated high density with high rise, and that they feared it may result in attracting a low socio-economic population, which in turn could lead to a level of insecurity in the area (Estill & Associates reports 2006 and 2007; *People, places, participation* report 2007). The report also stated that participants were more in favour of density typical of Subi Centro, Nedlands and Dalkeith (p. 3 in 2006 report; p. 17 in 2007 report; *People, places, participation* report 2007, p. 25) where low to medium-rise density developments are more common in the redevelopment process.

Estill & Associates' 2006 and 2007 reports both concluded that the Canning Bridge community was ready for a moderate increase in density. However, after the initial reports, and during 2009 community forums for the activity centre structure plan, only one design scenario with greater density was presented for consideration and no 3D view of the proposed design scenario was made available (GHD 2009). Later in the community consultation report, the proposed heights in design scenario were mentioined as key concerns of the community:

> It will not be acceptable to simply jump from 4/5 storeys to 10 storeys across the road. A reduction in heights in some areas may be necessary to achieve this. (GHD 2009, p. 57)

The precinct vision was released by the Minister for Planning in June 2011 (see Figure 4.3). The proposed building heights in City of Melville area ranged from 5 to 20 storeys and City of South Perth area from 3 to 10 storeys. The sharp mismatch between the design scenario proposed heights and residents' preferred density type generated significant community resistance[12] and an ongoing and uneasy community engagement process, which delayed the final

12 In August 2011, Mayor James Best said: "Over a series of six successive community meetings, the general opinion of those in attendance moved from resistance to acceptance as residents were able to see that this was a long-term plan – a 50-year vision – and that change was not going to be forced upon anyone overnight." Retrieved from: www.committeeforperth.com.au/assets/documents/newsletters/insightAugust2011.pdf.

plan by another four years.[13] The latest Canning Bridge activity centre (final plan) (Figure 4.4) was released in February 2016[14] by the City of South Perth, which was approved by the Minister for Planning in February 2017. In this final version, building heights range from 4 to 15 storeys.

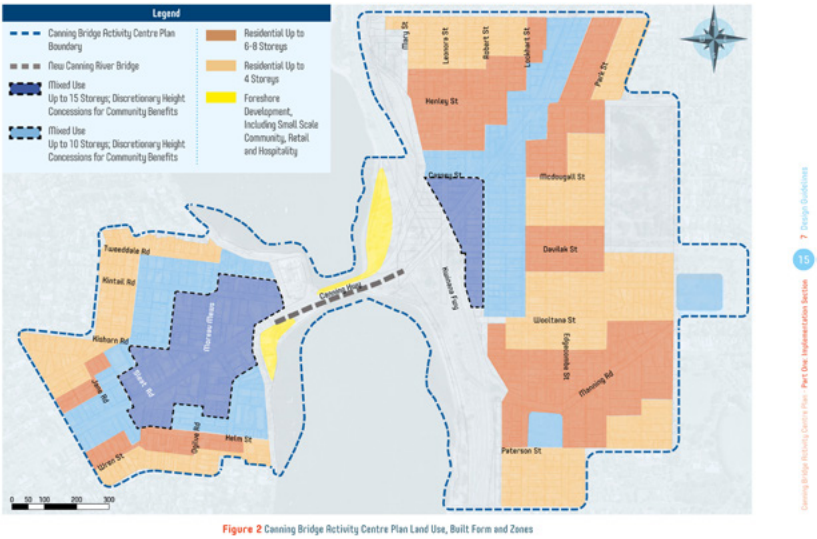
Figure 4.3 Canning Bridge precinct vision building heights map, 2011

Source: Department of Planning, Lands and Heritage, Canning Bridge Precinct Vision (2011) https://www.planning.wa.gov.au/dop_pub_pdf/Figures_1_and_2.pdf

13 In March 2015, City of Melville adopted the structure plan and in May 2015 City of South Perth adopted the structure plan. Retrieved from http://canningbridge.com.au/wp-content/uploads/2016/07/Where-to-from-Here-Canning-Bridge-Structure-Plan-11.05.2016.pdf.

14 Retrieved from http://www.southperth.wa.gov.au/Documents/Planning/Precinct-Studies/Canning-Bridge-Rail-Station-Precinct/Canning-Bridge-Activity-Centre-Plan-18-April-2016.pdf

Figure 4.4 Canning Bridge activity centre plan, 2016



Source: City of Melville, *Canning Bridge activity centre plan* (2016, p. 88) http://www.melvillecity.com.au/about-melville/future-vision/canning-bridge-structure-plan

In August 2014, an in-depth interview was conducted by the author with a prominent member of the group opposing high density in the Canning Bridge area. The member criticised the way density heights were proposed in the vision, ignoring Estill & Associates' (2006 and 2007) community consultation reports:

> They don't live here and I know that we can be accused of NIMBY, but that's not it. All of the people who are in my group [opposing the high rise developments] appreciate that if some divisions were not allowed we wouldn't live here because we live on subdivided blocks. All of us, I think, realised the need for higher density. Density is not the problem, but it is the way you go about that density.

Subiaco

Subiaco is an affluent and established area with 32 per cent of households in a high-income bracket; 56.3 per cent of households comprising couples without children or lone persons; and 33.1 per cent of the population above 50 years of age (ABS 2016). It is located 3 km west of the Perth CBD and assigned as a secondary activity centre under the activity centres hierarchy, set out in *State planning policy 4.2: activity centres for Perth and Peel* (SPP 4.2), with 35 dwellings per gross hectare (net density of R 105; 105 dwellings per hectare) – more than the Canning Bridge density target.

A community engagement process for the Subiaco activity centre structure plan commenced in February 2013 under a strategic planning framework for future developments over the next 10 to 20 years (City of Subiaco), and council endorsed the preferred version of the activity centre structure plan a few months later, in September 2013.

While there was no extensive preliminary community consultation or survey in Subiaco specifically regarding preferred density, the approach taken to garner community support for a broadly accepted design scenario resulted in the establishment of a collaborative community engagement process. In Subiaco a number of design scenarios were proposed within community forums, and these were rated and discussed by the community to develop a final or hybrid proposal. This created a genuine community engagement process, which resulted in a smoother and more expedient approval process for the ongoing planning and development of the Subiaco activity centre structure plan.

At initial community forums, three design scenarios were presented and comments were obtained for each. The aim was to propose a fourth (a hybrid) version based on community feedback, in an attempt to balance community views and planning objectives. The approach resulted in a more reassuring community engagement process. There was less resistance and the process was faster compared to Canning Bridge. The developed structure plan was endorsed by the council within seven months. Although there was some opposition, those supporting the final plan were in the majority and thus marginalised the opponents' views (Davis 2016; Giddens 2016). The presentation at the community forum was clear. The sites that

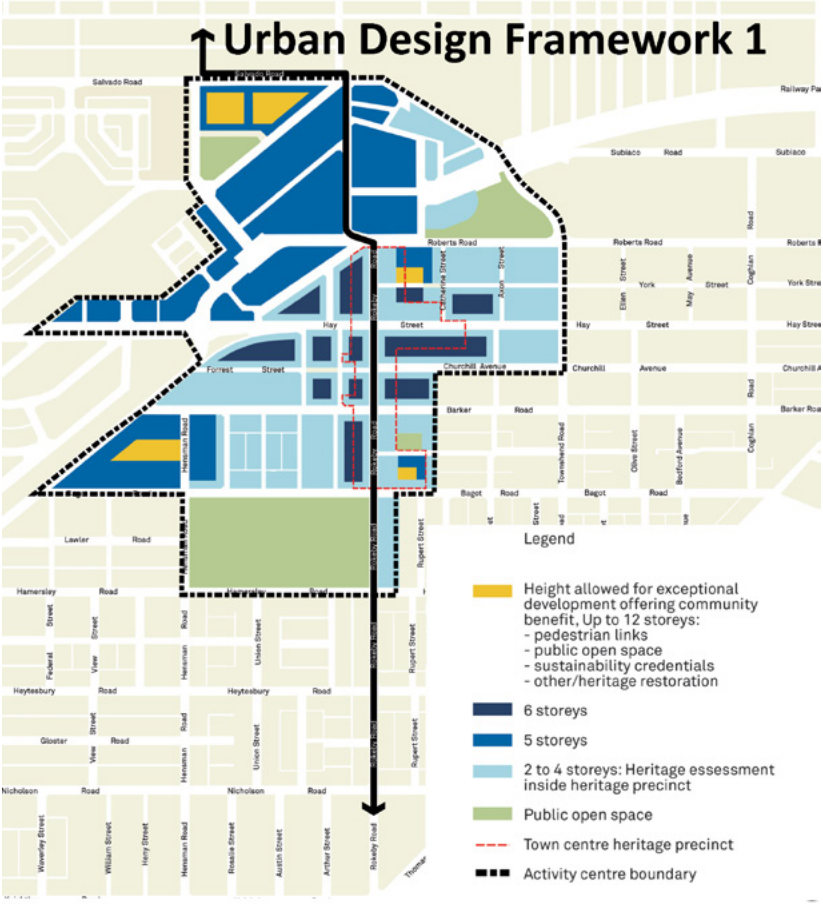
had opportunities for initial development were identified and presented to the community. For each design scenario, network maps, building height maps and 3D views were clearly presented. Scenarios were compared and presented to the community showing the character of proposed dwellings, the nature of future residents, the location of additional commercial floor space and the number of workers that would be attracted to the area. Comprehensive and clear information was tabled for the participants, who also had the opportunity of rating each scenario including the preferred building heights.

Key discussion themes revolved around height and density within the activity centre (ConsultWG 2013). Scenario/urban design framework 1 (Figure 4.5) received the greatest support among respondents, while urban design framework/scenario 3 (Figure 4.6), containing greater density, was the least desired (ConsultWG 2013).

While the preferred option (Figure 4.5) was regarded as more appropriate for the area, the only proposed 12-storey development in the scenario was not supported. Respondents stated that "12-storey developments could put people off the area" (p. 16) and "12 storeys is not desirable and way too high" (p. 22). They added that "high rise should be capped at four to five storeys" (p. 37) and "six storeys and over is not acceptable" (p. 23). The community supported low-rise development, acknowledging additional density was required for the area (ConsultWG 2013).

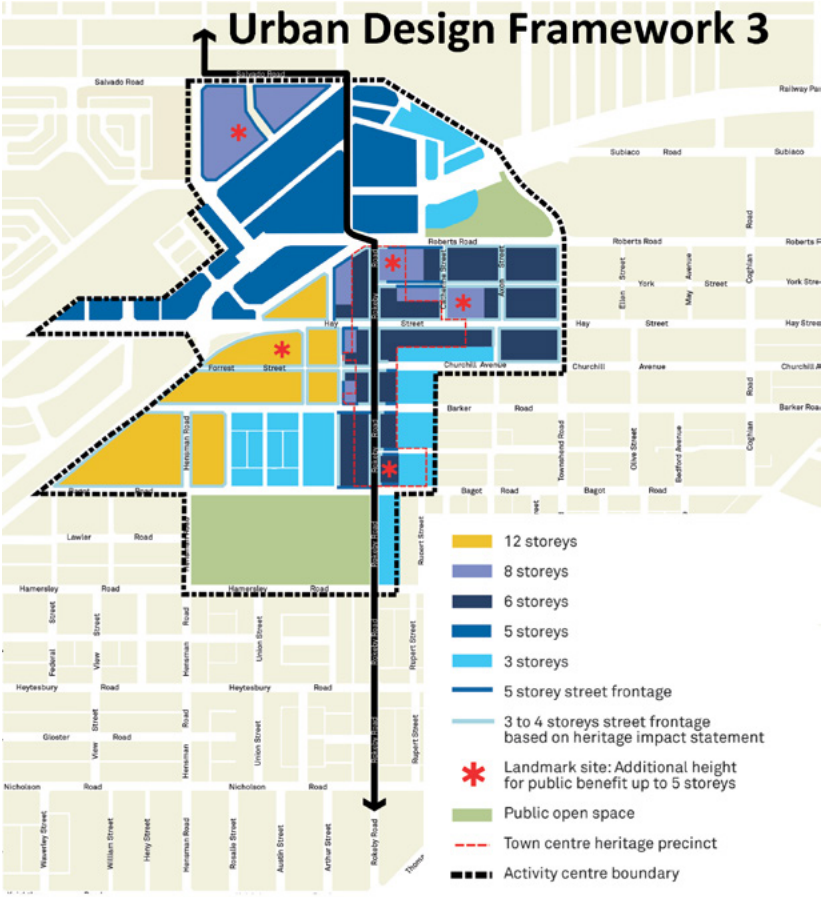
Workshop participants stated that developments need to be of a scale and character that respond to the lifestyle characteristics of Subiaco, with a 'village feel' (p. 39). They referred to 12-storey developments as an unacceptable option for liveability "due to problems such as traffic, privacy and future slums" (p. 23). Participants in community workshops also had negative views towards developers and said they "are not interested in creativity because it doesn't make money" (p. 25) (ConsultWG 2013).

Figure 4.5 Subiaco activity centre building height map, Urban Design Framework 1, 2013



Source: City of Subiaco, *Subiaco activity centre visions options report, part one*, (2013, p. 45)
http://www.haveyoursay.subiaco.wa.gov.au/2289/documents/1488
Note: The map legend has been scaled by author to enhance readability.

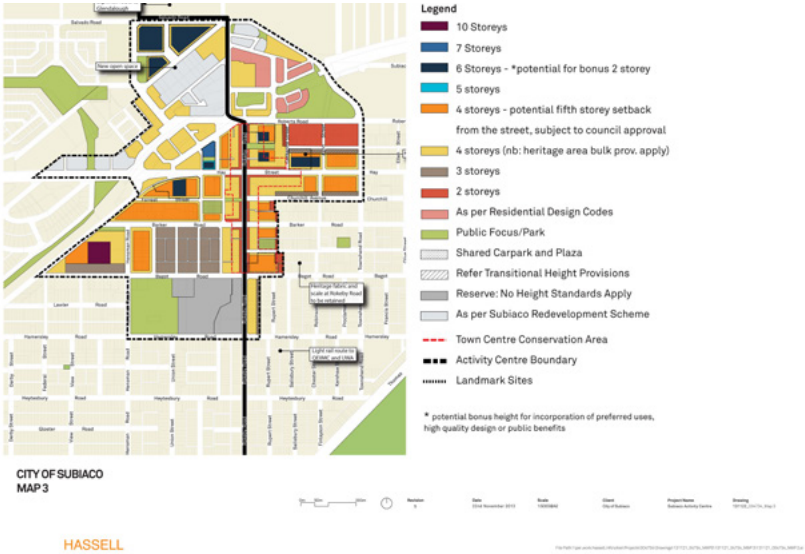
Figure 4.6 Subiaco activity centre building height map, Urban Design Framework 3, 2013



Source: City of Subiaco, *Subiaco activity centre visions options report, part one*, (2013, p. 57)
http://www.haveyoursay.subiaco.wa.gov.au/2289/documents/1488
Note: The map legend has been scaled by author to enhance readability.

In the final/hybrid design scenario (Figure 4.7), building heights range from two to 10 storeys, with taller developments limited to a few potential sites, while the dominant proposed building height in the plan is less than five storeys. Although Subiaco residents have been exposed to higher buildings in the earlier redevelopment at Subi Centro in 1997, it seems the preferred building height is now less than five storeys.

Figure 4.7 Subiaco activity centre plan, maximum height plan, 2016



Source: City of Subiaco, draft *Subiaco activity centre plan*, (2016, p. 5)
http://www.haveyoursay.subiaco.wa.gov.au/18240/documents/37252
Note: The map legend has been scaled by author to enhance readability.

KEY PRINCIPLES OF A SUCCESSFUL COMMUNITY ENGAGEMENT PROCESS

There are a number of principles which underpin successful community engagement. These principles have been developed from existing work in this area and from the two case studies discussed above. Although not exhaustive, these principles provide a good starting point for developers and local government looking to engage with the community within the infill development process.

Creating a genuine environment for discussion

Genuine engagement is created by allowing the community to talk about the project, to collaborate, and to mature with it gradually. The opportunity to identify major concerns, give realistic responses and have useful comments taken into account for a final development proposal creates a reassuring atmosphere. A genuine community engagement process is an ongoing, inclusive, collaborative process, engaging all groups who wish to be involved in the exercise.[15] Councils and elected members play important roles in creating a sense of fairness during the process.

Depoliticising community forums

Depoliticising the community engagement process is key to avoiding the escalation of opposition (Rowley & Phibbs 2012; Davison et al. 2016). For instance, it is better to educate and involve councillors and elected members and gain their support a few years ahead of infill developments (Giddens 2016; Davison et al. 2016). Consequently, in the case of any resistance, councillors could be mediators in the community engagement process rather than attaching themselves to the loudest voice.

Choosing realistic development boundaries

Boundaries of new developments, if adjacent to existing low-density residential dwellings, may cause sensitivity in community forums. Residents on the edge

15 For example, the City of Belmont involved migrant communities, the Aboriginal community and even primary students in the local planning strategy consultation process (Hammah, 2016).

of such boundaries will be particularly sensitive to the development and their concerns need to be addressed directly, and early on in the process.

Preparing development scenarios

Development scenarios can be presented as a collection of ideas rather than a final product in community consultation sessions. Guiding debates on scenarios in order to produce a hybrid one is considered a genuine approach to consultation and the development of community-led design outcomes. For instance, during debates on height-related issues, proposed design scenarios need to be presented clearly and honestly to the community and related to local built form examples to provide a basis for debate and discussion. Scenario development and 3D presentations can provide the basis for a rating of outcomes. In this way they can be used to build a hybrid scenario that combines the best supported ideas from an array of design options.

Tackling negative attitudes

Negative attitudes towards population growth, future residents/users of proposed new developments, and the fear associated with the potential for changing socio-economic characteristics can sometimes escalate opposition (Nematollahi et al. 2015; Davison et al. 2016). Concerns such as what the dominant household structure will be (family, couple, single); the dominant tenure of development (owners or renters); and the dominant income bracket of households are usually not discussed in community forums, although they are central to the individual's valuation of community characteristics. Such concerns could be addressed through a presentation of the market strategies of a proposed development and education around the characteristics of likely new residents and users of the area.

More than ever, councils should invest in new and fresh community development strategies, particularly in dealing with the challenge of infill development. Community development strategies that bring users of an area together can reduce the negativity associated with population growth and related debates around 'social difference'. Strategies such as these help them to overcome their 'fear of the unknown' (Nematollahi et al. 2015). After all, developing a sense of community is a crucial element in the success of any infill development.

REFERENCES

ABS – see Australian Bureau of Statistics.

Alexander, E 1993, 'Density measures: a review and analysis'. *Journal of Architectural and Planning Research*, 10(3), 181-202.

Argent, N 2008, 'Perceived density, social interactions and morale in New South Wales rural communities'. *Journal of Rural Studies*, 24(3), 245-261.

Australian Bureau of Statistics 2016, Retrieved from:
http://profile.id.com.au/melville/five-year-age-groups
http://profile.id.com.au/melville/households
http://profile.id.com.au/subiaco/five-year-age-groups
http://profile.id.com.au/subiaco/households
http://profile.id.com.au/subiaco/household-income.

Calthorpe, P 1993, *The next American metropolis*, New York, NY: Princeton Architectural Press.

Churchman, A 1999, 'Disentangling the concept of density'. *Journal of Planning Literature*, 13(4), 389–411.

Churchman, A 2002, 'Environmental psychology and urban planning: where can the twain meet?' In R Bechtel & A Churchman (Eds) *Handbook of Environmental Psychology* (191-200). New York, NY: John Wiley & Sons, Inc.

City of Melville 2016, *Canning Bridge activity centre plan*. Retrieved from http://www.melvillecity.com.au/about-melville/future-vision/canning-bridge-structure-plan.

City of Subiaco 2013, *Subiaco activity centre visions options report part one*, Retrieved from http://www.haveyoursay.subiaco.wa.gov.au/2289/documents/1488.

City of Subiaco 2016, Draft *Subiaco activity centre plan*. Retrieved from http://www.haveyoursay.subiaco.wa.gov.au/18240/documents/37252.

Ciulla, J 2004, *The ethics of leadership*, Belmont, CA: Wadsworth/Thomson Learning.

ConsultWG 2013, *Subiaco activity centre structure plan / vision scenarios: consultation summary report*. Retrieved from http://www.subiaco.wa.gov.au/CityofSubiaco/media/City-of-Subiaco/Planning-and-development/Town-planning-controls-and-policies/Consultation-Summary-Report.pdf.

Cook, N, Taylor, E, Hurley, J & Colic-Peisker, V 2012, *Resident third party objections and appeals against planning applications: implications for higher density and social housing*. (Report No. 197, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/research/final-reports/197.

Davis, S 2016, Interviewed by Shohreh Nematollahi.

Davison, G 2010, 'Changing places: a question of character'. (Unpublished PhD thesis). Melbourne: Melbourne University.

Davison, G, Legacy, C, Liu, E & Darcy, M 2016, 'The factors driving the escalation of community opposition to affordable housing development'. *Urban Policy and Research*, 34(4), 386-400.

Davison, G, Legacy, C, Liu, E, Han, H, Phibbs, P, Nouwelant, R, Darcy, M & Piracha, A 2013, *Understanding and addressing community opposition to affordable housing development*. (Report No. 211, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/research/final-reports/211.

Day, D 1997, 'Citizen participation in the planning process: an essentially contested concept?' *Journal of Planning Literature*, 11, 421-434.

Department of Planning, Lands and Heritage 2011, *Canning Bridge precinct vision*. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/Figures_1_and_2.pdf.

Dovey, K & Woodcock, I 2010, *The character of urban intensification*. (Report from Melbourne School of Design.) Retrieved from http://www.placeresearch.net/pdf/Character_of_Urban_Intensification.pdf.

Estill & Associates 2006, *Dialogue with the City of Melville (Melville visions), community consultation report*. City of Melville.

Estill & Associates 2007, *Canning Bridge train station precinct, community engagement report*, City of South Perth. Retrieved from https://southperth.wa.gov.au/docs/default-source/5-future/project-and-places/canning-bridge/community-engagement-report-(april-2007).pdf?sfvrsn=e7ebfcbd_2.

Flyvbjerg, B 1998, *Rationality and power: democracy in practice*. Chicago, IL: University of Chicago Press.

Forsyth, A 2003, *Measuring density: working definitions for residential density and building intensity*. (Design Brief Number 8). Design Center for American Urban Landscape, Minneapolis, Minnesota: University of Minnesota.

GHD 2009, *Report for Canning Bridge precinct. Consultation report*. Retrieved from https://southperth.wa.gov.au/docs/default-source/5-future/project-and-places/canning-bridge/ghd-consultation-report-(october-2009).pdf?sfvrsn=3c02fdbd_2.

Giddens, W 2016, Interviewed by Shohreh Nematollahi.

Hammah, J 2016, Interviewed by Shohreh Nematollahi.

Healey, P 1997, *Collaborative planning: shaping places in fragmented societies*. Vancouver, BC: UBC Press.

Hedgcock, D & Brunner, J 2015, 'Planning intervention in metropolitan urban form: the 21st-century challenge of urban consolidation in Australian capital cities'. *Contemporary Issues in Australian Urban and Regional Planning*, 95-112.

Jacobs, J 1958, 'Downtown is for people'. In *Fortune Classic*. Retrieved from http://fortune.com/2011/09/18/downtown-is-for-people-fortune-classic-1958.

Leitch, S, Motion, J & Davenport, S 2008, 'Community engagement and resistance: a discourse perspective'. Paper presented at the 22nd ANZAM Conference Auckland, New Zealand, December 2008.

Nematollahi, S, Tiwari, R & Hedgcock, D 2015, 'Desirable dense neighbourhoods: an environmental psychological approach for understanding community resistance to densification'. *Urban Policy and Research*, 34(2), 132-151. DOI:10.1080/08111146.2015.1078233.

Pierson, J 2008, *Going local, working in communities and neighbourhoods*. New York, NY: Routledge.

Rapoport, A 1975, 'Toward a redefinition of density'. *Environment and Behavior*, 7(2), 7-32, doi:10.1177/001391657500700202.

Rice, J 2009, 'There goes the neighbourhood? Or saving the world? Community views about transit oriented development'. In C Curtis, J Renne & L Bertolini (Eds) *Transit oriented development: making it happen*. Burlington, VT: Ashgate Publishing Ltd.

Rifkin, SB & Pridmore, P 2001, *Partners in planning, information, participation and empowerment*. London, UK: Macmillan Education LTD.

Rowley, S & Phibbs, P 2012, *Delivering diverse and affordable housing on infill development sites*. (Report No. 193, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/research/final-reports/193.

Ruming, K 2014, 'Social mix discourse and local resistance to social housing: the case of the nation building economic stimulus plan'. *Australia, Urban Policy and Research*, 32(2), 163-183. DOI:10.1080/08111146.2013.844121.

Tiwari, R & Pandya, Y 2014, 'An ethnographic and collaborative model of inquiry: activity centre project in India'. In R Tiwari et al. (Eds) *M2 models and methodologies for community engagement* (pp. 25-39). Singapore: Springer.

Urban Futures Research Program 1996, *Residents' responses to medium density developments / Planning Workshop Australia and Swinburne Centre for Urban and Social Research*. Canberra: Australian Government Publishing Service.

WAPC – see Western Australian Planning Commission.

Weller, R & Bolleter, J 2013, *Made in Australia: the future of Australian cities*. Perth, WA: UWA Publishing.

Western Australian Planning Commission 2010, *Directions 2031 and beyond: metropolitan planning beyond the horizon*. Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/plan_directions2031_part1.pdf.

5

NEW TECHNOLOGIES AND PROCESSES FOR INFILL DEVELOPMENT

Giles Thomson*
Keith D Hampson
Peter Newman

*Corresponding author: Giles Thomson, Faculty of Humanities, Curtin University, GPO Box U1987, Perth WA 6845. Email: giles.thomson@curtin.edu.au Tel: +61 413 501 346

INTRODUCTION

New construction technologies and processes have the potential to promote improvements in infill development-related outcomes across a range of indicators, including cost-effectiveness, delivery timelines, sustainability and liveability. This chapter will shed light on the potential benefits of new construction technologies and planning processes, particularly as they pertain to infill development. The discussion will be aided by a series of case studies on innovations in infill development processes in Perth and Melbourne.

The chapter begins by reviewing the benefits of prefabrication or off-site manufactured building as highlighted in existing industry and academic literature. It assesses the outcomes of prefabrication in the development of two apartment block projects, and gauges the market potential of manufactured building in Australia in the context of the international experience. This is followed by a review of digital design innovations that complement prefabrication processes, and its related benefits. The chapter ends by discussing innovations in governance processes aimed at maximising the quality of infill development outcomes. These governance processes range from speculative competitions for envisioning alternative scenarios, to design review panels, development bonuses for meeting design excellence, and deliberative processes aimed at increasing planning participation and effective governance.

PREFABRICATION

Off-site manufactured (or prefabricated) building has a long history in the Australian construction industry, beginning with kit homes in the late 19th century. Nonetheless, it has never grown to be more than a fragment of the sector. Currently, prefabrication accounts for only around three per cent of the domestic residential construction market, and this segment focuses on roof trusses, window fittings and pre-stressed concrete slabs (SBEnrc 2015). However, recently, and in line with international trends, interest in building prefabrication has grown due to changes in technology, on-site labour costs

and reliability, and the need for rapid and less disruptive construction methods in infill areas. Fabrication of building components and modules have the potential to achieve high-quality built form outcomes more quickly, efficiently and cost-effectively, with less waste and site disruption than traditional construction techniques. Hence, the development of the sector holds much promise for the Australian infill market.

Benefits

Recent research by the SBEnrc (2015; Hampson et al. 2014b) identifies many advantages to off-site manufactured building over traditional on-site, craft-based construction techniques:

- **Cost savings.** Manufactured building has the potential to generate cost savings related to rapid industrial construction of repeat elements, particularly for apartments, hotels, and student and mining accommodation. It can also result in a reduction in holding fees and labour costs.

- **Faster delivery of housing.** Manufactured building can result in a reduction in construction time and fewer on-site delays. Off-site construction allows for compressed development timelines, as structures can be built at the same time as site preparation occurs, hence allowing two work programs to run concurrently. Current modular technologies have been found to reduce construction time by around 40 per cent compared to traditional construction methods (Kamali & Hewage 2016).

- **Improved workplace conditions and safety.** Factory-based production permits stricter management of the micro-climate and greater control over workplace conditions than on-site production. This may in turn improve worker comfort, safety and productivity.

- **Waste reduction.** Construction waste minimisation is most efficient when development is controlled through an industrial process such as manufactured building. Efficiencies in production lines can eliminate considerable volumes of construction waste, which currently constitutes around 40 per cent of municipal solid waste. This in turn reduces site spoilage and associated clean-up costs.

- **Environmental sustainability.** Prefabrication requires intense focus on upfront design elements. This in turn facilitates greater opportunities for improving building performance, particularly in relation to energy or thermal conditions, and delivering reduced energy operating costs for occupants. Minimising material use through prefabrication or construction waste policies can also greatly reduce emissions associated with building materials.

- **Site disruption minimisation.** Manufactured building can greatly reduce site disruption. For example, reduced construction times in turn reduce the duration of site noise and traffic disruption. With coordination in delivery logistics, cleaner construction sites are achieved as on-site stockpiles are either not required or are minimal, leading to reduced material spillage, less visual clutter and reduced material run-off into drainage infrastructure, waterways and adjacent properties.

Overall, manufactured building technology offers considerable benefits to infill areas, particularly due to the minimisation of disruption in established areas and the rapid site assembly that prefabricated building elements permit. Infill development already offers substantial savings to taxpayers in terms of infrastructure cost savings (Trubka et al. 2010; Trubka et al. 2008), and manufactured assembly can make infill development even more cost competitive, while delivering a quality product.

Case study 1: One9 Apartments, Moonee Ponds, Melbourne

This apartment block was constructed in 2014. It comprises 32 apartments and ground-floor retail, and was constructed from 36 modules using the Hickory Unitised Building (UB) system as can be seen in Figure 5.1. The apartment block was designed by Amnon Weber Architects and developed by The Moloney Group.

The 36 modules were designed and fabricated off-site. The building comprises eight levels of residential units (32 apartments) above retail space on the ground level. The retail space was aimed at attracting residents into a largely commercial area to increase mixed-use development in the area. The development is relatively high density, increasing access to local services

Figure 5.1 One9 UB system modules under assembly, 2016

Source: Photo © Hickory Group (2016)

and benefiting residents and local businesses. While these outcomes could be achieved through conventional construction practices, this particular development is different in that the fabrication process took place over a nine-month period preceding on-site delivery, allowing the nine-storey apartment block to be assembled in just five days (Chua 2014a). The off-site prefabrication process allowed for rapid on-site construction and minimal disruption to the surrounding area.

Case study 2: Adara Apartments, Cockburn Central, Perth

This development supplied 77 apartments designed to be high quality and affordable in 2014-15. It was designed by Campion Design Group. The development was delivered via a public–private partnership between the WA Department of Communities – Housing, Goldmaster Enterprises and the Hickory Group.

The apartments were built using off-site construction. The project resulted in:

- cost savings of 10 to 12 per cent and improved return on equity for investors
- 30 per cent better thermal performance
- 50 per cent reduction in construction waste
- faster delivery, with rapid construction taking place over 11 months – around half the build time of a similar scale project built using conventional approaches (see Figure 5.2)
- less site disruption and less greenhouse gas than a conventional Perth apartment block (SBEnrc 2015).

Figure 5.2 Modular units of the Adara Apartments, 2015

Source: Photo © WA Department of Housing (2015)

Market potential

As the One9 and Adara case studies demonstrate, manufactured building tends to be quicker, can be designed to a high specification and replicated cheaply through economies of scale. This not only results in sustainability improvements in terms of thermal performance, but also in terms of reduced construction waste. As the proportion of higher quality, higher density infill increases, these reductions in raw building materials can be significant. A recent study by Arup, as part of the Strategic Assessment of the Perth and Peel Regions, showed that construction waste was among the largest waste streams by volume in Perth (Gardner & Newman 2013). The technological and construction innovations offered by prefabrication can significantly reduce these volumes. In combination with higher density development that allows more units to be served by better utilised infrastructure, the total raw material use for higher density manufactured building development could result in 20 times less raw materials than the equivalent population housed in conventional low-density development, and nearly 10 times less raw materials than conventional high-density development (Gardner & Newman 2013; Thomson & Newman 2017).

While the advantages of manufactured building are many, there are signs that Australia is lagging behind not only in the uptake of the technology, but also in local production. A 2013 estimate suggested that less than five per cent of the new housing market in Australia used prefabrication in that year. By comparison, various other nations have exhibited comparatively much higher levels of market penetration for manufactured new builds. Examples include Sweden, where around 75 per cent of residential housing is manufactured off-site, around 50 per cent in Finland (SBEnrc 2015), 12 to 15 per cent in Japan, and 9 to 15 per cent in Germany (Steinhardt et al. 2013).

Moreover, within Australia the uptake of prefabrication is largely concentrated along the east coast. Uptake in Perth has been relatively recent, and at rates lower than Sydney and Melbourne. These uptake patterns tend to mirror the market for medium to high-density residential dwelling projects (i.e. apartment towers).

Internationally, the compatibility of advancing digital technology and object-based modelling has ushered in a new era of off-site manufactured building

globally. Investment in prefabrication has soared from AU$80 billion (US$60 billion) in 2011 to AU$120 billion (US$90 billion) in 2012 (SBEnrc 2015). The use of off-site manufactured building can be expected to grow considerably in the coming years as the sector matures and its advantages become increasingly visible in the construction market (Hampson et al. 2014a).

DIGITAL DESIGN

Digital design tools greatly complement manufactured building approaches and the two techniques are increasingly being used in a complementary manner. As digital technologies become more sophisticated and affordable, digital modelling and analysis tools are expanding to shape how we deliver infrastructure and urban precincts. But digital tools are not only transforming design, construction and asset management, they are also driving innovation in planning processes, increasing collaboration and in turn the quality and acceptance of infill outcomes.

The evolution of digital communication for construction has shifted from two-dimensional (2D) digital drafting in the 1980s to increasingly three-dimensional (3D) and intelligent object-based modelling software across disciplines (e.g. architects, engineers and construction managers) and functions (e.g. design, construction and asset management). Increased integration through inter-operability is permitting collaboration between disciplines that use a common facility model across shared network-based servers (Cooperative Research Centre (CRC) for Construction Innovation 2009).

Building Information Modelling (BIM)

The CRC for Construction Innovation produced the *National guidelines for digital modelling: case studies* for building that identified two key qualities necessary for a model to be categorised as BIM: 1) it must be a 3D representation of a building (or other facility) based on objects, and 2) it must include some information in the model or the properties about the objects beyond the graphical representation (CRC Construction Innovation 2009).

BIM is defined as a virtual process that encompasses all aspects, disciplines and systems of an asset within a single virtual (digital) model, allowing all to collaborate more accurately and efficiently than using traditional processes (Azhar 2011; Keast & Hampson 2007). A standardised Australian practice for the exchange of digital building information is being developed by the National Building Specification not-for-profit organisation NATSPEC. NATSPEC provides BIM guidelines in line with the organisation's stance that digital information, including 3D modelling and BIM, will provide improved methods of design, construction and communication for the Australian building and construction industry.

Benefits

Advantages offered by BIM can include the following:

- visualisation using 3D renderings
- fabrication and the creation of shop drawings for construction
- compliance assessment (e.g. planning, fire)
- cost estimating through automatic extraction of material quantities
- construction sequencing to coordinate ordering, fabrication and delivery schedules
- conflict, interference and collision detection
- forensic analysis (e.g. for failures, evacuation plans, etc.)
- facilities management and maintenance operations (Azhar 2011).

Of these advantages, it is the integrated practice BIM facilitates which enables greater collaboration between members of a design team, consultants, fabricators and contractors through the use of a shared building model (CRC Construction Innovation 2009). This collaboration across the supply chain can be advantageous in testing design, construction scenarios and building performance prior to construction. It supports conflict resolution and process optimisation to minimise risks, permits rapid construction and improves end-use building performance and occupant experience.

BIM is particularly suited to prefabricated manufacturing, whereby any number of building elements, be they wall panels or entire building modules, can be fabricated off-site and transported to the construction site for assembly.

The ability to digitally prototype components and develop integrated construction/assembly systems between designers, suppliers, fabricators and constructors allows BIM to optimise manufactured building processes.

Therefore BIM is a natural companion for manufactured building. The technologies in combination can greatly improve the quality of design outcomes and, through greater investment of time upfront in the design process, reduce the production time and overall project costs. These efficiencies are particularly important for infill locations, as they enable coordination of the typically more complex, higher density developments in an existing urban fabric.

Case study 3: Perth Children's Hospital, Nedlands, Perth

The Perth Children's Hospital project used BIM for its design and construction (Figure 5.3). The development took place from 2015 to 2017. The design team was a joint venture between JCY Architects and Urban Designers, Cox Howlett & Bailey Woodland, and Billard Leece Partnership with HKS Architects. The developer was a public–private partnership between the WA Government and John Holland, with the latter undertaking construction of the project. BIM was seen to be particularly successful at speeding up information exchange to assist with overall design and construction efficiency, while the increased design transparency ensured design conflicts were minimised (Sanchez et al. 2015b). Following completion of the hospital, the digital legacy model, with its structured data in a single database, will be used for asset management throughout the building's lifecycle (Sanchez et al. 2015b). Analysis conducted in 2015, prior to project completion, noted that consistency between multidisciplinary teams was critical for achieving efficient outcomes with BIM, and that establishing and enforcing protocols such as naming conventions across all consultants was paramount at all stages of the project (Sanchez et al. 2015a).

Figure 5.3 Perth Children's Hospital, Nedlands, Perth, 2016

Source: Photo: © WA Department of Health (2016)

While having its origins in architecture, BIM represents a process that is transferable to other construction phases. Since 2001 the SBEnrc and its predecessor, the CRC for Construction Innovation, have been researching national and international case studies, and promoting application of digital process improvements not only to the building sector, but also to Australia's transport infrastructure industry. The Productivity Commission recommended more widespread adoption of digital modelling technology to enhance productivity and cost-effectiveness across infrastructure projects (Sanchez & Hampson 2015). The expansion of BIM into infrastructure expands the possibilities of digital tools to aid in the design of whole neighbourhoods. More widespread use of BIM in urban infill is in its infancy and will benefit from the creation of precinct-scale models, called PIM (Precinct Information Modelling).

From BIM to PIM

Planning is perhaps one of the last professions to 'go digital'. This is rapidly changing, but the tools to enable the transition are under development. It is expected in the near future that developments under consideration will be submitted online, released online for public consideration and assessed online. Digital planning tools currently being developed will be essential requirements for planners in local and state government, in preparation for developments.

They will be used by developers, community and authorities to help resolve issues of agglomeration and community concern about inappropriate development, or poor development outcomes (Curtis & Scheurer 2010; Newton et al. 2012; Newton & Glackin 2015).

This process will considerably reduce preparation time and the use of paper-based communications, and hopefully enable communities to recognise how best to integrate their concerns with the need for development and change. Having the ability to trial multiple virtual scenarios for development which show the impacts on financial viability, community facilities, carbon, water, traffic and human health should enable us to create better outcomes towards sustainable design.

The advantages of BIM or digital integration to help better understand the performance and construction sequencing of buildings is beginning to be applied to entire precincts. A PIM is a comprehensive 3D digital model of a precinct that contains all the information needed to support planning, design, development, construction, management, operation, use and retrofitting of urban precincts (Newton et al. 2013). These digital design scenario modelling tools represent the next wave of innovation, especially for urban infill, as it needs precinct scale to make it optimal in terms of cost and sustainability outcomes.

There is considerable research into PIM, globally and within Australia. For example, Curtin University, in partnership with Swinburne University have recently developed a PIM tool for the CRC for Spatial Information. The tool, Envision Scenario Planner, has been designed to rapidly test the costs and design performance of precinct scenarios using building typologies assigned with typical cost and performance attributes.

A number of digital models are currently being used or trialled in Australia to assist with urban planning decisions, with details on some of them available online. These include:

- AURIN portal aurin.org.au
- Envision/Scenario Planner aurin.org.au/projects/lens-sub-projects/esp
- BASIX https://www.planningportal.nsw.gov.au/planning-tools/basix
- UrbanSIM urbansim.com.

INNOVATIONS IN GOVERNANCE PROCESSES

In addition to the above technological advancements that will impact on the quality and speed with which infill can be constructed, new processes are driving innovation around governance and financing to deliver quality infill outcomes. Innovations in governance processes are becoming increasingly important as infill sites become denser, their ownership and access more complicated, and more valuable.

This section describes a number of innovative processes aimed to maximise the quality of development outcomes. Processes discussed range from speculative competitions for envisioning alternative scenarios, to design review panels, development bonuses for meeting design excellence, and deliberative processes aimed at increasing planning participation and effective governance.

Design review

As political, economic and market demand for infill grows, it drives an increase in the scale and complexity of development proposals. This places pressure on development authorities that may not have adequate skills or training to assess the relative merits of a major project. The need for expert advice can be met through design review (or advisory) panels.

Design review is an independent and impartial process for evaluating the quality of significant developments, urban extensions and major infrastructure projects (Design Council 2010). The best known in Australia is the NSW *State environmental planning policy 65, design quality of residential apartment development* (SEPP 65), which requires a multidisciplinary design review panel to assess any residential building of three or more storeys and four or more dwellings. Importantly, the panel is supported by detailed apartment design guides to support not only the panel members, but also councils, developers and the community to understand good practice (Government of NSW Department of Planning and Environment 2015).

A number of Perth-based local councils use design review panels now, but consistency across jurisdictions can constrain optimum development outcomes. A state-based system is ultimately required, with clear guidelines

and training for panel members, along with direct statutory control mechanisms that enable more than advisory commentary from the panel.

This process has begun in WA with the establishment of Design WA by the state government in late 2016, the aim of which is to ensure all development in WA has design at its heart. Through Design WA a series of draft documents has been released including a *Design of the built environment* policy, *Apartment design* policy, *Design review guide* and a *Design skills discussion paper*. The *Design Review Guide* was developed in collaboration with the Department of Planning, Lands and Heritage and the Office of the Government Architect, drawing on best practice from across Australia and the UK. The *Design Review Guide*, in conjunction with the new Design WA policies, provide a great opportunity to raise the quality and consistency of infill development outcomes across WA.

Design reviews may be combined with incentives to shape development proposals. Rather than simply meeting the minimum standards as outlined in planning regulations, incentives can be offered to encourage design excellence. This represents a shift from prescriptive-based controls to performance-based criteria. By way of example, a major development application in the City of Perth for a mixed-use podium and tower development in the city fringe suburb of Northbridge was granted a number of 'bonuses' based on meeting certain 'public good' criteria. The proposal was to replace a large (approximately one hectare), single-storey 'Megamart' with a 27-storey, mixed-use development including a 1400 m^2 public plaza, office tower and 60 residential apartments. Through the review process, the developer negotiated a total plot ratio bonus of 50 per cent, consisting of a 20 per cent bonus for the plaza, 20 per cent for residential development and 10 per cent for the provision of serviced apartments. The development proposal responded to City of Perth's strategic goals to increase residential activity in the city and provide public open space (City of Perth 2013).

Competitions and envisioning exercises

Competition is also being used to drive excellence in major projects through the provision of incentives for design excellence on a variety of grounds; for example, architectural excellence, sustainability excellence or public realm

excellence. The MRA has been using design review panels to assess design excellence and award development bonuses to developers whose proposals deliver excellence in public good outcomes.

The MRA pursues design excellence in architecture, urban design and the public domain. With the use of design review panels and a flexible planning framework already in operation, the MRA is moving to competitive design processes to further enhance design quality. At Elizabeth Quay, the MRA pioneered competitive design as part of the land sale process for Lots 2 and 3, building on the City of Sydney model. The preferred developer and the MRA held an architectural design competition, with an eminent jury selecting the winner. The developer then progressed with the winning firm of architects. The concept significantly exceeded the height limit for one of the two towers. However, the jury considered the scheme had the potential to achieve design excellence and deliver substantial public benefit. Public benefits included the provision of a major covered public plaza and a public sky deck, together with an elegant built form that was well integrated with the site and supported pedestrian life at the Quay.

Similarly, WA's urban regeneration agency, LandCorp, is actively driving 'innovation through demonstration'; for example, by developing Australia's first 6 Star Green Star community at Alkimos Beach and delivering WA's first One Planet Living residential project, WGV, at White Gum Valley. These projects seek to demonstrate design excellence for Perth's increasingly common smaller lot, medium-density infill sites.

Deliberative democracy and participatory planning

Cities are places of human creativity, enterprise, and economic and cultural exchange. Therefore, despite technological advancement, participatory processes that maximise input from end-users and the broader community remain essential.

The Grattan Institute report *Getting the housing we want* (Kelly et al. 2011) highlighted the importance, through lack, of giving Australian communities more control over what is delivered in neighbourhoods. The report suggested as a possible process the establishment of 'neighbourhood development

corporations' to create strong partnerships and build community support to shape the future of a community's neighbourhood. This process can be achieved through deliberative democracy tools that deliver genuine, community-based feedback and engagement with planning processes (Gollagher & Hartz-Karp 2013; Hartz-Karp & Newman 2006).

Collectives, co-ops and *Baugruppen*

Design-led processes can help achieve joy and delight by delivering variety in developments that respond to occupant needs and site characteristics. Collectives and housing co-operatives (also commonly known by the German name *Baugruppen*) are one way of generating diverse housing models. This participatory model empowers a group of citizens to deliver housing themselves, and while it has had a slow start in Australia the approach is rapidly gaining traction.

Typically, market-driven housing in Australia is provided by specialist developers, building a standardised product to a particular price point and usually for an unknown future occupant. Collectives aim to bring together owner-occupiers to co-design their future housing with the intention to save the typical 15 to 20 per cent developer's profit margin or reinvest that capital into higher specification materials for personalisation or sustainability, and so on. The major advantage of this model is that development decisions are led by the people who will ultimately reside there; thus personalisation and particular design requirements (such as universal access, ageing in place), can be delivered in the first instance and not have to be retrofitted post-occupancy. Personal investment in the project often drives design excellence because the project team, being the future residents, has a vested interest in achieving the best possible outcome for the dwelling from a cost, liveability and sustainability perspective.

This model has a long history in Europe. In some parts of Germany – for example, Tübingen (near Stuttgart) – co-op housing can be up to 40 per cent of the housing stock (London 2016). An early example in Australia was Christie Walk in Adelaide, which was led by architect Dr Paul Downton in the early 1990s. This 27-dwelling development was built on a 2,000 m^2 site in the heart of Adelaide. It managed to achieve high density within a verdant setting because of clever site arrangement and a 50 per cent car parking reduction (only 11 on-plot car

parking spaces). Within Australian cities there have only been a few housing co-op examples including WestWyck Ecovillage in Melbourne, established in 1998 on an old school site by involving the adaptive reuse of the school building, around which several high-performance buildings have been built.

In mid-2000, Jeremy McLeod, of Breathe Architecture in Melbourne, assembled a group of architects and investors to work on the sustainable housing development The Commons, delivered by ethical developers Small Giants. Affordability is delivered through reduced operating and maintenance costs for residents. For example, a resident in The Commons uses approximately 10 per cent of the expected electricity use of a comparable 'market' apartment. Since completion in 2014, the project has won 13 major architecture and sustainability awards including the Frederick Romberg Award for Residential Architecture – Multiple Housing, at the 2014 National Architecture Awards.

The collaborative model around which The Commons was formed has emerged as a spin-off social enterprise called Nightingale Housing, which has the expressed objective of advancing social or public welfare by supporting, promoting and advocating for housing which facilitates affordability, fosters environmental and social sustainability and strengthens communities (Nightingale Housing 2016). The organisation's constitution describes itself as an architect-led deliberative development model which:

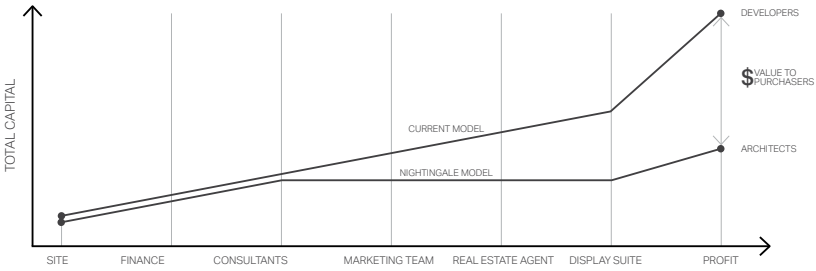
- advances environmental sustainability through design (including sustainable transport options)
- builds social connection, connection to services and community management
- contributes positively to neighbourhoods and urban culture through quality urban design
- promotes affordability by providing access to housing purchased at below market price
- minimises the ongoing costs of living in housing through design
- educates designers, potential home owners and the public in deliberative development and sustainable housing models
- involves groups of purchasers in cooperative/syndicate/collective planning and participation.

Nightingale Housing achieves affordability by leveraging word-of-mouth success from the prototype projects to gather potential purchasers for future developments. Money saved from marketing, real estate fees and display suites are passed on as value to the purchasers (see Figure 5.4). As of May 2017 one project is in construction (Nightingale) and another five are underway including the first in WA, Fremantle Nightingale by EHDO Architecture.

The advantages for infill include the increased democratisation of the design process because the co-design process empowers stakeholders to help shape their homes and communities. Perth, like most other Australian capital cities, has a metropolitan planning strategy (*Directions 2031*) that focuses on the delivery of a polycentric city (i.e. a city with multiple commercial and retail activity centres rather than one central business district). Essentially, these strategic plans identify locations, adjacent activity centres and transit as preferred areas for future infill (Western Australian Planning Commission (WAPC) 2010). Development models like Nightingale drive design excellence and offer potential residents greater consumer choice, increasing the competitiveness of infill as a place to live. In addition to reducing development and operation costs, the Nightingale model also offers housing choice. Presenting lower income home buyers with an alternative to lower-cost outer suburbs without access to services now enables consumers to access a development model that permits owner–developer consortiums to develop lower-cost, desirable housing in central locations with good access to social infrastructure.

The General Manager of Nightingale, Jessie Hochberg, explains: "Form follows finance". By incorporating future occupants in the co-design process, better outcomes result because architecture is 'done' by the community rather than to the community (Hochberg 2016). Including the future occupants in the design process ensures liveability and sustainability (including operational cost savings) are maximised. The vested interest of the owner in the co-design process has led to a more desirable built-form outcome than developer-led projects where financial return is the key driver.

Figure 5.4 The Nightingale model



Source: © Nightingale Housing (2016). Redrawn with permission.

Case study 4: The Commons, Brunswick, Melbourne

The Nightingale model prototype project was designed by Breathe Architecture and developed by Small Giants in 2013. It comprises 24 two-bedroom apartments with excellent sustainability and liveability specifications.

The Commons has been designed to offer high liveability and it does this without conventional air-conditioning or private on-plot car parks. Rather, it achieves thermal comfort passively, and travel considerations are met with a green travel plan that takes advantage of the site's immediate adjacency to the station and cycle-friendly, inner-city location (Figure 5.5). For times when a car is needed, there is a car-share scheme. Every room in the dwellings is designed with natural light and operable windows for cross-ventilation. Recycled materials are incorporated into the building fabric and there is a shared 5 kW rooftop PV system and solar hot water, with numerous communal spaces, including rooftop garden and a shared laundry (Chua 2014b).

The Commons presents an exemplary alternate development process for delivering quality infill development outcomes. It also represents an interesting built form typology that diverges from the almost universal dominant car-oriented planning and design of Australian cities, offering instead 72 spaces for bikes, ready access to public transport and car-share facilities.

Figure 5.5 The Commons, by Breathe Architecture, 2014

Source: Breathe Architecture (2014) Photo: © Andrew Wuttke

Drawing on the success of The Commons, Nightingale Housing was established to match future occupants to architects. This new model of development allows owner-occupiers to co-design high-quality spaces that place sustainability and liveability benefits at the forefront of the development process. Several Nightingale projects are now planned across Australia and New Zealand, and the first Nightingale project in Perth, EHDO Nightingale Fremantle, will be built in the Knutsford precinct redevelopment area. Announced in February 2017, EHDO Nightingale Fremantle (Figure 5.6) will comprise 12 units which are intended to be both affordable and sustainable, in keeping with the Nightingale philosophy (Taylor 2017).

Figure 5.6 Nightingale Fremantle, 2017

Image: © Bloxas (2017)

All the innovations in governance processes described in this section are aimed at delivering excellence in development outcomes, which is critical if infill development is to be successful. Competitions and design review panels are aimed at inspiring excellence rather than just seeking generic responses that do the minimum to meet planning regulations. Similarly, deliberative democracy and building collectives can lead to greater community involvement and in turn deliver more desirable infill development with greater diversity and increased occupant buy-in.

CONCLUSION

Sustainable infill in Australia will need higher density and meet higher performance criteria than historic residential development patterns. Design-led

innovation will assist this transition as the traditional quarter-acre block becomes an increasingly rare element of Australian cities and is replaced by higher density infill areas. Technological responses such as off-site manufacturing often facilitated by BIM or digital process improvements are already helping to minimise disruption, improve design outcomes and speed up project delivery. PIM is beginning to infiltrate large-scale precinct design to help developers, planners and communities understand the implications of a range of scenarios – and the impact of these scenarios on cost and urban performance, whether that performance be traffic generation, embodied energy, or energy/water consumption. As these tools become more refined and more powerful, their increased use in design, construction and operations will help ensure better built form outcomes for infill areas, as early adopters such as the One9, Melbourne, and Adara, Perth apartments are demonstrating.

Added to the construction innovation facilitated by digital tools and material technologies is a range of design-led innovations relating to governance that are being used to supplement traditional models of development assessment. Design review panels are becoming increasingly common, with many state and local governments now requiring design review for apartment blocks and public spaces.

Finally, in a move towards self-empowerment and to ensure greater diversity than is currently offered by conventional development, groups of individuals are starting to come together, often around one or several architectural practitioners, to co-design the living spaces occupants want. Innovative models are beginning to deliver sophisticated outcomes such as the award-winning multiple occupant development The Commons in Melbourne. As social enterprises such as Nightingale Housing work to replicate this model, with projects planned in other states including WA, this participatory co-housing model is expected to become more common in the coming years.

Coupled with political, economic and market drivers for increased infill development, the emergence of participatory models combined with the efficiencies of BIM, PIM and manufactured buildings suggests that a step change in infill quality and capacity is rapidly approaching.

REFERENCES

Azhar, S 2011, 'Building Information Modeling (BIM): trends, benefits, risks, and challenges for the AEC industry'. *Leadership and Management in Engineering*, 11, 241-252.

Chua, G 2014a, 'Nine storey Melbourne apartment goes up in just five days'. *Architecture & Design*. Retrieved from http://www.architectureanddesign.com.au/news/nine-storey-melbourne-apartment-goes-up-in-just-fi.

Chua, G 2014b, 'The Commons by Breathe Architecture named Best of the Best at 2014 Sustainability Awards'. *Architecture & Design*. Retrieved from http://www.architectureanddesign.com.au/awards-1/2014-winners/the-commons-by-breathe-architecture-named-best-of.

City of Perth 2013, Design Advisory Committee Minutes, Perth, Australia: City of Perth.

Cooperative Research Centre for Construction Innovation 2009, *National guidelines for digital modelling*. Brisbane, Australia: Cooperative Research Centre for Construction Innovation.

CRC for Construction Innovation – see Cooperative Research Centre for Construction Innovation.

Curtis, C & Scheurer, J 2010, 'Planning for sustainable accessibility: developing tools to aid discussion and decision-making'. *Progress in Planning*, 74(2), 53-106.

Design Council 2010, Cabe design review. Design Council. Retrieved from http://www.designcouncil.org.uk/what-we-do/cabe-design-review.

Gardner, H & Newman, P 2013, *Reducing the materials and resource intensity of the built form in the Perth and Peel regions*. Department of Sustainability, Environment, Water, Population and Communities. Retrieved from https://www.environment.gov.au/system/files/resources/012e6df0-dce8-4bb2-9861-dad1dfc0f779/files/built-form.pdf.

Gollagher, M & Hartz-Karp, J 2013, 'The role of deliberative collaborative governance in achieving sustainable cities'. *Sustainability (Switzerland),* 5(6), 2343-2366.

Government of NSW Department of Planning and Environment 2015, *Apartment design guide: tools for improving the design of residential apartment development*. Government of New South Wales. Retrieved from http://www.planning.nsw.gov.au/Policy-and-Legislation/Housing/~/media/E290B3EE3DB243C4A575ECC14B4522F1.ashx.

Hampson, KD, Kraatz, J & Sanchez, A 2014a, *R&D investment and impact in the global built environment*. Abingdon, Oxon: Routledge, Taylor & Francis.

Hampson, KD, Kraatz, J & Sanchez, A 2014b, 'The global construction industry and R & D'. In KD Hampson, J Kraatz & AX Sanchez (Eds) *R & D investment and impact in the global built environment* (pp. 4-23). Abingdon, Oxon: Routledge, Taylor & Francis.

Hartz-Karp, J & Newman, P 2006, 'The participative route to sustainability'. In S Paulin (Ed) *Communities doing it for themselves: creating space for sustainability*. Perth, Western Australia: UWA Press.

Hochberg, J 2016, Personal communication.

Kamali, M & Hewage, K 2016, 'Life cycle performance of modular buildings: a critical review'. *Renewable and Sustainable Energy Reviews*, 62, 1171-1183.

Keast, R & Hampson, KD 2007, 'Building constructive innovation networks: the role of relationship management'. *Journal of Construction, Engineering and Management*, 133(5), 364-373.

Kelly, JF, Breadon, P & Reichl, J 2011, *Getting the housing we want*. Melbourne: Grattan Institute.

London, G 2016, Personal communication.

Newton, P & Glackin, S 2015, 'Regenerating cities: creating the opportunity for greyfield precinct infill development'. In C Legacy & R Leshinsky (Eds) *Instruments of planning: tensions and challenges for delivering more equitable and sustainable cities*. London, UK: Routledge.

Newton, P, Marchant, D, Mitchell, J, Plume, J, Seo, S & Roggema, R 2013, *Performance assessment of urban precinct design: a scoping study*. Cooperative Research Centre for Low Carbon Living. Retrieved from http://blog.lowcarbonlivingcrc.com.au/media/uploads/files/RP2001_-_Performance_Assessment_Urban_Precinct_Design-FINAL.pdf.

Newton, P, Newman, P, Glackin, S & Trubka, R 2012, 'Greening the greyfields: unlocking the redevelopment potential of the middle suburbs in Australian cities'. *World Academy of Science, Engineering and Technology*, 71(11), 658-677.

Nightingale Housing 2016, *Constitution of Nightingale Housing Ltd*. Nightingale. Retrieved from http://nightingalehousing.org/s/Nightingale-Housing-Constitution-Final.pdf.

Sanchez, A & Hampson, KD 2015, 'Delivering value with BIM'. *The Earthmover & Civil Contractor*. Retrieved from http://sbenrc.com.au/app/uploads/2014/09/2015_08-Aug-P16-BIM-story.pdf.

Sanchez, A, Hampson, KD & Mohamed, S 2015a, *Driving whole-of-life efficiencies through BIM and procurement*. Sustainable Built Environment National Research Centre. Retrieved from http://www.sbenrc.com.au/research-programs/2-34-driving-whole-of-life-efficiencies-through-bim-and-procurement/.

Sanchez, A, Hampson, KD & Mohamed, S 2015b, *Perth Children's Hospital, case study report*. Sustainable Built Environment National Research Centre. Retrieved from http://sbenrc.com.au/app/uploads/2014/09/PCH-case-study-for-public-110815.pdf.

SBEnrc – see Sustainable Built Environment National Research Centre.

Steinhardt, D, Manley, K & Miller, W 2013, *Profiling the nature and context of the Australian prefabricated housing industry*. Queensland University of Technology. Retrieved from https://eprints.qut.edu.au/81176/1/nature-and-context-australian-prefabricated-housing.pdf.

Sustainable Built Environment National Research Centre 2015, *Investigating the mainstreaming of building manufacture in Australia*. Sustainable Built Environment National Research Centre. Retrieved from http://sbenrc.com.au/app/uploads/2013/10/SBEnrc-Manufactured-Buildings-Industry-Report-Project-1.29_edit.pdf.

Taylor, B 2017, 'Nightingale project could change WA housing market'. *Perth now*. February 26, 2017. Retrieved from http://www.perthnow.com.au/news/western-australia/nightingale-project-could-change-wa-housing-market/news-story/08aacb590131f68cbc9be89c17a1d784.

Thomson, G & Newman, P 2017, 'Urban fabric and urban metabolism – from sustainable to regenerative cities'. *Resources, Conservation and Recycling*. DOI: https://doi.org/10.1016/j.resconrec.2017.01.010.

Trubka, R, Newman, P & Bilsborough, D 2008, *Assessing the costs of alternative development paths in Australian cities*. Perth: Parsons Brinckerhoff Australia. Retrieved from http://www.earthsharing.org.au/wp-content/uploads/Curtin_Sustainability_Paper_0209.pdf.

Trubka, R, Newman, P & Bilsborough, D 2010, 'The costs of urban sprawl – infrastructure and transport'. *Environment Design Guide*, (83), 1-6.

WAPC – see Western Australian Planning Commission.

Western Australian Planning Commission 2010, *Directions 2031 and beyond*. Department of Planning, Lands and Heritage. Retrieved from https://www.planning.wa.gov.au/publications/826.aspx.

6

INNOVATIVE ARCHITECTURAL DESIGN

A key to sustainable infill development for Greater Perth

Sambit Datta*

*Corresponding author: Sambit Datta, School of Built Environment, Curtin University, GPO Box U1987, Perth WA 6845. Email: sambit.datta@curtin.edu.au Tel: +61 9266 3159

INTRODUCTION

This chapter discusses eight exemplary infill housing projects showing how a creative combination of planning and design strategies can mitigate the negative perceptions of urban consolidation and lead to good infill outcomes for sustainable development. The creation of successful infill outcomes depends on three key constitutive elements: response to context, regulatory innovation and spatial programming. It is the combination of the analysis of the existing fabric and street activation, combined with an understanding of the relationship of these to massing, height and materiality that create good infill outcomes (London & Anderson 2008).

SUSTAINABLE INFILL DEVELOPMENT: KEY ARCHITECTURAL ELEMENTS

Response to context

The rigorous analysis, evaluation and integration of local context is a *sine qua non* in good infill design. The incremental reinvigoration of urban blocks in traditional cities provides historic exemplars of context as connective tissue (Alfirević & Simonović Alfirević 2015). While Hall (1999) opines that the real story of 20th century urbanism has been the building of annular suburban rings around big city centres, Forster (2006) argues that urban consolidation in Australia will be characterised by multi-nuclear structures connected by transport hubs with infill and densification throughout the current inner and middle suburbs.

Regulatory innovation

This shift towards consolidation and compactness presents several opportunities and challenges for the planning and design guidelines that regulate the growth and development of the built environment (Magri 1994). Randolph (2004) distinguishes this change over the last two decades as a fundamental shift propelled by demographic change, increased migration, exposure to global trends in urban housing, lack of housing affordability, awareness of the environmental and social benefits of compact cities and

easy access to infrastructure and amenities. Modern planning and zoning mechanisms impose compliance rather than performance controls that constrain design innovation. For example, regulatory stipulations for setbacks are used to manage light, privacy and ventilation planning within the built environment. Compliance with regulations is often in conflict with the intentions of good development control and regulation. Compliant forms with poor design outcomes are sadly the norm.

The role of good design and architectural innovation for Perth's growth has long-term urban design and planning impact on the city and on the perceived habitability of medium-density infill developments (Roberts 2007). For example, lot setbacks for residential sites in WA (Western Australian Planning Commission (WAPC) 2015) provide a number of rules for daylight, direct sun and ventilation, as well as height and density control mechanisms. Incremental improvements and experimentation with existing regulatory frameworks and local planning norms are crucial drivers for design innovation.

Spatial programming

Australia's five major capital cities (Sydney, Melbourne, Brisbane, Perth and Adelaide) share common structural features such as low-density suburbanised housing, high rates of home ownership, low levels of social polarisation and high automobile dependence. There are strong social, spatial, technical and sustainable design benefits to medium-density design (Fincher & Gooder 2007). By 2050 as much as 30 per cent of the population will be living in housing typologies characterised by medium density.

The design, construction and appearance of some urban infill developments have at times been subject to criticism, for not offering the benefit of good design principles to either their residents, their neighbours or the city over their 30 to 50-year lifetime (Sajan 2015). The spatial programming of infill housing is often the result of a combination of planning overlays and building codes. More successful infill outcomes would result from a flexible and adaptive spatial programming regime that measures performance and a sophisticated mechanism for regulatory trade-offs. For example, urban infill should incorporate design criteria that extend the design brief, and programming to include public and open space that interfaces with it, while

allowing for flexible interpretations of regulatory envelopes. In the next sections, exemplar infill projects are presented which demonstrate that sophisticated spatial programming and contextual responsiveness combined with regulatory improvements can result in better infill outcomes for Greater Perth.

CASE STUDIES

Several forms of innovative infill design development have been developed in Perth and can be used as models or exemplars for the development of infill housing futures. These exemplars demonstrate medium-density infill as well as the reuse of existing empty spaces. The eight innovative exemplars in this chapter successfully address the three constitutive elements of urban infill housing identified in the previous section, namely response to context, regulatory innovation and spatial programming. The first four projects are built exemplars and range from single houses to mixed-use transitional housing, all in densifying inner-city contexts. All four projects address site context, planning controls and flexible volumetric programming, and provide lessons for the development of infill futures for the future in Perth's rapidly densifying inner suburbs.

The Two Houses project in Fremantle, by Bernard Seeber Architects, addresses constraints particular to the site and demonstrates the use of planning and volumetric design in fitting contemporary, factory-made building components within a heritage setting. The Lincoln Street duplex, by Donaldson + Warn, proposes a solution that fits in two double-storey, semi-detached houses in a typical Highgate lot in a street of single-storey dwellings. The Newcastle Street, Northbridge, Foundation Housing project, by CODA, demonstrates an innovative solution for inner-city infill with a shared central courtyard mediating between the transitional accommodation at the rear and the mixed-use development along the street edge. The final project, Glick House, is exemplary of an inner-city infill proposition on a tiny infill site.

To move to a more sustainable and progressive model for infill futures, it is also necessary to include a range of conceptual models developed for the

city that question existing norms of site and contextual responses, push the limitations of planning regulations and provide for diversification of the architectural program beyond current models of infill. The second set of four projects presents conceptual unbuilt exemplars that demonstrate the potential for design innovation to address infill futures. There is an urgent need to bring many of these prototypes from the research domain to physical realisation, where the public can experience and make choices about the wide range of infill options that are possible. Despite the excellent research and experimental work embodied in these design propositions, almost none of them have been realised, even as experimental prototypes.

Four unbuilt/conceptual projects are presented to illustrate how successful infill futures for WA will depend on the design innovation embodied in experimental projects. The first project is a tiny infill, Tube House, proposed in the City of Fremantle. The exploration of tiny houses shows that a range of dwellings and configuration types is possible to address density pressures through innovative planning amendments that take advantage of the potential for small infill lots. The next two case studies are courtyard typologies tested for infill solutions within the typical Perth suburbs; in this case, Wembley and Bassendean. The final project, the Urban Prototype, revisits the terrace housing typology and proposes a modified four-storey urban prototype based on industrialised procurement methods for cost savings, with a shell and infill approach for flexibility and adaptability (Anderson 2008; 2009). All four projects address the central concerns prevalent in Perth's inner suburbs. They demonstrate that reducing size, increasing density, lowering housing costs and providing amenity can be achieved with strong design and innovative typologies. However, the barriers to increasing residential choice and accommodating good design are many. Existing lot shapes and sizes, setback requirements in current planning guidelines, restrictions on height and massing will need to be revisited if these schemes are to lead to a flurry of innovative infill projects.

We are currently seeing the effects of the lack of design-led innovation across many densifying suburbs, inner-city apartment projects, and even greenfield developments in outer-suburban areas. Infill futures without strong design-led innovation in the urban and planning realm will inevitably lead to a further polarisation of Perth's housing and urbanisation into two distinct typologies:

battleaxe configurations and inner-city, high-rise apartments. The subdivision of lots into battleaxe developments does not add amenity, can compromise open space provisions and encourage the development of single occupancy, single-storey homes. Speculative inner-city, high-rise developments, which represent investor-driven infill, lead to increasing density but rarely represent an attractive option for owner-occupiers and younger families. Bold and experimental public policy in combination with private parties to introduce a varied set of typologies and designs can provide a suitable environment for the development of infill projects, where design-led innovation can enter the current marketplace and offer alternative choices. In the following sections, we discuss the eight projects and how they can be used to implement a suitable and sustainable policy for design-led infill development.

ARCHITECTURAL DESIGN INNOVATION EXEMPLARS

In this section we discuss the use of infill strategies in Perth, from doubling of existing lot density through single houses and use of the duplex typology, to medium-density lot amalgamations.

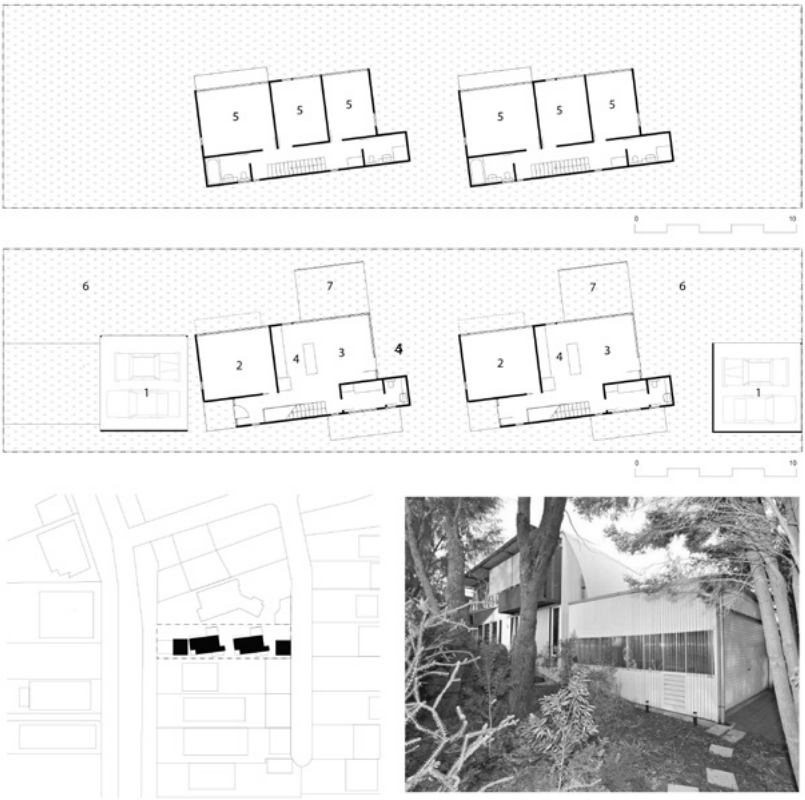
Two Houses, Fremantle

The Two Houses project, designed and constructed in 1993 at 198 South Terrace, is an early example of innovative residential infill in Perth by Bernard Seeber (Seeber 2008). The project involved the placement of two modest two-storey dwellings within a heritage, single-storey context, with optimised open external areas (Figure 6.1). The planning and volumetric design of the two houses adopt an east-west orientation, providing solar gain on the south and external spaces to the north. The two-storey envelope sits within the height of the adjacent single-storey buildings, using a low roof pitch that mitigates height impacts on adjacent sites. The lightweight steel-framed construction is achieved at modest cost using factory-made components. Measurements of parts are carefully controlled using a modular format of construction. The result is an airy, climate-responsive infill that demonstrates how careful response to context can be made with consideration to space planning and site orientation

Figure 6.1 Two Houses, Fremantle

Project: The two houses project is an early example of innovation residential infill development. The project involved the placement of two modest two-storey dwellings into a heritage, single storey context with a desire to optimise open external areas. The planning and volumetric design of the two houses adopt an East-West orientation providing solar gain on the south and external spaces to the north.
Year: 1993
Developer/Architect: Private/Bernard Seeber Architects
Local Government Area: City of Fremantle

Demonstration of good infill: The result is an airy, climate responsive infill that demonstrates how the combination of considering context through careful space planning and site orientation along with the choice of modular construction can lead to sympathetic infill which both provides for the occupants and enhances the surrounding environment. The two storey envelope is commensurate with the height of the adjacent single storey buildings, using a low roof pitch. The lightweight steel framed construction is achieved at modest cost using factory made components.



Source: Bernard Seeber Architects (2016)

alongside the choice of modular construction and volumetric design. This has led to sympathetic infill, which provides for the occupants and enhances the surrounding environment.

Over time, Bernard Seeber Architects has added to the infill architecture of the street. In 1999, a second-storey was added to the rear carport and a single storey added to the rear of 196 South Terrace. The practice is currently adding a new house to the rear of 200 South Terrace. The original infill and subsequent extensions over the last two decades in neighbouring sites demonstrate how thoughtful, innovative design can future-proof residential neighbourhoods, and enable the adoption and assimilation of increasing density.

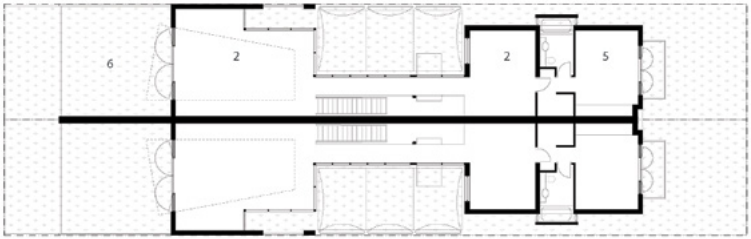
Lincoln Street duplex, Highgate

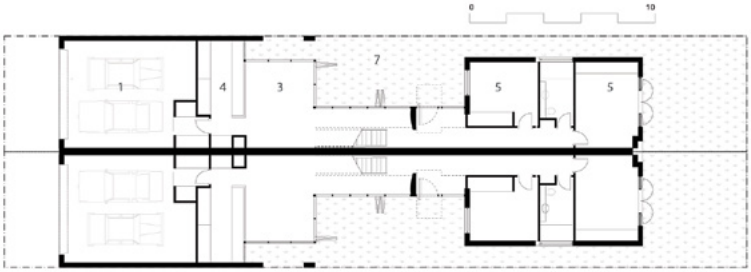
The Lincoln Street duplex project in Highgate, an inner-ring city suburb, exemplifies the development and lifestyle potential that contemporary infill housing can provide for the city (Figure 6.2). The project inserts two double-storey houses into a lot that is typical of the suburb. A tight, inner-city suburban single lot is the location for this pair of tightly planned infill houses. The formal design concept utilises a series of volumes, frames and planar elements to articulate the form in response to the brief and the site's topographic, urban and environmental conditions. The courtyard housing model was chosen, as it is ideal for the narrow site and its aspect. Each dwelling consists of a 'pavilion' separated by a central courtyard and connected by a double-storey glazed link and first-floor bridge. The central courtyard is the locus of the project and provides a secure and private outdoor living and entertainment space adjacent to the dining area. Establishment of the central courtyard maximises useable outdoor space and capitalises on the narrow northern aspect of the site to create a comfortable and spacious, quality-living environment. The design includes an intimate landscaped front court addressing the street, which provides a pleasant outlook from the ground-floor bedroom. A double garage is accessed from the rear right-of-way, providing secure lockup for two vehicles and safe entry directly into the duplex from the garage. Above the garage, at first-floor level, the living area opens to a paved deck with city views. The accommodation requirements, room sizes and layout of the houses cater for a variety of occupants and lifestyles.

Figure 6.2 Lincoln Street duplex, Highgate

Project: The Lincoln Street project is an innovative development of two residential units on a previously single residential site. Each duplex consists of two, two-story'pavilions' separated by a central courtyard and connected by a two storey glazed link and first floor bridge. The central courtyard is the locus of the project and was conceived as an outside 'room' contained by a two-storey pergola.
Year: 1999
Developer/Architect: Private/Donaldson + Warn
Local Government Area: Highgate/City of Vincent

Demonstration of good infill: The duplex demonstrates the development and lifestyle potential of contemporary infill housing in an old inner city subdivision of Perth, ideal for the narrow site and its aspect. Dividing the site longitudinally provides a street frontage and rear vehicular access to both units and creates design opportunities for a variety of living spaces with a complimentary outdoor space or view. The courtyard maximises usable outdoor space and capitalises on the narrow northern aspect of the site to capture the sunlight and create a comfortable and spacious quality living environment.





LEGEND
1. GARAGE
2. LIVING
3. DINING
4. KITCHEN
5. BEDROOM
6. ALFRESCO
7. OPEN SPACE

Source: Donaldson + Warn Architects (2016)

Foundation Housing, Newcastle Street, Northbridge

The Foundation Housing project (2009), designed by CODA, fills a standard 1190 m^2 lot in Newcastle Street with a mixed-use infill building (Figure 6.3), and extends the substantial revitalisation of Northbridge by the MRA. This exemplar demonstrates the potential of adopting a mixed-use infill strategy in older inner-city subdivisions in Perth. The project combines a lodging house with one and two-bedroom apartments with commercial tenancies to the street, including the restoration and conversion of a heritage warehouse to a cafe. The infill comprises a three-storey block along Newcastle Street and hostel accommodation to the rear. This configuration allows for a northern orientation to each habitable room, while successfully addressing the need for cross-ventilation. By increasing the height of the tower, the centre of the site was also freed to become a communal courtyard. The project integrates artwork designed by four artists into the building fabric.

The bold competition-winning design concept proposed a series of volumes (including a seven-storey building to the rear) to respond to the site's urban conditions and create better opportunities for northern light to all accommodation. To do this, the existing height constraints of the site were challenged. The project wraps around the corner site in a L-shape, creating a strong streetscape presence on Newcastle Street, and has a public forecourt and large, private courtyard internally.

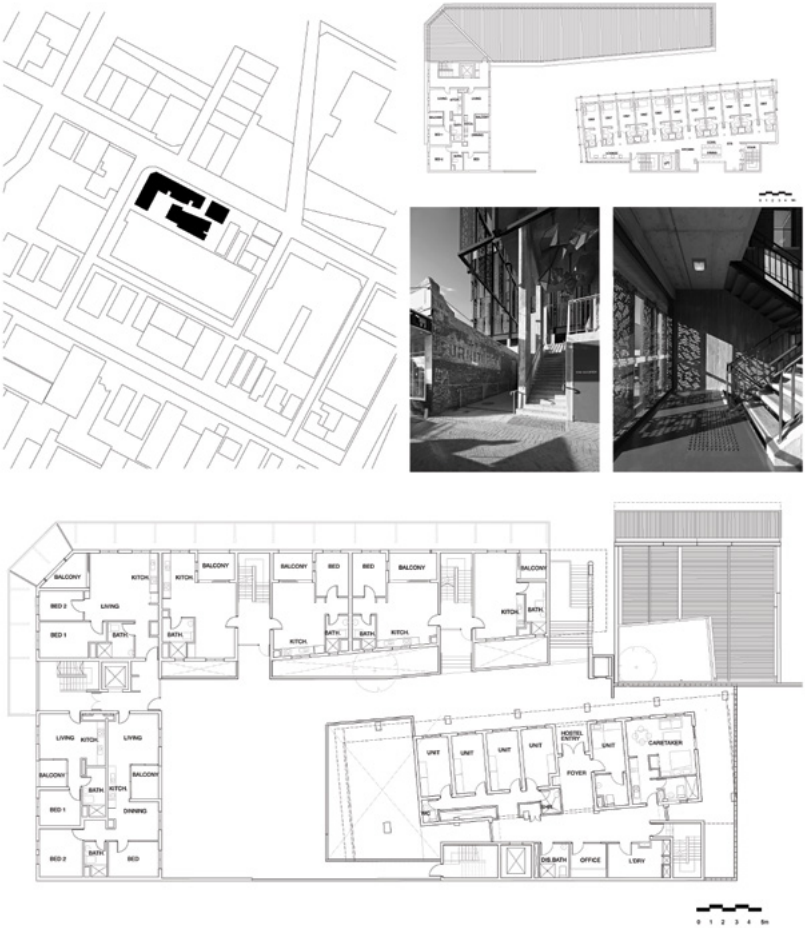
The urban lot and its diverse street frontages inspire the design responses for a variety of living typologies organised around a raised outdoor courtyard space. The accommodation requirements, room sizes and the layout of the apartments cater for a variety of occupants and lifestyles suitable for inner-city living.

This energy-efficient design reduces the running costs of the building, increasing the initiative's viability while also providing comfortable living spaces for tenants. The commercial tenancies provide an active street frontage. The articulation of the building facades provides visual interest and captures northern light for the dwellings. All rooms are oriented with a view and optimised for solar orientation.

Figure 6.3 Foundation Housing, Newcastle Street, Northbridge

Project: A tight inner-city lot in Northbridge is the location for this infill developmennt. An innovative exemplar using a mixed use strategy, combines a lodging house with 1 and 2 bedroom apartments with commercial tenancies to the street. The project wraps around the corner site in a L-shape a strong streetscape presence on Newcastle Street as well as a public forecourt and a large private courtyard internally.
Year: 2009
Developer/Architect: Foundation Housing/CODA
Local Government Area: Northbridge/City of Perth

Demonstration of good infill: This exemplar demonstrates the potential for adopting mixed-use infill in older inner city subdivisions of Perth. The urban lot and its diverse street frontages inspire the design responses for a variety of living typologies organised around a raised outdoor courtyard space. The commercial tenancies provide an active street frontage. The articulation of the building facades provides visual interest and captures northern light for the dwellings. All rooms are oriented with a view and optimised for solar orientation and the articulation of the building facades captures northern light for the dwellings.



Source: CODA (2016)

Glick House, Leederville

Glick House (1999) is an innovative studio and residence project undertaken in collaboration with then graduate architect Jane Wetherall, artist Rodney Glick and his father, Graham, a retired structural engineer. Glick's interest in a small, disused and soon-to-be demolished foundry was the initiating reference for his new residence and studio. The 90 m^2 suburban lot in Leederville is close to the city centre and has been converted into a spacious two-storey vertical arrangement with an artist's studio on the ground floor, living quarters on the first floor and a serviced patio and useable roof deck (Figure 6.4). Glick's creative work with mundane industrial equipment and products, such as electrical cabinets and security monitors, overlapped the artist's interests in an aesthetic that is influenced by practical decisions and low-cost construction, spoken in the language of modern architecture with a local accent.

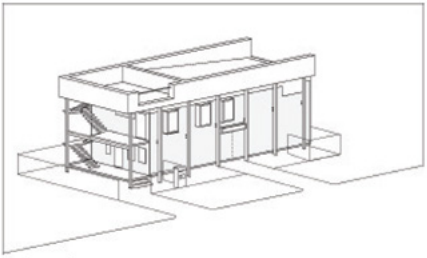
The arrangement of domestic elements common to the neighbouring cottages – front porch, compact house, rear patio and workshop/shed in the backyard – are stacked vertically above the shed, now an artist's studio. The patio, complete with water, light and gas for the barbecue is located on the roof. Contrasts are again prevalent – light and dark, light and heavy, frame and plane, transparent, translucent and opaque, ground deck and roof deck, strip window and boxed windows. An oversized structural frame is expressed externally and left to rust, giving the residence a long but limited life. The relationships between structure, skin and contained volume composed with a 'loose formalism' is skilfully worked within a low budget. The external materials and finishes create a strong streetscape presence. The clever use of space and site planning maximises indoor and outdoor living, combined with the considered use of innovative materials and construction methods.

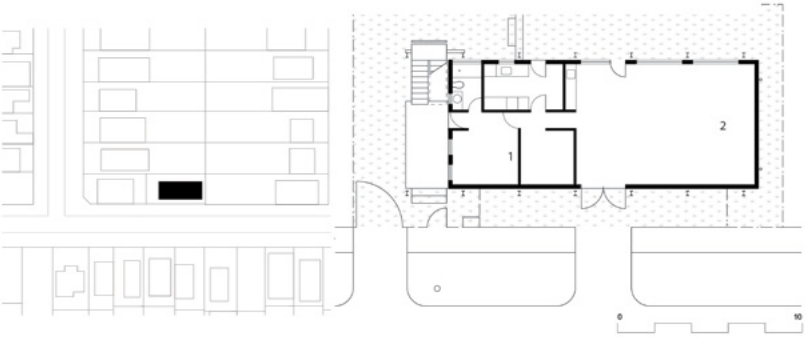
This project is a model for future mixed-use housing on infill lots. The energy-efficient design accommodates environmentally sustainable living, reduces the running costs of the building and provides a distinctly local patina derived from modernist design. The vertical arrangement of living and working space, separation of structure and skin, and expressive materials demonstrate the value of innovative design for tight infill conditions.

Figure 6.4 Glick House, Leederville

Project: The Glick House is an innovative studio and residence project in collaboration with artist and client Rodney Glick. A small 90 square metre suburban lot close to the city centre is converted into a spacious two-storey vertical arrangement with an artist's studio on the ground floor, living quarters on the first floor and a serviced patio and useable roof deck.
Year: 1999
Developer/Architect: Private/Donaldson + Warn
Local Government Area: Highgate/City of Vincent

Demonstration of good infill: The clever use of space and site planning maximizing indoor and outdoor living, combined with the considered use of innovative materials and construction methods. This project is a model for future mixed use housing on infill lots. This energy efficient design accommodates environmentally sustainable living, reduces the running costs of the building and provides a distinctly local patina derived from modernist design. The vertical arrangement of living and working space, separation of structure and skin and expressive materials demonstrates the value of innovative design for tight infill conditions.





LEGEND
1. GARAGE
2. LIVING
3. DINING
4. KITCHEN
5. BEDROOM
6. ALFRESCO
7. OPEN SPACE

Source: Donaldson + Warn Architects (2016)

UNBUILT EXPERIMENTAL PROTOTYPES

Innovative as they are, the built exemplars are only a small fraction of the possible housing innovations that have been proposed for Perth. In fact, despite their obvious appeal in diversifying the infill options, the majority of these design instruments remains in the 'unbuilt' category. Therefore it is important to highlight the opportunities and constraints that these experimental prototypes offer Perth in planning its residential infill futures. Several conceptual models have been proposed to increase the density of existing suburbs. These different forms include infill, reuse, development of existing empty spaces, and the new medium-density developments. In this section, we discuss conceptual propositions for Perth infill, including 'tiny' houses, two courtyard housing prototypes and medium-density urban housing based on terrace or row housing models.

Tube House, Fremantle

The City of Fremantle has recently conducted a study of an amendment to the WA planning scheme that could see more flexible and appropriate infill built in the city. The amendment proposes the possibility of the subdivision of larger residential blocks to allow smaller, independently owned houses to be built within existing neighbourhoods. Tube House is an example of an innovative design solution to an unusual U-shape strata title (Figure 6.5).

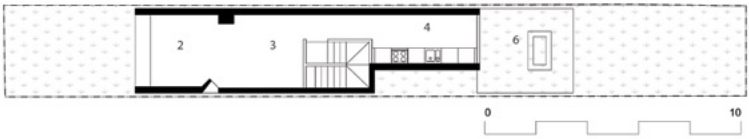
The amendment includes a set of open space requirements designed to maintain local neighbourhood characteristics while achieving increased density through infill housing. A study of the effects of the amendment on the dwelling typologies and neighbourhood characteristics has been carried out. It proposes a maximum size of 120 m^2 for each dwelling. The amendment also encourages the adaptive reuse of existing buildings. The council has voted to adopt the recommendations, which include a minimum of 70 per cent open space; a minimum 25 per cent development site area for an uncovered deep-planting zone – 50 per cent of which is at the rear of the property with a minimum width of 4.5 metres; and a minimum of one tree in the deep-planting zone.

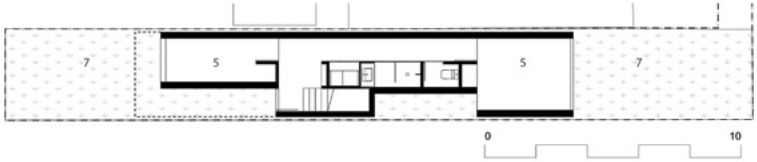
The City of Fremantle amendments show one way in which current planning schemes can be tested and improved for better infill outcomes.

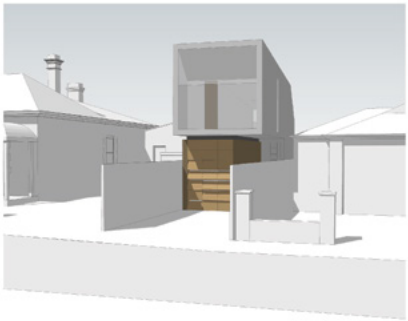
Figure 6.5 Tube House, Fremantle

Project: The Tube House is an exemplar of a "tiny" house infill suitable for micro lots in suburban conditions. A long and narrow dwelling is inserted into a strata title between two conventional suburban houses. The project addresses an unusual site constraint presented by the U-shaped strata title configuration. A narrow passageway to the existing dwelling connects the 3.75 metre wide and 29 metre long lot.
Year: 2014
Developer/Architect: Christian Nicolls/Donaldson + Warn
Local Government Area: City of Fremantle

Demonstration of good infill: This exemplar demonstrates the insertion of tiny dwellings into constrained suburban sites and unusual strata configurations in inner urban scenarios. Through spatial and volumetric manipulation, the tube house represents a novel addition to Perth's housing diversity and the need to upgrade current regulatory models to enable infill at the urban micro scale. The project addresses an unusual site constraint presented by the U-shaped strata title configuration. The minimum size regulations and the possibility of tiny insertions into highly constrained site conditions are demonstrated in this exemplar.







LEGEND
1. GARAGE
2. LIVING
3. DINING
4. KITCHEN
5. BEDROOM
6. ALFRESCO
7. OPEN SPACE

Source: Donaldson + Warn Architects (2016)

Courtyard Infill Prototype A, Bassendean

Despite its long history in the shaping of urban density, the courtyard house has not been developed as a major infill option in Australia. Courtyard houses have the potential to create higher density while retaining many of the features of the individual detached house. An example is the conceptual proposal for suburban Bassendean, Courtyard Infill Prototype A (Figure 6.6). The concept demonstrates both the design flexibility and infill potential of using courtyards as outdoor rooms and, in doing so, developing new dwelling types for suburban Perth. Studies of conceptual prototypes developed for Perth (London 2008) suggest that the courtyard model would result in the doubling of residential density (dwellings per hectare measure) while retaining existing lot structure and permitting incremental change. The efficiency of the courtyard house model arises from its 'loose-fit' characteristics, which can be made to adjust to varying lot sizes and orientations.

The Courtyard Infill Prototype A offers to double suburban density through infill while retaining existing lot subdivision structure, and thereby enable an incremental change while retaining the character of existing neighbourhoods. This proposition is demonstrated for infill strategies in the town of Bassendean. Suburban density is notionally doubled through innovative design that challenges current setback regulations and building regulations relating to height and extent of parapet walls to boundaries. The Courtyard Infill Prototype A demonstrates an innovative prototype for responding to the challenges of infill for accommodating the changing household structures and demographics in Australia. By separating the parking garage from the main house, the scheme improves both the quality of the street front and neighbourhood, and facilitates the creation of outdoor space. The organisation of the living spaces retains much of the existing character of the detached house while providing for varying conditions of useable private open space. The loose-fit characteristics of the prototype demonstrate the importance of improving planning regulatory frameworks that address street frontages and the quality of both internal and external aspects of infill neighbourhoods.

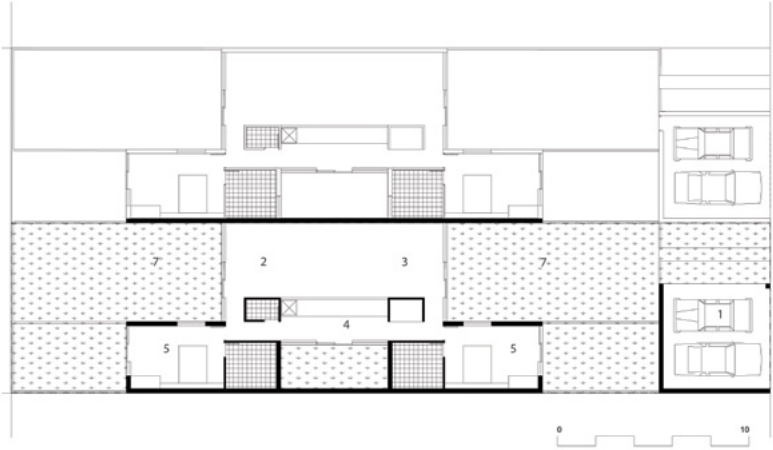
Courtyard Infill Prototype C, Bassendean

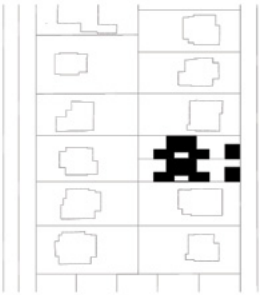
This proposal demonstrates the flexibility of the courtyard typology as an appropriate and climate-responsive exemplar for accommodating residential infill on suburban lots. This proposition extends the courtyard infill strategy

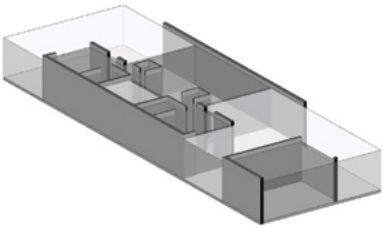
Figure 6.6 Courtyard Infill Prototype A, Bassendean

Project: The courtyard house A prototype proposes to double suburban density through infill while retaining existing lot subdivision structure, thereby enabling an incremental change while retaining the character of existing neighbourhoods. This proposition is demonstrated for infill strategies in Bassendean and challenges current setback regulations and building regulations relating to height, parapet walls and boundaries.
Year: 2007
Developer/Architect: NA/Geoffrey London
Local Government Area: Town of Bassendean

Demonstration of good infill: Suburban density is notionally doubled through innovative design. The courtyard house A demonstrates an innovative prototype for responding to the challenges of infill for accommodating the changing household structures and demographics in Australia. By separating the parking garage from the main house . The organization of the living spaces retains much of the existing character of the detached house while providing for varying conditions of useable private open space. The loose fit characteristics of the prototype make it a flexible and climate responsive exemplar for urban infill







LEGEND
1. GARAGE
2. LIVING
3. DINING
4. KITCHEN
5. BEDROOM
6. ALFRESCO
7. OPEN SPACE

Source: Geoffrey London (2016)

for addressing suburban density by relaxing the setback and site boundary regulations. The infill strategy demonstrates how residential density can be enhanced through innovative design without compromising internal amenities. To enable this innovative prototype as a model for infill futures, existing setback requirements, height of privacy walls, internal configurations and external massing restrictions will need to be revisited.

The Courtyard Infill Prototype C demonstrates a variation on a theme, on the use of the courtyard prototype for accommodating increased residential density through infill (Figure 6.7). Once again, the internal organisation of the living spaces retains much of the existing character of the detached house while providing for significant private outdoor space. The courtyard strategy in this prototype reaffirms good design through solar-responsive orientation, internal daylighting and cross-ventilation for indoor and outdoor living suitable to Perth's climate and lifestyle. Pursuing regulatory amendments and reform to enable good design to create quality infill is therefore an urgent imperative so that such schemes are moved from conceptual discussion to realised prototypes. By doing so, the community will be enabled to make informed choices from a more diverse project housing market, with community scale outcomes that enhance internal programming of infill housing and public frontages, the residential streetscape and neighbourhoods.

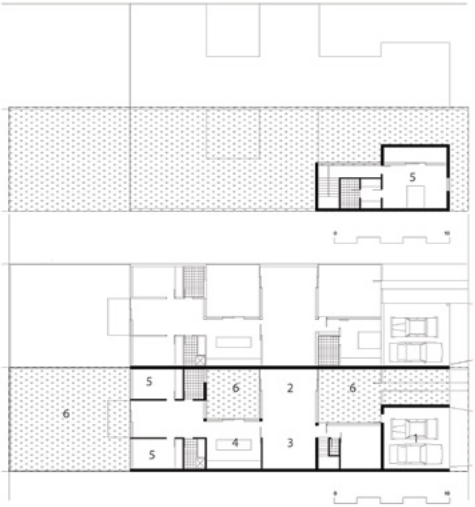
Urban Prototype

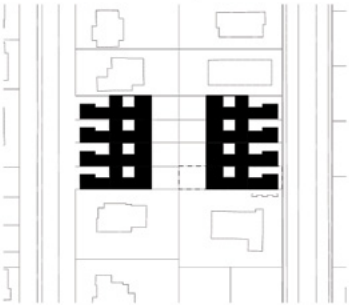
Terrace housing is a medium-density typology that offers many benefits for inner-city residential housing. This is borne out by the prevalence of terrace housing in the early history of housing in Australia, exemplified in Sydney's Paddington, Carlton in Melbourne and Fremantle in Perth. The terrace type is an ideal exemplar for residential infill, as it offers efficiencies of lot use and addresses privacy and overlooking issues. It also provides flexibility of use, allows multiple floors and permits good access, and has unified and activated street frontages and passive surveillance. Anderson (2009) combines the advantages of this type with contemporary construction methods and mixed-use possibilities to propose a four-storey walk-up 'shell' and infill model suitable for contemporary Perth (Figure 6.8). The key to efficiency in this model is the proportion and orientation of lots. Long, narrow lots, differential lot widths and the use of factory-made party walls (based on industrial construction) are

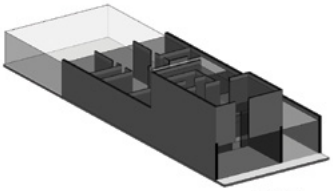
Figure 6.7 Courtyard Infill Prototype C, Bassendean

Project: This proposal demonstrates the loose fit characteristics of the courtyard prototype as a flexible and climate responsive exemplar for accommodating residential infill in suburban lots. By relaxing the setback and site boundary regulations, the proposal demonstrates how residential density can be enhanced through innovative design without compromising internal amenities.
Year: 2008
Developer/Architect: NA/Geoffrey London
Local Government Area: Town of Bassendean

Demonstration of good infill: The courtyard house C demonstrates the use of the courtyard prototype for accommodating increased residential density through infill. The internal organization of the living spaces retains much of the character of a detached house while providing for significant private outdoor space. The courtyard strategy in this prototype reaffirms good design through solar responsive orientation, internal daylighting and cross ventilation for indoor and outdoor living suitable to Perth's climate and lifestyle. Existing building regulations are revisited to realize the potential of courtyard infill within existing lots.







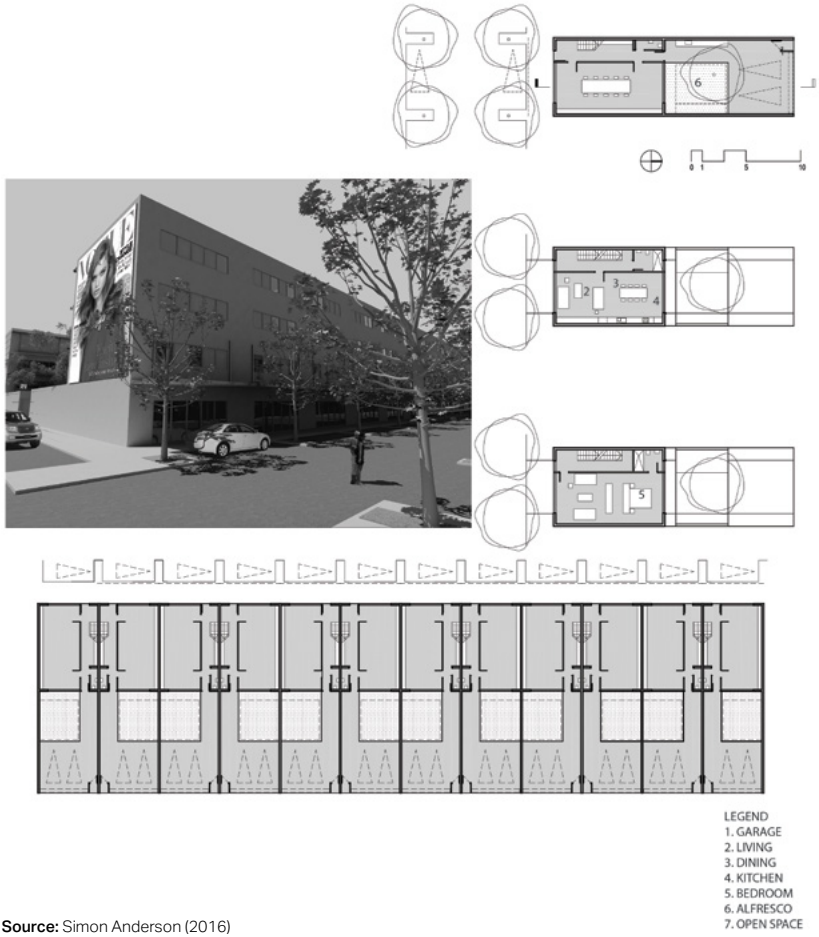
LEGEND
1. GARAGE
2. LIVING
3. DINING
4. KITCHEN
5. BEDROOM
6. ALFRESCO
7. OPEN SPACE

Source: Geoffrey London (2016)

Figure 6.8 Urban Prototype

Project: The Urban Prototype exemplar proposes a four storey walk-up "shell" and infill model suitable for contemporary densification of Metropolitan Perth. The housing strategy employed in this scheme is the terrace typology with a natural height of 12 metres (4 storeys) utilising tilt up construction and constrained by the size of standardised pre-cast panels.
Year: 2009
Developer/Architect: NA/Simon Anderson
Local Government Area: City of Perth

Demonstration of good infill: The terrace type is also an ideal exemplar for residential infill as it offers efficiencies of lot use, addresses privacy and overlooking issues, provides flexibility of use, allows multiple floors and permits good access, unified and activated street frontages and passive surveillance. The key to this model is the proportion and orientation of lots. Long narrow lots, differential lot widths and the use of factory made party walls (based on industrial construction) are proposed for affordability, environmental efficiency and flexible space usage within the shell based on occupants' needs.



Source: Simon Anderson (2016)

proposed for affordability and environmental efficiency. The housing terrace may achieve a natural height of 12 metres (based on the availability of precast panels). The volumetric shell thus obtained from the lot subdivision and use of tilt-up construction can be planned and zoned in a flexible manner based on occupants' needs. Anderson argues that current housing is over-programmed and the use of space becomes inflexible (2009). The urban strip prototype based on the classical terrace affords an easy way to provide affordability and flexibility.

RECOMMENDATIONS

Encouraging neighbourhoods and local governments to embrace innovative architectural and urban design solutions to address infill futures is a critical ingredient for positive community outcomes that address residential density, preserve neighbourhood character and foster vibrant residential communities. The three key constitutive elements of good infill outcomes are a combination of response to context, regulatory innovation and good spatial programming. The following recommendations are based on the review of built and unbuilt exemplary projects undertaken in Perth over the last decade:

- **Contextual responses.** As seen in the exemplars, quality infill is heavily dependent on the local urban context. Greater Perth offers a wide variety of diverse contexts ranging from tiny, single-family infills (Tube House), through to work–live (Glick House) arrangements and medium-scale, mixed-use developments (Foundation Housing). Therefore it is recommended that street, precinct and neighbourhood-level urban contextual analysis be incorporated to develop local, differentiated infill norms fit for street-level contexts. This can be achieved in consultation with local government, industry stakeholders and local university researchers and students.

- **Regulatory innovation.** Quality infill is determined by the regulatory envelopes and their interpretation. The R-Codes framework, which is used to control the form and volume of residential development, imposes a strict and restrictive view on design innovation. As shown in the exemplars,

challenging height (Foundation Housing) and setback restrictions (Courtyard prototypes) can result in appropriate local optimisation, better street frontages, active edges and increased density. Therefore it is recommended that experimental built prototypes that challenge regulatory frameworks be commissioned within existing and new infill projects. This would permit housing authorities and the community to make informed choices on the regulatory frameworks and their interpretation.

- **Spatial programming.** One of the hallmarks of good design is innovation in spatial programming. Residential housing in general, and infill sites in particular, can be the beneficiaries of such an approach. As demonstrated in the exemplar projects, spatial programming can range from innovative arrangements of living spaces (Two Houses) and volumetric composition (Glick House, Urban Prototype), to mixed-use propositions in inner-city contexts (Foundation Housing). It is recommended that spatial programming be incorporated as a driver of housing procurement to enable the creation of better inside–outside relationships and coherent internal and external spaces within infill sites and the street.

CONCLUSION

Infill strategies and urban consolidation for compact cities are a strategic imperative for the future of residential housing in Greater Perth. As can be seen from the eight projects presented, exemplary infill design projects in Perth over the last decade cover a broad range of housing typologies. Combined with best practices developed elsewhere in Australia (Murcutt 2008; Neustupny et al. 2008), innovative architectural design can lead to good infill outcomes. The three key aspects identified for innovative development of infill programs – local context, flexible regulatory controls and volumetric spatial planning – are all design dependent. Therefore the barriers to good design need to be addressed at local, community and government levels.

Currently, the compressed and speculative nature of most infill developments mitigate the widespread adoption of innovative, design-led approaches.

Therefore one critical element is the need to address upfront costs associated with good design. By providing leading design practices and enlightened clients with the research and development tools necessary to create successful infill, housing and planning authorities can enhance the appeal of these typologies.

Our challenge for innovative infill futures is to develop policies and processes that ensure design innovations discussed in this chapter find their way into the provision of infill housing for the mass housing market. To provide sustainable growth within the existing Greater Perth region through a sustainable infill strategy, the following barriers will need to be addressed:

- Planning schemes based on compliance with traditional residential codes and zoning overlays will need to incorporate flexible and adaptive methods of decision-making. Particular attention needs to be paid to minimum space sizes, horizontal separation between private spaces and visual/audio privacy.

- Publishing conceptual projects with built-in design controls can help promote good infill outcomes, as shown by the unbuilt experimental projects. One innovative solution would be to develop and disseminate a digitally interactive pattern book of architecturally designed examples that already meet the requirements of planning and development controls (Murcutt 2008).

- The use of visualisation, social media and information technology can bridge the gap between good design and successful infill outcomes. Interactive software to provide design advice on how selected plans would sit on blocks would provide guidance to the community about the impact of their choices.

Increasing community appetite for medium-density architecture requires creating or enhancing a sense of place, developing a place of value, and forming a durable and environmentally sustainable development. The dissemination of good design is also an important public activity to ensure evidence-based design outcomes are accessible to all stakeholders, to raise awareness of the challenges involved in infill development and the best ways to solve them.

REFERENCES

Alfirević, D & Simonović-Alfirević, S 2015, 'Infill architecture: design approaches for in-between buildings and "bond" as integrative element'. *Arhitektura i urbanizam*, 41, 24-39.

Anderson, S 2008, 'Factories for living in'. In G London & S Anderson (Eds) *TAKE 7, Housing Australia: how architects can make a difference* (pp. 14-23). Manuka, ACT: Australian Institute of Architects.

Anderson, S 2009, 'Hype housing'. In R Weller (Ed) *Boom town 2050: scenarios for a rapidly growing city* (pp. 403-418). Perth, WA: UWA Publishing.

Fincher, R & Gooder, H 2007, 'At home with diversity in medium-density housing'. *Housing, Theory and Society*, 24(3), 166-182.

Forster, C 2006, 'The challenge of change: Australian cities and urban planning in the new millennium'. *Geographical Research*, 44(2), 173-182.

Hall, P 1999, 'How cities can be expected to change'. *Australian Planner*, 36(2), 66-71.

London, G 2008, 'The courtyard house'. In G London & S Anderson (Eds) *TAKE 7, Housing Australia: how architects can make a difference* (pp. 66-75). Manuka, ACT: Australian Institute of Architects.

London, G & Anderson, S (Eds) 2008, TAKE 7, *Housing Australia: how architects can make a difference*. Manuka, ACT: Australian Institute of Architects.

Magri, S 1994, 'Urban density definitions'. *Urban Futures*, 4(2/3), 49-53.

Murcutt, N 2008, 'On density and street activation'. In G London & S Anderson (Eds) *TAKE 7, Housing Australia: how architects can make a difference* (pp. 100-109). Manuka, ACT: Australian Institute of Architects.

Neustupny, M, Mclean, L, Bertram, N & Murray B 2008, 'Small groups'. In G London & S Anderson (Eds) *TAKE 7, Housing Australia: how architects can make a difference* (pp. 110-119). Manuka, ACT: Australian Institute of Architects.

Randolph, B 2004, 'The changing Australian city: new patterns, new policies and new research needs'. *Urban Policy and Research*, 22, 481-493.

Roberts, BH 2007, 'Changes in urban density: its implications on the sustainable development of Australian cities'. In *Proceedings of State of Australian Cities Conference*, 28-30.

Sajan, J 2015, 'Design implications for multi-owned properties from a household survey'. *International Journal of Housing Markets and Analysis*, 8 (4). 502-518.

Seeber, B 2008, 'Climatic orientation and construction technology – residential building form'. In G London & S Anderson (Eds) *TAKE 7, Housing Australia: how architects can make a difference* (pp. 130-173). Manuka, ACT: Australian Institute of Architects.

WAPC – see Western Australian Planning Commission.

Western Australian Planning Commission 2015, R-Codes. Explanatory guidelines (1.5) of *State planning policy 3.1: residential design codes*. Department of Planning. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/State_Planning_Policy_3.1-Residential_Design_Codes_.pdf.

7

INFRASTRUCTURE FOR INFILL DEVELOPMENT

Giles Thomson
Peter Newman*

*Corresponding author: Peter Newman, Curtin University Sustainability Policy Institute, Curtin University, GPO Box U1987, Perth WA 6845. Email: p.newman@curtin.edu.au Tel: +61 8 9266 9032

INTRODUCTION

Infrastructure, especially transport infrastructure, is fundamental to how a city is built. In economic literature there is often a belief that infrastructure can be assessed without looking at its impact on the city. However, the two are inextricably linked (Newman & Kenworthy 2015). Hence, if a city like Perth is looking to increase its proportion of urban infill, then the kind of infrastructure it chooses will strongly influence this outcome. For instance, if a city builds more fast-road capacity, then urban sprawl will result. If a city builds urban rail into areas where urban regeneration is desired, then it will facilitate urban infill.

This chapter considers infrastructure for infill at two scales – firstly, the strategic city planning scale, and secondly, the local geographic units of plot, block and precinct, which represent the typical scales of infill delivery. The most evident output of infill development is the built form, but a significant and highly influential component of infill, particularly in terms of performance, is the underlying infrastructure.

The chapter discusses the different urban qualities and costs resulting from different types of infrastructure, and the benefits to infrastructure quality that result from comprehensive planning instead of piecemeal delivery. The chapter concludes by discussing implications for the town planning system, and a new integrated process to catalyse infill development using infrastructure investment such as the new City Deal process.

GREENFIELD VERSUS INFILL DEVELOPMENT: A COST COMPARISON

Table 7.1 compares the costs of greenfield development (outer) with the costs of infill (inner). The cost estimates are based on a detailed Western Australian assessment by Trubka et al. (2008).

Table 7.1 Estimated development costs for 1000 dwellings, 2008

	Inner	Outer
Infrastructure		
Roads	$5,086,562	$30,378,881
Water and sewerage	$14,747,616	$22,377,459
Telecommunications	$2,576,106	$3,711,851
Electricity	$4,082,117	$9,696,505
Gas	-	$3,690,843
Fire and ambulance	-	$302,509
Police	-	$388,416
Education	$3,895,458	$33,147,274
Health (Hospitals, etc.)	$20,114,867	$32,347,327
Transport		
Transport and travel time	$206,542,055	$342,598,098
Roads and parking	$46,937,535	$154,826,095
Externalities	$2,219,884	$9,705,379
Greenhouse gas	$17,388,226	$36,703,251
Health (from activity)		
Direct		$1,933,088
Indirect		$2,296,863
Total	$323,590,426	$684,103,839

Source: Trubka et al. (2008)

This assessment found that the economic cost to society of infill development was almost half that of greenfield development on the city fringes. A large proportion of this cost was related to infrastructure. Development in the inner-

city areas resulted in higher density, so more users were accessing existing infrastructure and services, reducing per capita costs. Similarly, higher density infill requires shorter travel distances and hence times between destinations, with subsequent economic value. Secondary impacts on health and greenhouse gases were also significantly in favour of infill.

Infill has economic benefits, but certain areas are more suitable for infill than other areas, especially those areas where urban rail exists or is planned. The theory outlined below helps us to see where it can best be done.

URBAN FABRIC AND INFILL

Characterising three urban fabrics

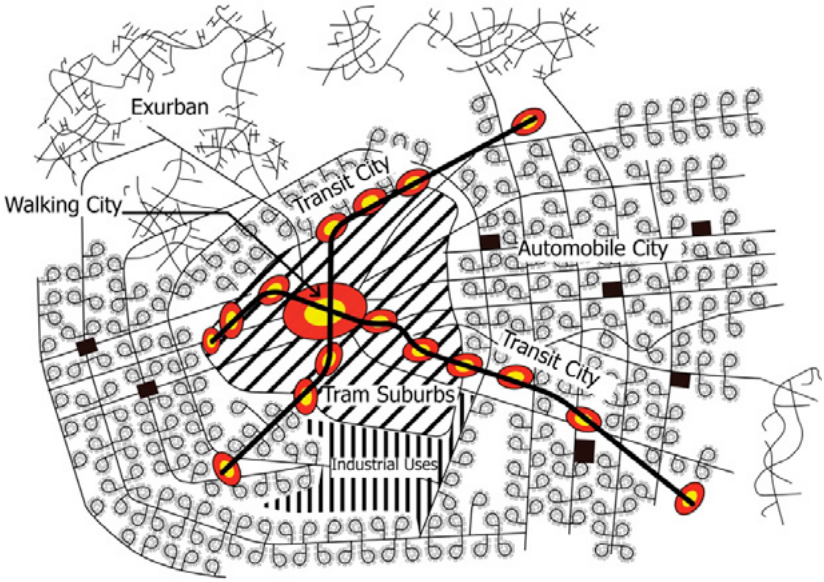
The theory of urban fabrics was developed by Newman, Kosonen and Kenworthy (2016) to help planners see that there are three main city types, not one (automobile fabric) as has been suggested by modernist city planners since the 1940s. The theory enables planners to create strategies for managing the different fabrics to highlight how some urban fabrics have inherently more sustainable properties that need to be optimised and extended to other parts of the city through infill strategies. Urban fabric is shorthand for describing the urban environment that results from the different types of underlying infrastructure within a city. Urban fabric includes transport infrastructure, such as road or rail technology, setbacks and road widths, which in turn shapes the form of the more localised infrastructure of buildings, open space and utilities.

There are three city types from history that form the basis of urban fabric theory: walking cities, transit cities and automobile cities. Most cities today have a mixture of all three urban fabrics (see Figure 7.1).

Walking cities

These are the oldest typology, as walking, or at best, animal-powered transportation, was the only form of transport available to enable people to move across cities. Walking cities are characterised by dense, mixed-use areas of generally more than 100 persons per hectare. This fabric dominated

Figure 7.1 Automobile city, transit city and walking city: a mixture of three city types



Source: Newman and Kenworthy (2015)

until the 1850s. Many modern cities, including Australia's colonial capitals, are built around a nucleus of an older walking city, but they struggle to retain the walking urban fabric due to the competing automobile city fabric which now overlaps it (Matan & Newman 2016; Newman & Kenworthy 2015). Reacting to this competition, many modern cities are now attempting to reclaim the fine-grained street patterns associated with walkability (Gehl 1987) but often don't have the tools to do so, as modernist planning manuals rarely focus on pedestrian needs. However, this is slowly changing; for example, the new National Association of City Transportation Officials (NACTO) (2016) manuals and the work of Jan Gehl emphasise the importance of human-centred urban design (Matan & Newman 2016; Gehl 2010).

Transit cities

Between 1850 and 1950, trains, followed by trams from the 1890s, extended the old walking city. Trams and trains supported corridor development with typical densities between 35 and 100 persons per hectare, yet higher density walking fabric still remained around transit stops. The increased speed of the transit urban fabric allowed development to extend 20 km or more from the centre. Transit city fabric has had a considerable revival in recent decades and is the preferred location – along with walking city fabric – for knowledge economy jobs such as education, hospitals and health professionals, and consulting services, with the highly spatially confined jobs associated with financial services, government and high-end services keeping to the old walking cities (Newman & Kenworthy 2015).

Automobile cities

From the 1950s onward, cities are no longer constrained to fixed corridors. Population densities fall to less than 35 persons per hectare because the flexibility and speed (average 50-80 km/h on uncongested roads) allow automobile cities to spread well beyond a 20 km radius. Perth, for example, is larger than many more populous cities, spreading around 80 km from north to south, and growing.

The term 'automobile dependence' was developed in the 1980s to express how cities were increasingly being built around the car (Newman & Kenworthy 1989). A fundamental problem with 20th-century town planning has been the belief that there is only one type of city: the automobile city. Low urban intensity reduces the potential for cost-effective transit and as a result, sprawling suburbs become the basis of automobile dependence (Newman & Kenworthy 1989). Car dependence is also created by drivers using their cars always because they are a sunk cost.

As Perth and other major Australian cities continue to grow, there is a need to recognise that there are real issues associated with the dominance of automobile urban fabric, especially where it extinguishes the best features of walking and transit fabric (Newman, Kosonen & Kenworthy 2016). The automobile city is the most resource-consumptive type of urban fabric, and it has economic and social outcomes that are significantly worse than other city types (Glaeser 2011), as set out below in a case study on Perth.

In recent decades, most cities have begun to slow down in their traffic, hence there is greater commitment to transit-oriented development that can provide a better option for more people. Globally, and increasingly in Australia, a resurgence in the walking and transit urban fabrics has begun to reduce automobile dependence as a city planning paradigm. This is why Perth and most other cities are looking for a greater proportion of urban infill (Newman & Kenworthy 2015).

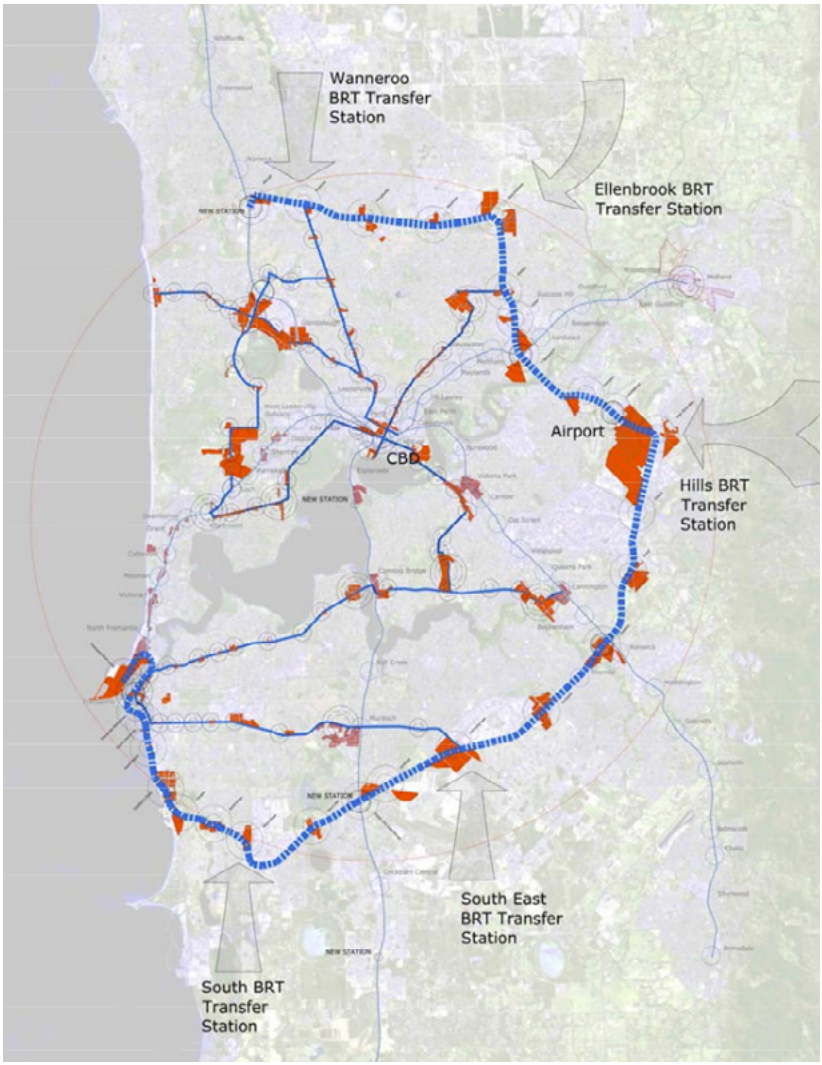
Directions 2031 identifies the location for additional transit fabric (usually called TODs) to be delivered in the Greater Perth region over the next 20 years (Western Australian Planning Commission (WAPC) 2010). A discussion paper by Hendrigan and Newman (2013) investigating the potential TOD capacity for Perth identified that future regeneration areas, if developed as high-density, mixed-use centres, could absorb the next 30 years of projected growth (see Figure 7.2). The paper suggests that such a scenario could save around $3.9 billion on infrastructure costs no longer required to service urban fringe land release. While costs of $24 million to $28 million per kilometre (light/heavy rail respectively) would require almost $4.4 billion to finance, much could be recouped through 'value capture' (discussed further below).

URBAN FABRIC AND RESOURCES

There is a significant set of differences between the three kinds of urban fabrics in terms of land consumption, resource use and urban qualities that can form the basis of statutory and strategic town planning. The differences are stark when considering the need to decarbonise development due to climate change policy and reducing waste due to economic and environmental efficiencies (Newman et al. 2017).

Many city studies tend to aggregate data and the resulting analysis is crude because it hides the bumps and troughs that differentiate performance between the various neighbourhoods. However, a 2013 study for the WA Government reveals the material flow (or urban metabolism) variations across three urban fabrics in Perth.

Figure 7.2 A possible future Perth scenario of highly connected rail and urban development



Source: Hendrigan and Newman (2013)

Perth urban fabric case study

The Perth case study compares three urban fabrics in Table 7.2 and Table 7.3[16] (Gardner & Newman 2013). These data show the variations in energy, water, land, food and basic raw materials (BRM) in three parts of the city and the wastes produced from these material flows. The study looks at the normal quantities of material that went into construction in three parts of the city: central/inner (e.g. City of Perth and East Perth), which is very similar to the old walking city; middle suburbs, which are similar to the transit city (e.g. Nollamara and Hilton); and outer/fringe suburbs (e.g. Alkimos), which are the automobile city.

Two major observations stand out. Firstly, the area of land required to accommodate the same population is more than four times greater in automobile fabric than in walking urban fabric. The other significant but less obvious difference relates to the volumes of BRM embedded in the infrastructure of the types of urban fabrics.

16 For full explanation of assumptions used, refer to the original report: Gardner, H & Newman, P 2013. *Reducing the materials and resource intensity of the built form in the Perth and Peel regions*. Perth, WA: WA Government, Department of Sustainability, Environment, Water, Population and Communities.

Table 7.2 Resource input variations between urban form types

Input (per person per year)	Automobile city	Transit city	Walking city
Resources			
Fuel in megajoules (MJ)	50,000	35,000	20,000
Power in megajoules (MJ)	9,240	9,240	9,240
Gas in megajoules (MJ)	4,900	2,940	2,940
Total energy in gigajoules (GJ)	64.14	47.18	32.18
Water in kilolitres (KL)	70	42	35
Food in kilograms (kg)	451	451	451
Land in metres square (m^2)	547	214	133
Urban footprint in hectares (ha)	2.29	1.97	1.78
Basic Raw Materials (BRM) for new building types per person			
BRM 1) Sand in tonnes (T)	111	73	57
BRM 2) Limestone in tonnes (T)	67	44	34
BRM 3) Clay in tonnes (T)	44	29	23
BRM 4) Rock in tonnes (T)	66	43	33
Total BRM in tonnes (T)	288	189	147

Source: Gardner and Newman (2013)

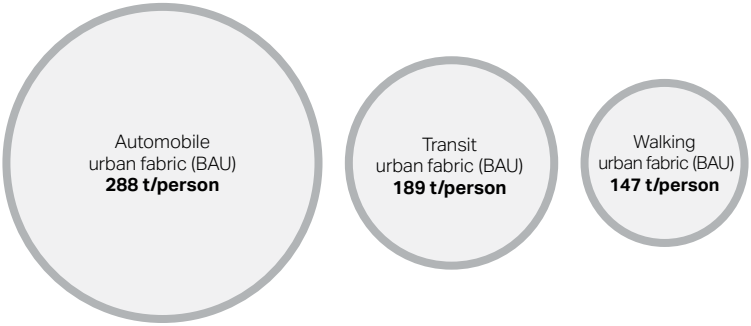
Table 7.3 Resources and waste variations between urban form types

Output (per person per year)	Automobile city	Transit city	Walking city
Waste			
Greenhouse gas (fuel, power and gas) in tonnes (T)	8.01	5.89	4.03
Waste heat in gigajoules (GJ)	64.14	47.18	32.18
Sewage (incl. stormwater) in kilolitres (KL)	80	80	80
Construction and demolition (C&D) waste in tonnes (T)	0.96	0.57	0.38
Household waste in tonnes (T)	0.63	0.56	0.49

Source: Gardner and Newman (2013)

BRM includes the sand, clay and stone that form the foundation for building construction. They literally are built into the underlying infrastructure (urban fabric) of a city. The variations in BRM are illustrated in Figure 7.3, where the areas of the circles represent the proportional volume of basic raw materials required, measured in tonnes per person.

Figure 7.3 Perth's basic raw material demand in terms of three urban fabrics



Adapted from: Gardner and Newman (2013)

The full study also shows how technology and construction innovations such as manufactured buildings can drive material and cost savings further. Scenarios for high-density infill with technology and construction innovation indicate per capita BRM reductions to 15 tonnes per person, almost 20 times less than conventional automobile fabric (for a detailed discussion of the benefits of technology and construction innovation, see Chapter 5).

Examples of the additional materials embedded in low-density automobile fabric include double garages, land fill for 'benching' (i.e. terracing with retaining walls), on-plot driveways and additional lengths of infrastructure (e.g. roads or pipes) to service fewer dwellings for the same length. For example, 10 times the road length is required to service dwellings at 10 persons per hectare (a common density for automobile fabrics) versus 100

persons per hectare (a common density for walking fabric). This offers some insight into why the per capita costs for infrastructure are considerably higher in automobile urban fabric.

For a city to substantially reduce its material volumes and costs, ideally it will be designed, or redesigned, as transit or walking fabric rather than automobile fabric. In Australian cities with more than half a century of automobile-oriented planning, this will be challenging, but there are signs that a shift has begun, albeit slowly. Certainly, the intent behind the major metropolitan strategic planning documents of each state is that high infill targets provide a structural incentive for this shift. Infill targets are based on the premise that development within the city's existing growth boundary is more desirable than greenfield development, which perpetuates sprawl and stretches cities to unsustainable levels, thereby increasing BRM demand, water and transport-related fuel consumption (Newman & Kenworthy 2011).

Given the multiple advantages to a city of more compact walking and transit fabrics, how then do we begin to transform Australian cities? How do planners incorporate the theory of urban fabrics into town planning practice to manage the rapidly changing set of factors outlined above, and where the 20th century modernist certainties about automobile urban fabric are now losing their appeal? The secret seems to be in how the planning is done and in how the infrastructure is funded and financed.

LOCAL INFRASTRUCTURE AND INFILL

Perth's recent strategic plans, *Directions 2031* (WAPC 2010) and the draft *Perth and Peel @3.5 million* (WAPC 2015) echo the planning approach of other capital cities by promoting a better balance between greenfield and infill development. In Perth, widespread rezoning has promoted infill, with approximately 26,300 dwellings demolished in Greater Perth between 2001/02 and 2011/12; unsurprisingly, the vast majority (76.1 per cent) of total demolitions were within the central sub-region, but this redevelopment has brought about only marginal intensification, averaging only 1.8 residential lots

for every dwelling demolished during that period (WAPC 2015). The net result has been an intensification of automobile fabric in these areas through the ad hoc market-driven 'knock down rebuild' model (Newton & Thomson 2016).

The obvious market for redevelopment using denser kinds of urban typologies like apartment complexes typically only occurs on (increasingly rare) larger sites in single ownership. Such developments in Perth are much less common in inner and middle suburbs due to developers focusing on one block at a time and a lack of planning tools or mechanisms to assist larger land assembly. The challenge remains to develop new mechanisms to do this in a comprehensive and publicly acceptable manner (Thomson et al. 2016).

How this might be achieved was the focus of a major study by the Australian Housing and Urban Research Institute (AHURI). The study brought together 70 leading built environment thinkers over a 12-month period to explore how infill redevelopment could be undertaken more effectively on a precinct basis to meet a range of strategic metropolitan planning objectives (Newton et al. 2011). The study revealed that greyfield areas (ageing, low-density suburbs) need a residential precinct regeneration approach, but a number of barriers need to be overcome for successful implementation. Much of the innovation needed was found to be organisational and institutional, supported by some technological innovations (see Newton et al. 2011). For example, this might include planning agencies finding sites suitable for land assembly and master planning precincts prior to offering infill locations to the market, and creating area improvement zones where developers could bid on how best to redevelop.

COMPREHENSIVE VERSUS PIECEMEAL INFILL

While infill can be well designed, it is not always the case. Automobile-oriented, battleaxe subdivisions can lead to suboptimal outcomes as a result of tree removal and more car-dependent housing, which fail to improve any infrastructure or amenity and only increases traffic. Fortunately, such development proposals are increasingly rejected by most local councils. Instead, planning at the neighbourhood or precinct scale is increasingly favoured, as it provides opportunities for the optimisation of urban fabric and incorporation of supportive district-scale infrastructure and community services. Examples in Perth are the WGV development and the Carine Rise development, both of which are LandCorp developments in the middle suburbs. These began as controversial developments due to their density (not more than three or four storeys), but have become highly sought after infill developments providing housing for those who want to downsize in their district. However, they are still based on a single-owned, large block rather than being assembled from multiple owners as suggested above, and so are not yet the models needed for mainstreaming infill.

An integrated, comprehensive approach to infill offers greater opportunities for optimisation of the urban fabric and its supporting systems (Newton et al. 2012; Newman 1999; Bunning et al. 2013; GIZ & ICLEI 2014). This type of approach is beginning to be seen in Sydney, adjacent to railway stations; for example, the precinct planning at St Leonards, Green Square and Crows Nest.

The comprehensive planning of 'traditional neighbourhood developments' gained popularity with New Urbanism from the late 1980s, although its origins predate the automobile era (Carmona et al. 2012). New urbanism advocates for the structural organisation of a neighbourhood unit within a short walk (typically a notional 5 to 10-minute walk or 'ped-shed'), centred on a transit node (e.g. rail station) and incorporating commercial services (Talen 2013). More urban (i.e. dense, mixed-use) infill is well documented as being an important contributing factor to increasing economic vitality, community stability and environmental health. The literature also shows that the increased densities of walking and transit fabrics offer strong liveability functions such as vitality and

economic agglomeration benefits that attract the creative classes, who in turn foster entrepreneurial activity (Glaeser 2011; Gehl 2010; Landry 2012). Such developments can also include social housing opportunities (Newman et al. 2017).

New urbanist principles for the (re)urbanisation of low-density development have been created to maximise the social and environmental benefits that higher density affords the community (Tachieva 2010; Calthorpe 2010; Sanderson 2013). However, these are hard to achieve without the associated transit infrastructure to enable it. In Perth, exemplars such as Claisebrook Cove in East Perth (see Figure 7.4), Subi Centro in Subiaco and, more recently, Cockburn Central demonstrate these neighbourhood-based approaches to infill that prioritise walkable infrastructure and its transformative capacity to revitalise the area, and are anchored by quality rail transit. This comprehensive approach to neighbourhood-scale redesign delivers better outcomes than ad hoc planning-based approaches to infill densification, which invariably are car dependent.

Figure 7.4 Claisebrook Cove redevelopment, East Perth

Photo: © Giles Thomson

The late Sir Peter Hall, the UK Professor of Urbanism, noted in his last book *Good cities, better lives* that the best European case studies "enjoyed heavy investment in infrastructure, including streets and sewers and services, in advance of housing construction" (Hall 2013, p. 299). Hall goes on to say, "without doubt" the single most important element behind the best of European urbanism is:

> … strong city planning departments (or city agencies) with real planning powers and a willingness to take a positive lead, particularly in developing overall master plans as a framework for development or regeneration of specific areas … [I]n every successful case, the public agency took the lead: it drew up a master plan, usually in considerable detail as to layout of streets and buildings and open space. (Hall 2013, p. 305)

Hall explains that this is vital to ensure the city is aware of the commercial viability of the planning scheme to be able to recoup large amounts of money invested in the basic infrastructure of transport, water, sewerage and flood control that must precede the development. This is another reason why densities are increasingly important as the means for developments to become viable. If density is just seen as aesthetic (often this is the only issue in public debates about infill), then it can lead to development being driven away and the area rapidly declining for the remaining residents.

This comprehensive approach with the coordination of buildings, public realm and infrastructure through a master-planned approach sits behind the success of Subi Centro and Claisebrook Cove (through the leadership of the MRA and through its precursor organisations, the East Perth Redevelopment Authority and Subiaco Redevelopment Authority) and Cockburn Central (through the leadership of LandCorp and the City of Cockburn). However, the approach does depend on large government capital being available as in the Better Cities Program. Another approach is outlined below that tries to achieve the same outcomes but involves far more private investment, from major investors, such as superannuation companies.

HOW TO BUILD MORE WALKING AND TRANSIT FABRIC – VALUE CREATION THROUGH THE ENTREPRENEUR RAIL MODEL

Most of the comprehensive and integrated plans for infill that are being planned in cities around the world need urban rail to enable them to create the dense, mixed-use urban form around stations. Rail infrastructure is expensive, and developing a comprehensive transit network in Perth will require substantial investment. There is a range of new options for funding and delivering public transport infrastructure, with differing degrees of private sector involvement:

- full public sector capital
- some private and substantial public capital
- substantial private and some public capital
- totally private capital.

In WA, and indeed in all Australian cities, transport infrastructure has been delivered under the first model – full public sector capital. However, policymakers are now considering how to find different funding forms that incorporate private capital, as most governments can no longer provide the capital being demanded through the political process, and thus infill development has been hampered as it does not have the anchor infrastructure that enables it. The various types of investment are evaluated below, not just for how and where they work, but also what they can do to enable infill.

Full public sector capital

Where transport infrastructure is delivered wholly by public sector funding, the process is dominated by transport planners and little consideration is given to their infill outcomes. The public sector performs all network and regional planning, and oversees the detailed design and engineering work, which is performed by private sector engineers. There is a range of potential mechanisms for raising government revenue from the increase in land values created by public transport infrastructure, collectively known as 'value capture', but these mechanisms are so far not used in Australia. Where infill occurs after the infrastructure is built, there are windfall profits made by the landholders near

station precincts once the land values increase, as they invariably do after rail projects happen (McIntosh et al. 2014).

Some private and substantial public capital

Private funding can be sourced to contribute to a major urban rail project because of the urban development opportunities created near stations. A successful example of this approach is London's Crossrail, an underground, heavy-rail project connecting major employment centres. The project had substantial contributions from developers and a 'business rate supplement' (BRS), an increment on the municipal rates paid by London businesses that were the beneficiaries of the infrastructure.

Of the £14.8 billion funding for Crossrail, £4.1 billion will be sourced from London businesses through various mechanisms, including the BRS. Financial contributions were also made from some of the key land development beneficiaries from the project.

Substantial private and some public capital

Substantial private capital can be supplemented by some government capital. Expected rises in property tax revenue could be hypothecated to cover part of the public contribution, such as through tax increment financing. This approach would ensure that the rail project is still generating all the capital required, though some is from public sources at the three levels of government.

The Tokyo rail network is mostly privately funded and operated by a range of companies, including privatised former public rail companies. Ticketing revenue is often supplemented by the profits of station-area land development and leasing integrated retail premises. In recent years, rising construction costs and a lack of low-cost farming land to develop has eroded profits for the Tokyo rail companies, and their finances have been bolstered by government grants and low-interest loans, guaranteed by the Development Bank of Japan, an effective subsidy.

Japan has one of the more highly integrated and successful rail systems in the world. That they use land development to help build their rail indicates there is a major potential mechanism for how to do infill better in Australian cities.

Totally private capital

Wholly privately funded rail can be achieved with integrated property development. The government's role would be kept to in-kind activity to ensure land assembly and land acquisition, zoning and other transport planning integration are fully covered. It would mean that the project could be 'off balance sheet', and hence would help with state government credit ratings. This has been called the Entrepreneur Rail Model by Newman et al. (2016). There is still substantial scope to influence the layout of the network through land assembly.

However, the main value in this approach is to achieve public value from additional urban rail funded by the value derived from creating new activity centres around the rail stations. Thus it achieves simultaneously new urban rail and new urban infill to realise targets set by the state government. It does this because the integrating force is not so much bureaucratic integration of transport and planning (which has substantially failed in Australian cities), but the financing process, which ensures that both occur together. The same mechanism can be used in redevelopment around present rail systems, where much opportunity still exists (Hendrigan & Newman 2013).

The Hong Kong Mass Transit Rail Corporation (MTRC), while still majority-owned by the Hong Kong Government, operates on commercial principles as if it were a fully private enterprise. Land is leased to the MTRC at pre-rail prices, and TODs around the stations provide substantial returns to the MTRC, as well as boost patronage through better land-use integration.

In the USA, Brightline, a new rail line in Florida, is linking Miami, Fort Lauderdale, West Palm Beach and Orlando; it is built entirely from land development opportunities and is financed by a New York hedge fund. The company involved believes that when the model has been demonstrated it could do it in another 100 cities.

There is now a market for urban rail because traffic is slowing due to congestion, and the cost of rail is much cheaper and more effective at carrying people quickly down corridors (Newman & Kenworthy 2015). The market is also there for urban centres and infill that attract knowledge economy jobs and enable sprawl to be minimised.

Thus the role of government may be to enable this market to build the infrastructure and enable more walking and transit urban fabric. It must also ensure that such fabric includes social housing to ensure there are equitable outcomes from such an infill strategy. Such a strategy is what lies behind the Australian Government's new City Deals, which set up integrated redevelopment using private investment to fill out public investment, and uses community engagement to ensure sustainability goals are met (Australian Government 2017). In Perth, the City Deal is likely to provide 10 to 15 new Metrohubs associated with heavy rail and new light rail, with the potential to transform the opportunities for attractive and sustainable infill.

The City Deals initiative, indeed most urban planning documentation in Perth and elsewhere, is trying to achieve a range of other outcomes that will help to meet national goals such as the Paris Agreement on climate change and the Sustainable Development Goals (SDGs) (Newman et al. 2017). This chapter will thus conclude by outlining three major strategies that are developing to help deliver new infrastructure associated with major infill sites like power and water, which help with both carbon and SDG outcomes.

STRATEGY 1: DISTRIBUTED INFRASTRUCTURE

Distributed systems are particularly useful for the provision of power and water infrastructure for infill. The characteristics of the ideal distributed system are:

- **localised** – positioned close to resource supply and demand
- **modular** – the capacity to operate independently and combine with other networks
- **open** – ownership of the system is (more) democratic, is transparent and may involve or encourage local stakeholders to have a greater understanding and role in the supply chain (Biggs et al. 2010).

Consider the uptake of rooftop solar photovoltaics (PV). This is an ideal distributed system. It is localised, supplying rooftop PV electricity to supply the energy demand of the residence below; it is modular, capable of supplying the home independently but may be networked to feed into a local micro-grid or regional electricity grid; and it is open, in that households or communities generally own the infrastructure.

The uptake of distributed rooftop solar has been so popular in Perth that small-scale solar is growing by 10 to 20 per cent, per year. It is now installed on 28 per cent of all homes in WA and this could increase to 50 per cent by 2050. The electrical output is so great that rooftop solar is now the "biggest power station" in WA (Clover 2016).

An interesting observation in 2013 was that the majority of the uptake was in the low-density automobile fabric suburbs, in part led by generous feed-in tariffs that have since been removed yet PV growth continues (Newton & Newman 2013). This appears to be largely due to the ease and cost-effectiveness of owner-occupiers managing their own energy from PV on their roofs. The situation can become more complicated in higher density areas due to the split incentive – there is no motivation for landlords to invest in PV for rental apartments. It is also more complicated for strata units to manage PVs and the equitable fee structure for the use of the generated energy among residents in multi-storey apartments. However, research and policy changes around strata governance are helping unleash the potential for far greater market penetration of solar energy in higher density areas (Roberts et al. 2015; Green & Newman 2017). In July 2016 an infill development in Fremantle, known as WGV, became the first strata development in Australia to offer solar and battery storage (Jewell 2016). The Sustainable Housing for Artists and Creatives (SHAC) cooperative at WGV will be testing their solar PV system along with a shared electric vehicle that completes the opportunity to be zero carbon and to do it with social housing.

Water can also be provided by distributed, not centralised, infrastructure with highly efficient appliances, recycled grey water and rainwater tanks. Water sensitive urban design (WSUD) is a distributed infrastructure mechanism for reducing the impact of peak stormwater run-off events, to incorporate public

realm improvements and landscaping such that this 'green infrastructure' performs multiple eco-system services and helps make infill much more attractive to residents. Figure 7.5 illustrates an example of WSUD by the MRA and City of Perth as part of the City Link infill redevelopment. This WSUD intervention provides public seating, reduces peak flows, assists with local groundwater recharging, provides a medium for biodiverse planting and allows tree growth for shade and to mitigate 'urban heat island effects' – the warming impact of decreased canopy cover. Collectively, across many city streets, WSUD retrofits such as this represent a truly integrated infrastructure intervention. WSUD offsets the need for enlarging conventional stormwater pipes to accommodate increased run-off volumes, while providing multiple other benefits.

Figure 7.5 High-quality water sensitive urban design infrastructure in the City of Perth

Photo: © Giles Thomson

A similar approach to stormwater management can be achieved at the larger precinct scale. For example, Figure 7.6 shows how the original stormwater sump has been revegetated at the new WGV development in the City of Fremantle. Typically this infrastructure would be fenced off and inaccessible to the public; however, in this retrofit the infrastructure has been turned into an accessible landscape feature and biodiversity habitat adjacent to the SHAC development. The multifunctional approach to infrastructure is particularly important for infill developments like WGV to maximise the benefits of open space in areas where increased density reduces the overall area of open space.

Figure 7.6 Infrastructure as landscape – the soak at WGV

Photo: © Josh Byrnes and Associates

STRATEGY 2: DIFFERENT URBAN FABRICS LEND THEMSELVES TO DIFFERENT INFRASTRUCTURE FUNDING AND FINANCING

As outlined above, there are three primary transport infrastructure types that lead to three different urban fabrics. Associated with each is a different way of funding and financing them to recoup investment in infrastructure.

In the centre of the city (the walking city fabric), most major development projects are funded and financed by the private sector. Small-scale amenity improvements such as cycle paths and footpaths, some landscaping, even security systems can be provided by BIDs (Business Improvement Districts) which are self-taxed by the local area business community. In Perth, the city council generates enough from rates to make this unnecessary. The Perth parking levy enables the CAT bus system to operate and it has been highly successful in helping Perth's regeneration as a walkable, attractive city that has brought around 30,000 people back to live in it (Newman et al. 2017).

Biophilic urbanism is increasingly on the agenda for local amenity in urban redevelopments (Newman et al. 2017). Such amenity improvements are mostly found in high-density urban centres, where green roofs, green walls, green balconies and green canopies over roads can substantially improve the urban heat island effect and enable people in high-density dwellings and offices to have daily connection with nature. These are mostly provided by private developers as part of their building's market attraction, although the integration with public spaces needs public investment.

Infill projects in middle and outer suburbs are usually a mixture of private and public infrastructure. If they are associated with dense development around rail stations (transit fabric), then significant funding and financing can be obtained from private sources based on the Entrepreneur Rail Model outlined above. The recent strata solar and battery system at WGV builds a business case for bill repayments using blockchain technology. The resulting model, called 'citizen utilities', may have broader applications (Green & Newman 2017), and such an approach looks best for medium-density developments.

Infill projects away from such large land value uplift areas (in the automobile fabric) will require councils to apply direct developer contributions and perhaps increased rates as density increases the land tax base, or apply 'special area rates' to the beneficiaries.

Business cases will vary dependent on the infrastructure to be provided, but as a rule, the higher densities will make most distributed infrastructure models more viable. Finally, it is worth noting that many councils in low-density, car-dependent areas have only a low rate base to cover maintenance, not only of infrastructure, but also of large areas of public realm, with the resulting maintenance burden typically straining the council's financial ability to invest in other public-good infrastructure. This is also a driving force behind infill.

STRATEGY 3: INFRASTRUCTURE AND TOWN PLANNING IMPLICATIONS

Since World War Two, modernist urban planning is almost universally applied to Australian cities and creates predominantly an automobile city set of fabric areas and fabric qualities. However, this is now changing in Australia's largest cities, in line with the global trend to 'peak car' (a trend towards declining per capita car use) and a dramatic growth in transit and walking city fabric (Newman & Kenworthy 2015). The infill needed to fulfil this demand, however, requires different planning regulations from those being used in greenfield development.

An urban fabric-oriented set of planning regulations would help Australian cities more easily accommodate larger populations while improving liveability and sustainability associated with less automobile city fabric. However, this requires a move away from standard automobile fabric-oriented town planning statutory regulations on densities, car parking, mixed-use and other key regulations that end up producing automobile city fabric. At the same time, it requires new infrastructure plans that enable more walking city and transit city fabric. Generating town planning regulations that enable walking and transit infrastructure and their associated urban fabric is part of the way local and state planning authorities can encourage and not discourage infill.

CONCLUSION

As Australian cities continue to grow, the limitations of traditional low-density suburban development have become apparent. Greenfield sprawl on our city fringes typically provides increased costs of travel to inhabitants and increased CO_2 emissions associated with longer travel distances. In addition, the economics of development in the outer suburbs has been demonstrated to have high infrastructure and social costs, making greenfield sprawl less cost-effective as a public policy when compared to infill development.

The resulting planning strategy in cities like Perth has been to create more infill. However, blanket increases in infill across all developed suburbs does not recognise that there are significantly better outcomes in cost and performance if a more nuanced approach is adopted. The theory of urban fabrics shows us types of development and where they are best located to greatly improve liveability and sustainability. The Perth resource case study shows us how cities based on automobile infrastructure with low densities have far greater environmental impact, and an economic assessment shows that this also comes at greater financial cost. These economic costs are often hidden and absorbed by taxpayers through infrastructure provision, funded by all residents no matter where they live. Thus it is important to not enable infill that is automobile dependent as has been the case with much of the backyard infill approach adopted so far. Moreover, it is important to tailor infrastructure policy to enable the creation of more walking and transit city fabrics with much improved outcomes in liveability and sustainability.

The secret to doing better infill, and more of it, is twofold: it requires new planning approaches and new infrastructure funding and financing models.

The best planning outcomes are achieved where there are comprehensive approaches to planning at the neighbourhood scale that coordinate residential density, transport, energy, water and social infrastructure needs. Higher densities allow thresholds to be met for the provision of cost-effective transit and distributed infrastructure that can improve liveability. This requires land assembly to create whole precincts for redevelopment.

The best infrastructure to enable such precinct-scale redevelopment is urban rail, either heavy rail or light rail. Such infrastructure requires new funding and financing from the private sector linked into the infill development potential created by the rail stations. Thus infill is best done in such TODs. It needs to include private sector investment and community engagement to enable funding and financing of infrastructure, and to ensure the local area amenity is significantly improved. Such a model is at the base of the City Deals approach. This model is likely to create a substantial boost to infill regeneration with multiple economic, social and environmental values. It is hoped that it will enable a new model of partnership and the ability to fund and finance the anchor and associated infrastructure necessary to create better cities.

Most Australian cities are moving towards a polycentric model with multiple activity centres to distribute activity and take the pressure off the traditional CBD. However, polycentric infill will not happen unless the amenity and land value is unlocked by new planning approaches and the provision of new or upgraded urban rail services as the anchor infrastructure – along with associated energy, water and amenity infrastructures that can be provided using new distributed technologies and design systems. We seem poised in Perth, ready to try new approaches that will unlock this value in urban infill.

REFERENCES

Australian Government 2017, City Deals, Department of Prime Minister and Cabinet. Retrieved from https://cities.dpmc.gov.au/city-deals.

Biggs, C, Ryan, C & Wiseman, J 2010, *Distributed systems: a design model for sustainable and resilient infrastructure*. The University of Melbourne. Retrieved from http://veil.msd.unimelb.edu.au/__data/assets/pdf_file/0015/2324103/Resilient-Systems-Briefing-Paper.pdf.

Bunning, J, Beattie, C, Rauland, V & Newman, P 2013, 'Low-carbon sustainable precincts: an Australian perspective'. *Sustainability*, 5(6), 2305-2326.

Calthorpe, P 2010, *Urbanism in the age of climate change*. Washington, D.C.: Island Press.

Carmona, M, Tiesdell, S, Heath, T & Oc, T 2012, *Public places – urban spaces: the dimensions of urban design*. London, UK: Taylor & Francis.

Clover, I 2016, 'Western Australia's rooftop solar now state's "biggest power station"'. Reneweconomy website. Retrieved from http://reneweconomy.com.au/western-australias-rooftop-solar-now-states-biggest-power-station-27206/.

Gardner, H & Newman, P 2013, *Reducing the materials and resource intensity of the built form in the Perth and Peel regions*. Department of Sustainability, Environment, Water, Population and Communities. Retrieved from https://www.environment.gov.au/system/files/resources/012e6df0-dce8-4bb2-9861-dad1dfc0f779/files/built-form.pdf.

Gehl, J 1987, *Life between buildings: using public space*. Washington, D.C: Island Press.

Gehl, J 2010, *Cities for people*. Washington, D.C.: Island Press.

GIZ and ICLEI 2014, *Operationalizing the Urban NEXUS: towards resource efficient and integrated cities and metropolitan regions*. Retrieved from http://www.iclei.org/fileadmin/PUBLICATIONS/Papers/Urban_NEXUS_Publication_ICLEI-GIZ_2014_web.pdf.

Glaeser, E 2011, *Triumph of the city: how urban spaces make us human*. London, UK: Pan Macmillan.

Green, J & Newman, P 2017, 'Citizen utilities: the emerging power paradigm'. *Energy Policy*, (105), 283-293.

Hall, P 2013, *Good cities, better lives: how Europe discovered the lost art of urbanism*. New York, NY: Routledge.

Hendrigan, C & Newman, P 2013, *A three mode plan for Perth: connecting heavy rail, light rail and bus with urban development to achieve 21st century goals*. Curtin University. Retrieved from https://blogs.curtin.edu.au/sustainability-policy-institute/wp-content/uploads/sites/24/2013/01/A-Three-Mode-Plan-for-Perth_-Draft-for-Public-2013-revised.pdf.

Jewell, C 2016, 'Perth developer in strata solar and battery first'. The Fifth Estate. Retrieved from https://www.thefifthestate.com.au/innovation/residential-2/perth-developer-in-strata-solar-and-battery-first.

Landry, C 2012, *The creative city: a toolkit for urban innovators*. London, UK: Earthscan.

Matan, A & Newman, P 2016, *People cities: the life and legacy of Jan Gehl*. Washington, D.C.: Island Press.

McIntosh, J, Trubka, R & Newman, P 2014, 'Can value capture work in a car dependent city? Willingness to pay for transit access in Perth, Western Australia'. *Transportation Research Part A: Policy and Practice*, 67, 320-339.

Newman, P 1999, 'Sustainability and cities: extending the metabolism model'. *Landscape and Urban Planning*, 44(4), 219-226.

Newman, P, Beatley, T and Boyer, H 2017, *Resilient cities: overcoming fossil fuel dependence*. Washington, DC.: Island Press.

Newman, P, Jones, E & Davies-Slate, S 2016, 'Entrepreneur Rail Model: a discussion paper'. Curtin University. Retrieved from http://www.aph.gov.au/DocumentStore.ashx?id=1a39de67-0b67-40bb-b2b2-fc4348938bfb&subId=408950.

Newman, P & Kenworthy, J 1989, *Cities and automobile dependence: an international sourcebook*. Brookfield, VT: Gower Publishing.

Newman, P & Kenworthy, J 2011, 'Peak car use: understanding the demise of automobile dependence'. *World Transport Policy and Practice*, 17(2), 32-42.

Newman, P & Kenworthy, J 2015, *The end of automobile dependence: how cities are moving beyond car-based planning*. Washington, D.C.: Island Press.

Newman, P, Kosonen, L & Kenworthy, J 2016, 'Theory of urban fabrics: planning the walking, transit/public transport and automobile/motor car cities for reduced car dependency'. *Town Planning Reviews*, 87(4), 429-458.

Newton, P, Murray, S, Wakefield, R, Murphy, C, Khor, L & Morgan, T 2011, *Towards a new development model for housing regeneration in greyfield residential precincts*. (Report No. 171, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/__data/assets/pdf_file/0011/2018/AHURI_Final_Report_No171_Towards_a_new_development_model_for_housing_regeneration_in_greyfield_residential_precincts.pdf.

Newton, P, Murray, S, Wakefield, R, Murphy, C, Khor, L & Morgan, T 2012, *How do we regenerate middle suburban 'greyfield' areas?* (Issue 150, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/__data/assets/pdf_file/0015/3084/AHURI_RAP_Issue_150_How-do-we-regenerate-middle-suburban-greyfield-areas.pdf.

Newton, P & Newman, P 2013, 'The geography of solar photovoltaics (pv) and a new low carbon urban transition theory'. *Sustainability* 5(6), 2537-2556.

Newton, P & Thomson, G 2016, 'Urban regeneration in Australia'. In P Roberts, H Sykes & R Granger (Eds) *Urban regeneration*. London, UK: SAGE Publications.

Roberts, MB, Bruce, A & Macgill, I 2015, 'PV in Australian apartment buildings – opportunities and barriers'. In *Asia-Pacific Solar Research Conference*, Brisbane, Australia.

Sanderson, E 2013, *Terra Nova: the new world after oil, cars, and suburbs*. New York, NY: Abrams.

Tachieva, G 2010, *Sprawl repair manual*. Washington, D.C.: Island Press.

Talen, E 2013, *Charter of the new urbanism*, 2nd Edn. New York, NY: McGraw-Hill Education.

Thomson, G, Newton, P & Newman, P 2016, 'Urban regeneration and urban fabrics in Australian cities'. *Urban Regeneration and Renewal*, 10(2), 169-190.

Trubka, R, Newman, P & Bilsborough, D 2008, *Assessing the costs of alternative development paths in Australian cities*. Parsons Brinckeroff Australia. Retrieved from http://www.earthsharing.org.au/wp-content/uploads/Curtin_Sustainability_Paper_0209.pdf.

WAPC – see Western Australian Planning Commission.

Western Australian Planning Commission 2010, *Directions 2031 and beyond: metropolitan planning beyond the horizon*. Retrieved from http://www.planning.wa.gov.au/dop_pub_pdf/plan_directions2031_part1.pdf.

Western Australian Planning Commission 2015, *Perth and Peel@3.5 million*. Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/pp_summary.pdf.

8

SUSTAINABLE INFILL DEVELOPMENT

Giles Thomson*
Peter Newman

*Corresponding author: Giles Thomson, Faculty of Humanities, Curtin University, GPO Box U1987, Perth WA 6845. Email: giles.thomson@curtin.edu.au Tel: +61 413 501 346

INTRODUCTION

Sustainability has local implications, but the most pressing sustainability issues relate to global environmental issues. Human consumption patterns exceed planetary boundaries and are placing unsustainable stress upon the biosphere (Steffen et al. 2015; Rockström et al. 2009). In an attempt to rectify this imbalance, the recent Paris Agreement (COP21) and the SDGs represent major international efforts to develop unilateral policy directions to address sustainability in an equitable manner. However, the mechanisms to implement these goal-based agreements are yet to be determined.

The solution may lie in cities. This is because the majority of the world's population now live in cities; and cities are centres of power, both governance and financial, making cities the central force driving global change. If refocused to create sustainable outcomes, cities could become the driving force to regenerate the planet (Fink 2013; Girardet 2010; Newman & Jennings 2008; Thomson & Newman 2016). However, theoretical propositions such as this can only work if applied in practice. This means that thousands of decisions on the ground need to be aligned to a shared sustainability vision either through shared community values, or policy (e.g. Australian interpretations of the Paris Agreement or SDGs), or increasingly through the financial savings that sustainable living can offer.

The purpose of this chapter will be to discuss some of these issues in relation to infill decisions in Perth that, when aggregated, can go a long way to making a more sustainable, more liveable and more prosperous city. Infill opportunities, especially at the larger precinct scale, present an excellent opportunity for enhancing city sustainability, so this chapter considers a range of sustainability elements in light of a recent Perth case study – WGV. It concludes by outlining various steps that will accelerate the mainstreaming of sustainable urbanism in Australian cities.

SUSTAINABLE AND LIVEABLE CITIES

Australian cities are renowned for the high quality of life afforded to citizens. According to the OECD better life index, Australia ranks a close second after Norway for quality of life across 11 indicators (OECD 2016), while the *Economist* in 2017 ranked Melbourne the most liveable city in the world, with Adelaide 5th and Perth 7th (Economist Intelligence Unit 2017). However, research by Newton (2012) shows a clear correlation between higher city liveability to higher ecological footprint. Decoupling ecological footprint from the high consumption patterns currently associated with liveability will be one of the key challenges of the 21st century (Gómez-Baggethun & Barton 2012; Steffen et al. 2015; Swilling et al. 2013). However, the challenge is not so much related to what to do, but rather how to do it at scale. Numerous exemplars can be found to demonstrate sustainable urban development, but these are the exception not the rule.

Rapid urban growth in Australia is fuelled by high population growth, from both natural and immigration sources. To put this in context, Australia's population in the year to 31 December 2015 grew by 326,100 people consisting of:

- 148,900 people natural increase
- 177,100 people of net overseas migration (ABS 2015).

This annual growth equates to nearly the population of Canberra, with the majority of that growth concentrated in the four major cities of Melbourne, Sydney, Perth and Brisbane.

In attempting to absorb this rapid population growth, care must be taken to ensure Australian cities continue to perform at current levels. While quality of life indicators are universally high, there is some indication that performance is slipping. The Mercer Quality of Living Survey ranks Australian cities very highly but over time, between 2004 and 2011, observes a slight reduction in quality of living in the four most populous and fastest growing cities (Commonwealth of Australia 2012). Moreover, the survey notes this trend is likely to become more pronounced if population growth continues to outpace investment in lifestyle-enhancing infrastructure (e.g. public transport). Chapter 7 provides more discussion around what infrastructure is needed where and how it might be funded better.

Liveability includes the affordability of housing and of urban living. Australian cities have mostly created affordable housing on the urban fringe, but increasingly this is not affordable living as the costs of transport are so high from these far-flung suburbs (Rowley & Phibbs 2012).

The challenge for sustainable urban development is, therefore, twofold: firstly, there is the need to decouple liveability from high ecological footprint; and secondly, to do so while accommodating urban growth through the provision of infrastructure and development in a way that creates liveability and sustainability.

Key to achieving this will be the mass implementation of low-impact substitutes for delivering urban services (e.g. housing, transport, energy) that still offer high quality of life outcomes (Newman & Jennings 2008; Newman & Kenworthy 1999).

DENSITY, DESIGN AND INFILL

Urban density can improve the sustainability of our cities by preventing urban sprawl and creating opportunities for better transport options (Newman & Kenworthy 1999; Newman & Kenworthy 1989; Newman & Kenworthy 2015). However, the argument is more nuanced than this, as not all density is equal. Density is a metric, most commonly referring to urban population and, by extension, building concentration. Good density is a product of good design (Llewelyn-Davies 2000). Design variations will make a big difference to how attractive the options are for liveability and sustainability.

Density targets can also be applied to public realm outcomes such as green open space, canopy cover, WSUD interventions and solar panel penetration. While these are uncommon, they would deliver more sustainable infill outcomes. Critically, it is design quality that matters and how these disparate urban elements work together as an integrated whole (Fraker 2013). Dense urban infill should aim not only to be dense in buildings, but also dense in urban services, dense in canopy cover and green open spaces, and dense in other liveability enhancing urban elements.

When density is prescribed as a mandatory measure, as is standard with infill development, it is possible and quite common to get poorly performing urban outcomes (Newton, Newman et al. 2012). More useful is the application of performance criteria and form-based codes that can better incorporate design considerations.

SUSTAINABLE INFILL

Individual buildings can be designed to be highly autonomous structures with very efficient operating performance. However, larger sites present additional advantages over plot-scale infill. Planning at the precinct or neighbourhood scale allows greater scope to integrate sustainability-enabling infrastructure; for example, public transport, public open space, social amenities, water catchments, underground power, biodiversity corridors, social housing and/or aged housing. Various urban elements such as energy, water, waste, biodiversity and canopy cover, and how decisions around infill interact with these elements, have the potential to create more (or less) sustainable environments. Well-planned infill will better integrate these urban elements, and in so doing will deliver more sustainable outcomes that also better provide for residents, thus making these places more desirable to live in.

Case Study – WGV

To help explain the application of some of the concepts in a Western Australian context, this chapter links initiatives to one of the most recent and best known sustainable infill precincts in Perth, WGV (named for its location in the Fremantle suburb of White Gum Valley). WGV consists of more than 80 dwellings on a two-hectare site, three kilometres from Fremantle. It is the first Western Australian project to be awarded the One Planet Community[17] sustainability accreditation and the second only in Australia (after WestWyck Ecovillage in Melbourne). The development is currently under construction, offering a wide housing mix (including villas, townhouses and apartments), and is around three times as

17 For more on One Planet Communities see http://bioregional.com.au/oneplanetliving/oneplanetcommunities/

dense as the surrounding 1950s housing stock on big blocks (Figure 8.1). WGV has a range of sustainability goals developed as part of its One Planet Living action plan. The development integrates WSUD features and seeks to be zero carbon (through solar and batteries), while also providing other community amenities such as social housing.

Part of the reason this development has been able to deliver so much can be related to strong leadership and complementary partnerships. The project was developed by LandCorp, the Western Australian land and infrastructure agency, as an Innovation through Demonstration project but has shared support from the local authority, the City of Fremantle. Instead of a NIMBY reaction from the community, many local people have requested to shift into the development because it enables downsizing as well as community-based amenity.

The delivery of sustainable infill precincts requires a combination of the right urban fabric, infrastructure integration and technology (Girardet 2015; Newman et al. 2012). Integration will need to address each of the following components –

Figure 8.1 Artist rendering of WGV

Source: © LandCorp (2016)

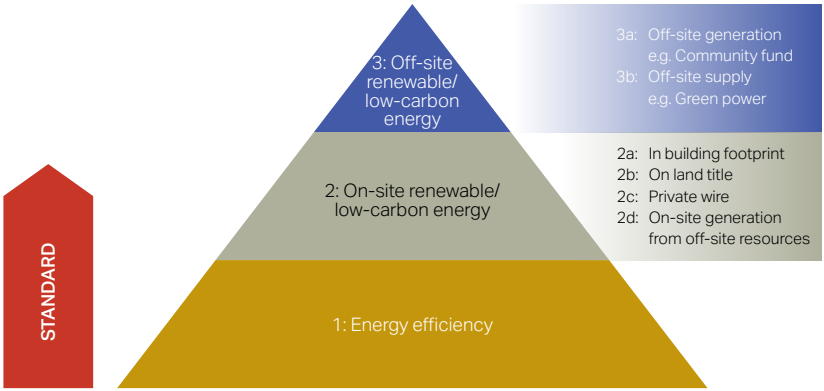
energy, water, biodiversity and waste – to collectively work towards the delivery of a sustainable, or potentially regenerative, city.

Each of these is discussed below, with reference to WGV where appropriate.

Energy

Energy use can be greatly reduced through demand management; for example, through highly energy-efficient buildings. While relatively rare in Australia, the super-insulated, high-performance *Passivhaus* standard building envelopes are almost airtight, requiring only the smallest amount of energy to heat or cool internal space. Building an energy-efficient building and supplementing this with renewables (either on-site or off-site) can deliver a zero-carbon building. Figure 8.2 illustrates the Australian Sustainable Built Environment Council recommendation for an Australian standard zero-carbon building definition (Reidy et al. 2011).

Figure 8.2 Recommendation for Australian standard zero-carbon building definition



Source: Reidy et al. (2011)

It is even possible to create an energy-plus precinct (i.e. one that creates more energy than it uses) by providing renewable energy generation at all available sites, from sun, wind and geothermal sources.

Uptake of solar in Perth has been rapid, to the point that aggregate rooftop solar is now effectively "the largest power station in the state", with 200,000 arrays covering more than 20 per cent of rooftops (Clover 2016). However, the majority of solar is found on the rooftops of single-owner detached villas (Newton & Newman 2013). To date, uptake of solar has been much slower in strata buildings given the business and governance difficulties related to multiple ownership. Given that around one-third of Australian dwellings are strata titled, and this number is growing due to infill, this presents a major barrier to solar uptake.

In the WGV case study, energy demand reduction and renewables aim to reduce grid energy consumption by 60 per cent across the development as a whole, and 100 per cent (zero net annual energy) in dwellings which take advantage of the WGV Sustainability Rebate Package.

One of the most innovative aspects of the WGV demonstration is a trial for the use of solar PV and storage where power bills come to individual tenants not from an electricity company, but from the body corporate. The model will reduce carbon, provide electricity cost savings to the resident and repay the upfront capital costs for the PV infrastructure (Parkinson 2016). This is of particular relevance to infill because it presents a mechanism to unlock current barriers for the easy application of solar within strata developments. This not only allows more residents access to ethical power, but also has financial benefits, as recent research has found that in Perth a combination of solar PV and batteries can enable developments to be zero carbon at a lower cost than coal-fired power (Green & Newman 2015).

Integrating higher density, mixed-use urban areas with public transport will reduce transport energy needs due to shorter distances between locations and the efficiencies of mass transit (Kenworthy et al. 2001; Newman & Kenworthy 2011). Mass transit can be supplemented by car-share schemes for longer journeys, and good cycling and walking networks to make local trips more pleasant and safer. Where the fuel used to build and operate buildings, and to build and run transport is renewable, an oversupply of energy can be harvested and used to help power and fuel the surrounding bioregion. This is likely to be renewably powered electric systems in buildings and transport as well as renewably powered gas (Newman & Kenworthy 2015).

Water

Potable water demand can be greatly reduced through water efficiency measures as well as water harvesting from rainwater and stormwater collection, and recycling wastewater. Water can be fully collected at source within a city, as well as being recycled from grey water and black water, and used to help regenerate aquifers and water bodies in the bioregion.

WGV demonstrates several initiatives to improve water consumption and maximise water harvesting. The water goal for the development is a 70 per cent reduction on typical mains water consumption. This will be achieved through the use of large, shared underground (strata owned) rainwater tanks, a community bore, grey water recycling, irrigation meters, sensors and a distribution network for non-potable irrigation water via 'purple pipes'. Excess water will infiltrate on-site to recharge local groundwater through the existing on-site sump that has been revegetated to double as an accessible landscape feature. Landscaping the sump was a win-win for the developer, the community and broader site sustainability. This approach transformed what would typically remain as unsightly and inaccessible infrastructure into an attractive and biodiverse communal open space, while still performing its drainage function. All houses will be dual metered for mains water and purple pipe water. Because much of this work is innovative, metering will be conducted to determine the benefits of these approaches for application to other developments (Josh Byrne & Associates 2016).

Privately owned on-plot rainwater tanks are most efficient in areas where there is relatively constant annual rainfall to continually recharge what are typically small storage volumes in most domestic tanks. The climate in much of southern Australia is known for cool and wet winters, with long, hot, dry summers, meaning small rainwater tanks can be quickly exhausted. A complementary measure capable of storing much larger volumes of water is Aquifer Storage and Recovery (ASR). ASR is a large-scale process that can be used wherever the underlying stratigraphy permits. ASR has been used with considerable success in Playford, South Australia, where water is channelled through the street network to the Munno Parra urban wetland. The wetland reduces the nutrient content of the water, and the clean water is then actively injected into the aquifer during periods of high rainfall and recovered from the aquifer during periods of low rainfall (City of Playford 2015). The geomorphology of

some cities is less suited to ASR; for example, Perth's Quaternary sands are not suitable, but deeper stratigraphy may have potential. A 2013 study by the CSIRO demonstrated the technical feasibility for aquifer storage and recovery in the Leederville aquifer (Prommer et al. 2013).

Biodiversity and canopy cover

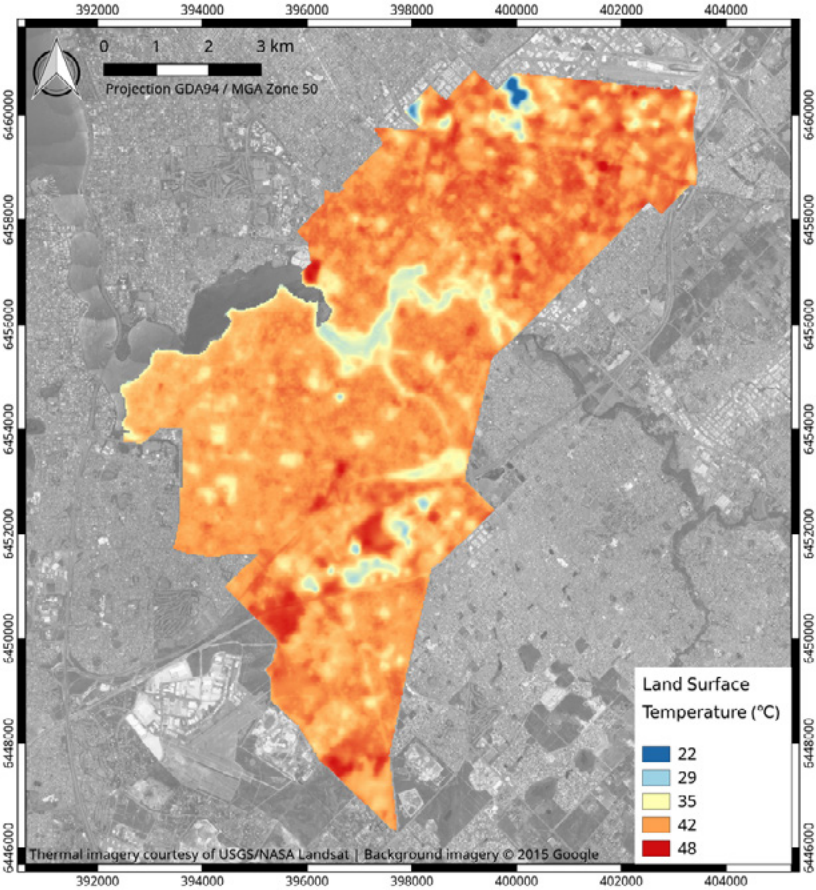
Given that much of southern Australia is a hot and heating environment, the maintenance of vegetation cover, particularly taller tree canopies, is critical not only for biodiversity, but also for climate change resilience and urban comfort in periods of hot weather.

The impact of the urban heat island effect is greater than thermal comfort alone, as increased hot weather is also associated with adverse health impacts and is closely correlated to increased mortality (Norton et al. 2015) and higher energy costs required for active cooling by air-conditioning. Recent research by the Nature Conservancy and C40 Cities also demonstrated that leafy trees are the only cost-effective solution for addressing both air quality and rising urban temperatures (McDonald et al. 2016). Yet, strangely, the benefits of urban greenery and the ecosystems services they provide are often overlooked as areas are redeveloped with infill.

A 2016 study by the City of Canning in Perth found that on a hot day the land surface temperature differential could be greater than 10 degrees Celsius dependent on the underlying land use (see Figure 8.3).

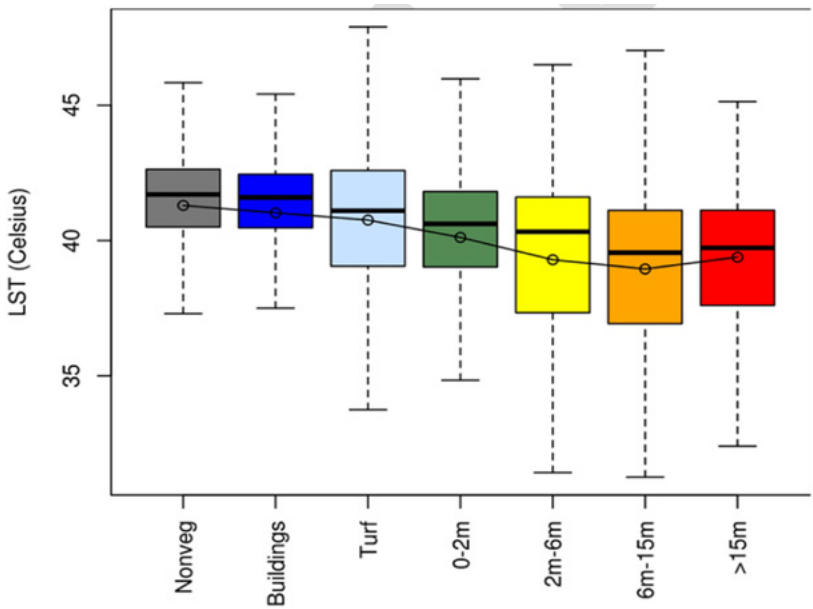
Comparisons of land cover temperature correlations within the City of Canning show that the median variation across a plot sees buildings and non-vegetated land five to six degrees Celsius warmer than land covered by trees (see Figure 8.4). Conventional infill tends to neglect urban greenery, therefore in April 2016, the council committed to investigate a range of policy measures that will allow infill to occur while increasing canopy density.

Figure 8.3 City of Canning land surface temperature map



Source: Image prepared by Astron for City of Canning (2016) ©.

Figure 8.4 Land cover temperature correlation



Source: Image prepared by Astron for City of Canning (2016) ©

The findings at Canning reflect the situation in many other councils (Hall 2007). In Perth, the City of Stirling is rapidly losing canopy cover to infill development. In 2014, the council set a target to increase canopy cover from 12.7 per cent to 18 per cent. In 2013, the council lost 22 hectares of canopy cover and predicts that without a mandate to protect trees it will lose 45 per cent of all trees on private development sites over the next 15 years to infill development (leaving only five per cent of residential areas shaded by trees) (Young 2016).

Similarly, the City of Fremantle, with only around 10 per cent canopy cover, is well behind the average national suburban canopy cover of 39 per cent (Jacbos et al. 2014). In recognition of this limitation, in 2015 the Fremantle

council introduced an ambitious target of 20 per cent canopy cover by 2040. This will be achieved by increasing plant cover in the public realm, but as this is insufficient to meet the target, in August 2016 the council committed to explore measures aimed at reducing canopy loss on private land, including requiring planning permission to remove larger trees (Emery 2016).

Even the most urban areas have considerable opportunity to increase greenery; for example, an Urban Forest Strategy has been prepared for both the City of Melbourne (which aims to increase canopy cover from 22 per cent to 40 per cent by 2040) (City of Melbourne 2012), and the City of Sydney (which aims to increase from 15.5 per cent to 23.25 per cent by 2030, and then 27.15 per cent by 2050) (City of Sydney 2013). Both these urban forest strategies increased canopy cover, but also increased species diversity and community education, and improved urban ecology.

Trees can be integrated into urban infill, and given the liveability and health risk of canopy loss, higher vegetation density within redevelopment areas is critical. Sydney, which has seen the greatest amount of infill of all Australian cities, has used the *State environmental planning policy No. 65 – design quality of residential apartment development* (SEPP65) to mandate minimum areas for 'deep soil zones' since 2004. The requirement stipulates minimum areas suitable for tree growth within all apartment building developments of three storeys or more with four or more dwellings (Government of NSW 2015). The Government of Victoria's draft *Better apartments design standards* introduced similar requirements when it was released for comment in May 2016 (Government of Victoria 2016). Provision of minimum deep soil zones enables deep-rooted vegetation the space in which to grow in even the densest of infill areas, and is a measure that would be wisely adopted in other planning jurisdictions.

It is difficult to control urban canopy cover on private land, but increasingly sophisticated remote sensing can cost-effectively track canopy cover and be used as a planning tool to incentivise tree growth or retention – and potentially penalise canopy cover loss.

In degraded urban environments with minimal endemic habitat there may be numerous opportunities for revegetation. Table 8.1 summarises the

canopy cover of inner city areas in Australia's major capital cities from a 2014 benchmarking exercise by the Sydney-based Institute for Sustainable Futures. It also indicates the potential within each capital city to increase canopy cover (Jacbos et al. 2014).

Table 8.1 Capital city land cover, per cent, 2014

Area	Trees (%)	Shrubs (%)	Grass/bare ground (%)	Hard surface (%)
City of Melbourne	12.9	1.8	22.3	63.0
City of Sydney	15.2	2.5	13.2	69.1
City of Adelaide	20.3	1.3	31.9	46.5
City of Perth	26.1	3.3	23.8	46.8
Inner Brisbane	16.3	3.9	20.1	59.7
City of Hobart	58.6	8.5	14.2	18.7

Source: Jacobs et al. (2014)

The table shows that just over a quarter of the City of Perth (i.e. central Perth) is covered by trees (this includes Kings Park and other reserves), yet there is an almost equal amount of grass and bare ground totalling nearly 3 km^2. Even a moderate replanting program on grassed and bare surfaces could add considerable canopy cover. Similarly, there is the potential for the conversion of hard surfaces. Councils regularly insert new tree planting in footpaths using concrete cutting equipment. Car parks and roads can incorporate trees, and swales and potentially biodiversity can be built into every part of the urban fabric, including green roofs and green walls. Bioregional needs in biodiversity can be facilitated by local councils in partnership with civic groups, such as the metropolitan Natural Resource Management groups which, in combination, are best positioned to coordinate planting of different structural habitats, and managing and motivating intensive human power (e.g. urban agriculture and urban biodiversity conservation) (see: Newman & Jennings 2008; Newman & Matan 2013; Newman 2014). The introduction of such biophilic urbanism strategies that enable green roofs, green walls and water sensitive design can transform degraded urban environments into habitat-rich ecosystems, and in some instances create more habitat

opportunities than existed on the site before it was built on (Beatley 2009; Beatley 2012; Beatley & Newman 2012).

By way of example, tree canopy cover on the site at WGV will be restored to 30 per cent site coverage. In addition, 30 per cent of the street trees will be planted as edible fruiting species to support local food production.

Waste

Waste can be reduced to very small amounts through urban industrial ecology approaches whereby waste is reframed as resources (Broto et al. 2012). For example, sewerage may be 'mined' for a variety of products including water, biogas (methane) and elements such as carbon, phosphorus, nitrogen and other trace elements (Newman & Jennings 2008). Many councils are bulk composting green garden waste rather than burying it, utilising this resource on public land as mulch. The City of Adelaide's Green Waste Recycling and Mulch Centre has created a small green enterprise by charging non-city residents for dumping green waste and selling mulch and compost to the community.

Recycling within domestic waste is common and increasing in most council areas. In Perth, the largest waste stream by volume is construction and demolition material. The Western Australian Local Government Association (WALGA) estimates that this stream contributes around 50 per cent of waste by volume (WALGA 2016).

Construction materials can be significantly reduced if new technologies and construction techniques (such as modular) can be used and recycling is optimised (Sanchez et al. 2015); however, thermodynamic limits mean that productive material outputs can never be greater than material inputs, unlike water and energy (Gardner & Newman 2013). Manufactured buildings are well suited to infill locations (as described in Chapter 5) and enable high-performance building envelopes to offer sustainability and operational cost benefits to the occupants. They also greatly reduce construction waste volumes, offering sustainability and cost benefits to developers and waste management authorities.

Integration

Collectively, consideration of these sustainability elements creates numerous opportunities for infill to be delivered in a more sustainable manner. The planning of new developments should seek infrastructure synergies at the energy, water and waste nexus (GIZ & ICLEI 2014); such integration of utilities can optimise efficiency through an industrial ecology (Kennedy et al. 2007) and the circular metabolism of a regenerative city (Girardet 2015; Gardner & Newman 2013).

However, this cannot be done unless the economic and social generators from the site are simultaneously being achieved. The articulation of a sustainable city vision will also require commitment to high quality of life provision, affordability and new green enterprises to replace jobs that may be lost from a sustainability transition.

Many of these sustainability measures work best where there are higher densities. This is because higher densities reduce per-capita costs for any shared infrastructure. Where the provider of sustainability infrastructure is government (e.g. public realm and WSUD), costs can be recouped through rates, and where the provider is private industry (e.g. car share), the higher density of residents offers a larger market to pay for services.

CONCLUSION

Across all tiers of government from local, state, national and international (Paris Agreement and SDGs etc.) there is policy direction to improve the sustainability performance of our cities. This chapter demonstrates the importance of sustainable planning and technology to help achieve this objective. The very fabric of our urban environment has a strong influence on urban performance, including both the location of density (e.g. adjacent transit or in activity centres) and the composition of density (as discussed in Chapter 7). In addition, incorporating sustainability overlays such as energy, water, waste and biodiversity, as outlined in this chapter, can push sustainability performance further.

As infill becomes increasingly common in Australian cities, highly sustainable redevelopments such as WGV demonstrate what is possible when an integrated approach to urban design, energy, water, waste and biodiversity occurs. The sustainability advantages are obvious; however, there are also financial benefits to residents, with projected cost savings of up to $1200 per year when compared to the utility bills of a typical Perth home. It is on templates such as this that Perth and other Australian cities need to build to help reduce Australia's disproportionately high per capita ecological footprint, while also providing liveability and financial benefits to citizens.

Monitoring and accrediting the energy, water and waste flows of a building, development or city provides a powerful evidence-based approach to assess the sustainability of urban populations. Such monitoring can be used both to measure the operational performance and, particularly when used in conjunction with design tools such as PIM (see Chapter 5), may be used to design highly sustainable developments.

Whole-of-city targets can be set for infill sites to encourage new development to meet or exceed these goals; this may require new governance mechanisms and authorities. Policy approaches that can learn from exemplary projects such as WGV will allow high sustainability standards to be translated into regulation, which in turn will help enable demonstration projects to be scaled up from niche to mainstream practice. Prescription of additional standards may be resisted by some as 'green tape'. However, the public-good benefits through better performing cities, and to individuals, through the provision of homes that are more comfortable and more affordable (to operate) present a powerful case for striving to achieve sustainable infill development.

REFERENCES

ABS – see Australian Bureau of Statistics.

Australian Bureau of Statistics 2015, 3101.0 – Australian demographic statistics, Dec 2015. Australian Bureau of Statistics website. Retrieved from http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Dec%202015?OpenDocument.

Beatley, T 2009, 'Biophilic urbanism: inviting nature back to our communities and into our lives'. *William & Mary Environmental Law & Policy Review*, 34(1), 209-238.

Beatley, T 2012, *Green urbanism: learning from European cities*. Washington, D.C.: Island Press.

Beatley, T & Newman, P 2012, *Green urbanism Down Under: learning from sustainable communities in Australia*. Washington, D.C.: Island Press.

Broto, VC, Allen, A & Rapoport, E 2012, 'Interdisciplinary perspectives on urban metabolism'. *Journal of Industrial Ecology*, 16(6), 851-861.

City of Melbourne 2012, *Urban forest strategy: making a great city greener 2012–2032*. Melbourne, Victoria: City of Melbourne.

City of Playford 2015, *Waterproofing Playford wetlands & aquifer storage recovery processes*. City of Playford website. Retrieved from https://www.playford.sa.gov.au/webdata/resources/files/Munno_para_wetland_factsheet.PDF.

City of Sydney 2013, *Urban forest strategy*. City of Sydney. Retrieved from http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0003/132249/Urban-Forest-Strategy-Adopted-Feb-2013.pdf.

Clover, I 2016, 'Western Australia's rooftop solar now state's "biggest power station"'. Reneweconomy website. Retrieved from http://reneweconomy.com.au/western-australias-rooftop-solar-now-states-biggest-power-station-27206/.

Commonwealth of Australia 2012, *State of Australian cities 2012*. Australian Government, Department of Infrastructure and Transport. Retrieved from https://infrastructure.gov.au/infrastructure/pab/soac/2012.aspx.

Economist Intelligence Unit 2017, Daily chart: Global liveability has improved for the first time in a decade. *The Economist*. Retrieved from https://www.economist.com/blogs/graphicdetail/2017/08/daily-chart-10.

Emery, K 2016, 'Fremantle council ban on cutting down mature trees'. *The West Australian*. Retrieved from https://thewest.com.au/news/wa/fremantle-council-ban-on-cutting-down-mature-trees-ng-ya-116467.

Fink, JH 2013, 'Geoengineering cities to stabilise climate'. *Proceedings of the ICE - Engineering Sustainability*, 166(5),242-248.

Fraker, H 2013, *The hidden potential of sustainable neighborhoods: lessons from low-carbon communities*. Washington, D.C.: Island Press.

Gardner, H & Newman, P 2013, *Reducing the materials and resource intensity of the built form in the Perth and Peel regions*. Department of Sustainability, Environment, Water, Population and Communities. Retrieved from https://www.environment.gov.au/system/files/resources/012e6df0-dce8-4bb2-9861-dad1dfc0f779/files/built-form.pdf.

Girardet, H 2010, *Regenerative cities*. World Future Council website. Retrieved from http://www.worldfuturecouncil.org/wp-content/uploads/2016/01/WFC_2010_Regenerative_Cities.pdf.

Girardet, H 2015, *Creating regenerative cities*. New York, NY: Routledge.

GIZ and ICLEI 2014, *Operationalizing the urban NEXUS: towards resource efficient and integrated cities and metropolitan regions*. Retrieved from http://www2.giz.de/wbf/4tDx9kw63gma/UrbanNEXUS_Publication_ICLEI-GIZ_2014_kl.pdf.

Gómez-Baggethun, E & Barton, DN 2012, 'Classifying and valuing ecosystem services for urban planning'. *Ecological Economics*, 86, 235-245.

Government of NSW 2015, *State environmental planning policy No. 65 – design quality of residential apartment development*. NSW Legislation. Retrieved from http://www.legislation.nsw.gov.au/#/view/EPI/2002/530/whole.

Government of Victoria 2016, *Better apartments – design standards*. Environment, land, water and planning. Retrieved from https://www.planning.vic.gov.au/__data/assets/pdf_file/0024/9582/Better-Apartments-Design-Standards.pdf.

Green, J & Newman, P 2017, 'Planning and governance for decentralised energy assets in medium-density housing: the WGV Gen Y case study', *Urban Policy and Research*, DOI: 10.1080/08111146.2017.1295935.

Hall, T 2007, *Where have all the gardens gone? An investigation into the disappearance of back yards in the newer Australian suburb*. (Urban Research Program Research Paper 13, Griffith University.) Retrieved from https://www.healthyplaces.org.au/userfiles/file/where%20have%20all%20the%20gardens%20gone%20Tony%20Hall(1).pdf.

Jacbos, B, Mikhailovich, N & Delaney, C 2014, *Benchmarking Australia's urban tree canopy: an i-tree assessment, final report*. Institute for Sustainable Futures. Retrieved from http://202020vision.com.au/media/7141/final-report_140930.pdf.

Josh Byrne & Associates 2016, WGV Waterwise Development Exemplar 2015/16 Partner Update. LandCorp website. Retrieved from https://www.landcorp.com.au/Documents/Corporate/Innovation%20WGV/Innovation-WGV-Waterwise-Development-Exemplar.pdf.

Kennedy, C, Cuddihy, J & Engel-Yan, J 2007, 'The changing metabolism of cities'. *Journal of Industrial Ecology*, 11(2). 43-59.

Kenworthy, J, Laube, F & Vivier, J 2001, *Millenium cities database for sustainable transport*. Brussells, Belgium: Murdoch.

Llewelyn-Davies 2000, *Urban design compendium*. London, UK: English Partnerships & The Housing Corporation, U.K.

McDonald, R, Kroeger, T, Boucher, T, Wang, L & Salem, R 2016, 'Planting healthy air: a global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat'. *The Nature Conservancy*. Retrieved from www.nature.org/healthyair.

Newman, P 2014, 'Biophilic urbanism: a case study on Singapore'. *Australian Planner*, 51(1), 47-65.

Newman, P & Jennings, I 2008, *Cities as sustainable ecosystems: principles and practices*. Washington, D.C.: Island Press.

Newman, P & Kenworthy, J 1989, *Cities and automobile dependence: an international sourcebook*. Brookfield, VT: Gower Publishing.

Newman, P & Kenworthy, J 1999, *Sustainability and cities: overcoming automobile dependence*. Washington, D.C.: Island Press.

Newman, P & Kenworthy, J 2011, 'Peak car use: understanding the demise of automobile dependence'. *World Transport Policy and Practice*, 17(2), 32-42.

Newman, P & Kenworthy, J 2015, *The end of automobile dependence: how cities are moving beyond car-based planning*. Washington, D.C.: Island Press.

Newman, P & Matan, A 2013 *Green urbanism in Asia: the emerging green tigers*. Singapore: World Scientific Publishing.

Newton, P & Newman, P 2013, 'The geography of solar photovoltaics (pv) and a new low carbon urban transition theory'. *Sustainability (Switzerland)*, 5(6), 2537-2556.

Newton P, Newman, P, Glackin, S & Trubka, R 2012, 'Greening the greyfields: unlocking the redevelopment potential of the middle suburbs in Australian Cities'. *World Academy of Science, Engineering and Technology*, 71(11), 658-677.

Norton, BA, Coutts, AM, Livesley, SJ, Harris, RJ, Hunter, AM & Williams, NS 2015, 'Planning for cooler cities: a framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes'. *Landscape and Urban Planning*, 134, 127-138.

OECD 2016, OECD Better Life Index. OECD website. Retrieved from http://www.oecdbetterlifeindex.org/#/55555555555.

Parkinson, G 2016, 'Citizen utility: housing estate to offer solar, storage and EVs to residents'. One step off the grid website. Retrieved from https://onestepoffthegrid.com.au/citizen-utility-housing-estate-to-offer-solar-storage-and-evs-to-residents/.

Prommer, H, Descourvieres, CD, Handyside, M, Johnston, K, Harris, B, Li, Q, ... & Martin, M 2013, *Aquifer storage and recovery of potable water in the Leederville Aquifer*. CSIRO. Retrieved from https://publications.csiro.au/rpr/download?pid=csiro:EP136027&dsid=DS7.

Reidy, C, Lederwasch, A & Ison, N 2011, *Defining zero emission buildings*. Australian Sustainable Built Environment Council. Retrieved from http://www.asbec.asn.au/files/ASBEC_Zero_Carbon_Definitions_Final_Report_Release_Version_15112011_0.pdf.

Rockström, J, Steffen, W, Noone, K, Persson, Å, Chapin III, FS, Lambin, E ... & Nykvist, B 2009, 'Planetary boundaries: exploring the safe operating space for humanity'. *Ecology and Society*, 14(2).

Rowley, S & Phibbs, P 2012, *Delivering diverse and affordable housing on infill development sites*. (Report 193, from the Australian Housing and Urban Research Institute). Retrieved from https://www.ahuri.edu.au/research/final-reports/193.

Sanchez, A, Hampson, KD & Mohamed, S 2015, *Driving whole-of-life efficiencies through BIM and procurement*. Sustainable Built Environment National Research Centre. Retrieved from http://www.sbenrc.com.au/research-programs/2-34-driving-whole-of-life-efficiencies-through-bim-and-procurement/.

Steffen, W, Richardson, K, Rockström, J, Cornell, SE, Fetzer, I, Bennett, EM, ... & Folke, C 2015, 'Planetary boundaries: guiding human development on a changing planet'. *Science*, 347 (6223), 1259855. 736-747.

Swilling, M, Robinson, B, Marvin, S & Hodson, M 2013, 'City-level decoupling: urban resource flows and the governance of infrastructure transitions'. World Resources Forum. Retrieved from https://www.wrforum.org/uneppublicationspdf/city-level-decoupling-urban-resource-flows-and-the-governance-of-infrastructure-transitions/.

Thomson, G & Newman, PWG 2016, 'Geoengineering in the Anthropocene through regenerative urbanism'. *Geosciences*, 6(4), 46.

WALGA – see Western Australian Local Government Association.

Western Australian Local Government Association 2016, Construction and demolition waste. WasteNet website. Retrieved from http://www.wastenet.net.au/construction-and-demolition-waste.aspx.

Young, E 2016, 'Stirling's landmark tree protection attempt falters at finish line'. *WA Today*. Retrieved from http://www.watoday.com.au/wa-news/stirlings-landmark-tree-protection-attempt-falters-at-finish-line-20160320-gnmnpt.html.

9

PERTH'S INFILL HOUSING FUTURE

Steven Rowley*
Rachel Ong
Amity James

*Corresponding author: Steven Rowley, School of Economics and Finance, Curtin University, GPO Box U1987, Perth WA 6845. Email: steven.rowley@curtin.edu.au Tel: +61 8 9266 7721

The Greater Perth region is characterised by a low-density, sprawling housing landscape. But Perth is witnessing a shift in its demographic structure and in its housing demand. While a separate house in a new greenfield development remains popular for many, more and more households are looking for housing opportunities which are close to the central regions that offer access to job opportunities and a high level of amenity. As such, the WA Government has embarked on a strategic direction to expand infill development and housing diversity, focused on key transport nodes to better match the housing aspirations of the population. However, while net rates of infill development have increased in recent years, from 28 per cent in 2013 to 34 per cent in 2015, they remain well below the government's target (see Chapter 2).

There has been a change to the housing stock between 2011 and 2016 with a two per cent reduction in the proportion of separate dwellings across the Greater Perth region. Individual local government areas will have seen very different patterns of development dependent on local politics, the planning system, development costs and profitability. Infill development has a long way to go to meet the government's 47 per cent target set in *Directions 2031*, but at least there is some movement, albeit slow, in the right direction. What Perth needs is a shift away from piecemeal infill development, which largely involves the replacement of one separate dwelling with two others, towards delivery on a much greater scale, and hopefully the Metrohubs[18] strategy will deliver some of the scale.

This book sheds light on a number of important and interrelated issues necessary to deliver high-quality infill development. These include the role of the planning system, community engagement, architectural and design innovations, infrastructure investment and sustainability. It represents an extensive collection of practical and policy-relevant research that can be used to inform the future of infill development in this state. This concluding chapter draws together the research presented within this book and highlights key strategies that are likely to promote higher rates of quality infill development.

18 https://www.markmcgowan.com.au/files/METROHUBS_.pdf

DRIVERS OF INFILL DEVELOPMENT

The key driver of infill development, like any private sector development, is the level of return given the risk involved. If landowners, developers and builders are unable to meet their required returns from a site, there will be no development. There are a number of constraints on return, not least what can be delivered on that site (e.g. planning, ground conditions), the revenue that can be generated from sales, the physical costs of development (e.g. labour, materials, infrastructure), the availability and cost of finance and the costs of compliance (e.g. taxes, regulations). If these factors do not align, developments are likely to stall. Government has control over some, but not all, of these factors.

The level of return from a development is driven by market conditions. When revenues are rising because the market is strong, rates of infill development increase, largely driven by high-density building. Record dwelling completions during the period 2013 to 2015, where WA was developing at a per capita rate of nearly twice that of NSW, were driven by strong population growth in the preceding years. There is always a lag with built form development due to planning requirements and the time it takes to physically construct a building, and this construction lag tends to accentuate market cycles. In the current market, characterised by weak population growth and consumer confidence, new supply has contracted sharply, down more than a quarter on the previous year (Housing Industry Forecasting Group 2017). When the market does change, it is important that the development industry is able to respond quickly and supply keeps up with demand to avoid the type of price rises seen in the past.

Planners need to be aware of the costs of developing infill sites, which can vary tremendously given local infrastructure requirements, but also need to consider how their decisions relating to density and height impact on revenues and therefore profitability. Chapter 3 highlighted how the planning system can be used to deliver high-quality infill development, and a balance needs to be struck between code-driven planning which can stifle innovation and merit-based approaches which can take too long to operate. The planning system ultimately needs to strike a balance between supporting development and protecting local amenity and communities to reduce the burden of red tape on developers.

Many of the recommendations around the delivery of diverse and affordable housing made by Rowley and Phibbs in their work *Delivering diverse and affordable housing on infill development sites* (2012, p. 69) are still relevant today, particularly in terms of assembling sites, leadership driving the infill agenda, and the use of public land. A way to respond quickly to changing demand pressures is to have a stock of shovel-ready land that can be activated at short notice, and public land is ideal for this.

The availability and conditions of finance are a barrier to infill development, with the impact of this barrier depending on the policies of financial institutions. In the current market the pre-sales requirements of major lenders make it very difficult for developers to secure project-specific finance. Infill development at any scale then becomes problematic and infill is delivered through piecemeal, single-lot redevelopment. There is little government can do to free up private sector finance, which is why the operations of LandCorp and the Department for Communities – Housing are so important during a market downturn.

HOUSING DIVERSITY – AFFORDABILITY, TYPE AND TENURE

Housing affordability in the ownership and rental markets has improved for those on moderate incomes and above, but WA still lacks options for those households on low incomes (Duncan et al. 2016). This is partly due to the scarcity of social housing, a problem common throughout Australia, but also due to a lack of housing diversity. Diversity provides a range of housing options across a local housing market offering expensive as well as cheaper dwellings. If a local market is dominated by four-bedroom dwellings there will be no smaller alternatives available for those on lower incomes. Diversity within a market also provides opportunities for seniors to downsize in place. Research has found (Duncan et al. 2016) that most seniors downsize to reduce the costs of running and maintaining a house and garden rather than release equity, and they want to downsize in their local community. Housing diversity that can offer such options and diversity within existing suburbs is essential.

It isn't just diversity of dwelling types that is required, but also of tenure, offering a range of short and long-term rental options, ideally including subsidised rental currently available through the National Rental Affordability Scheme, shared ownership products and, of course, social housing. Increasing funding within the community housing sector, be it through direct government funding or private sector investment, is critical to address housing cost concerns among the growing number of renters, especially among the ageing population (Dockery et al. 2015).

The state of Western Australia is fortunate to have an established affordable housing strategy which keeps the issue of delivering affordable housing across the housing continuum front and centre for departments responsible for housing and, to a lesser extent, planning. The Department of Communities – Housing has delivered a range of affordable products. However, there remains scope for the private sector to engage in the delivery of subsidised products accessible either directly or indirectly to low-income households. This will of course require some form of government intervention, a potential example being intervention at the size rezoning or upzoning stage mandating affordable housing contributions. Flexibility within the planning system to offer density or height bonuses in return for affordable housing products can also further promote development.

POLICY DEVELOPMENT TO MEET FUTURE HOUSING NEED

Landgate (2017) has proposed reform to strata legislation which aims to "provide more flexible and sustainable housing options to benefit strata owners, residents, tenants, investors and developers". New legislation should make it easier for developers to deliver more complex staged and mixed-use developments through the introduction of community titles and more flexible staged strata development. Broadly speaking, legislations that overcome barriers to development will enhance delivery of greater quantities of infill housing, when combined with favourable market conditions, of course.

The Metronet proposal potentially opens a number of areas for precinct-level infill development creating communities around amenity. These infill communities will increasingly offer important housing options for older Australians looking to downsize. Precinct-scale development around transport hubs offers a more meaningful solution than piecemeal infill development, as amenities can be integrated into the development. These new precincts, given the right planning tools, could deliver affordable and sustainable housing opportunities for a range of household types including first home buyers, private renters in need of subsidised housing, social housing occupants and the downsizers mentioned above. With high levels of amenity comes relatively high prices, so once again some form of intervention is essential to ensure a proportion of dwellings remains affordable for low to moderate-income households.

The cost of developing infill sites remains an issue for developers. The proposed City Deals may assist government to overcome some of the costly infrastructure barriers preventing large-scale infill development. Land is a major cost and the ability of LGAs and state government to enter into joint ventures using their land as their equity contribution, thus reducing upfront costs for the developer, is a powerful one. Local government should be encouraged to develop infill land in partnership with the private sector, and discounting land can deliver affordable housing opportunities. The Department of Communities – Housing has demonstrated how the use of land is an effective tool in leveraging private sector investment.

OVERCOMING COMMUNITY OPPOSITION

Chapter 4 highlighted a series of principles that underpin community engagement in infill development. These principles include: creating a genuine environment for discussion that is ongoing, collaborative and inclusive of all stakeholder groups; depoliticising community forums; choosing realistic development boundaries that are less likely to spark community angst; preparing development scenarios; and addressing negative attitudes through educating current residents about the characteristics of likely new residents of

the infill development and fostering a community spirit in the area. Genuine and early community engagement has been shown to deliver better development outcomes.

Local communities are more likely to select medium over high-density development and it is therefore less vulnerable to opposition. Medium-density housing such as small-scale apartment developments, terraces and semi-detached options have the potential to deliver diverse, sustainable, well-designed and high-quality housing to supplement traditional forms of development. To provide a better alignment with the types of dwellings that are being demanded, and to mitigate the risk of community opposition, the state government will need to facilitate medium-density development in the coming years.

As noted in Chapter 6, innovative architectural solutions in infill development that preserve neighbourhood character and foster vibrancy in communities can also enhance the appeal of infill housing. This is important in getting the community on board. Parking and traffic tend to be the major causes of public opposition, which is why an effective transport system is necessary to reduce car dependence, as discussed in Chapter 7.

CHAMPIONING INNOVATIONS IN INFILL HOUSING

Both LandCorp and the Department of Communities – Housing have been at the forefront of innovative infill development. LandCorp's WGV and Gen Y housing, and their recent Step Up Affordable Housing Design Competition are good examples. The Department of Communities – Housing has championed innovative modular construction at the Adara apartments in Cockburn Central, initiated private sector joint ventures such as One on Aberdeen, Northbridge, supported TOD at Cockburn Central and Wellard, and medium-density housing combined with smaller lot products at a number of their new communities such as Brighton and Harrisdale. Such innovation leads housing markets and encourages the private sector to follow suit.

Housing innovation is critical for delivering housing that is diverse, affordable and sustainable. As shown in chapters 5 and 6, significant benefits can be derived from innovative housing processes. Technological innovations such as off-site manufactured building accompanied by digital process improvements such as BIM and PIM give rise to a number of benefits that boost the quality, sustainability and timely delivery of infill housing. Innovations in governance processes are also critical to supplement traditional models of development assessment. For instance, design review panels are increasingly the norm, with many state and local governments now requiring these for apartment blocks and public spaces. Innovative co-housing models have also shown success. For instance, as highlighted in Chapter 5, The Commons in Melbourne is an award-winning project that has been replicated by social enterprises such as Nightingale Housing. These sorts of innovations are critical to deliver housing tenure diversity. As noted above, innovative architectural solutions in infill development that preserve neighbourhood character and foster vibrancy in communities can mitigate community opposition, and eight exemplars have been provided in Chapter 6.

However, as noted in Chapter 6, the current compressed and speculative nature of infill development acts as a barrier against widespread adoption of innovative design-led approaches. A key challenge relates to the resourcing required to fund upfront research and development costs in the area of design-led innovation. Another key challenge is the need to tailor some policies and processes towards channelling design innovations typologies to the mass housing market.

HARNESSING PLANNING PROCESSES FOR INFILL FUTURES

As explained in Chapter 3, the role of the planning system in infill development depends heavily on the context within which the development is taking place. The state government's Metrohubs plans offer potential sites suitable for higher-density infill that are well located and will offer strong public transit services. It is more difficult to deliver quality infill housing along road corridors,

so careful design of the adjacent road environment will be required to minimise the impacts of heavy traffic. Existing suburban areas also provide opportunities for delivering infill targets through targeted densification. However, infill processes in suburban areas will need to avoid potentially negative impacts on private open space, safe streets and affordability.

Clearly, it is critical to deploy a nuanced planning approach that is uniquely fitted to the urban context so as to deliver quality infill housing that is sensitive to the preferences and expectations of residents. Such a planning approach accompanied by effective community engagement strategies will reduce the infill project's exposure to community opposition. In addition, the success of innovative infill housing will also require greater flexibility in planning regulations to accommodate innovative housing solutions that deviate from traditional norms.

INVESTING IN SUSTAINABLE INFILL FUTURES

As highlighted in Chapter 7, higher density development is more conducive to continuing population growth in our cities than traditional low-density suburban development. Unfortunately, greenfield urban sprawl not only generates increased CO_2 emissions, but also is perceived to result in higher infrastructure costs than infill development.

Preferences are changing among populations in some of Australia's largest cities, with per capital car use declining over time, outside WA at least. There is a potential shift away from the automobile city towards transit and walking city fabrics that better support population growth without jeopardising liveability and sustainability. Hence, infrastructure policies tailored towards supporting infill development within transit and walking city fabrics are likely to achieve more sustainable outcomes than those that enable infill futures that are automobile dependent. Again, the Metrohubs policy might offer some solutions at a scale that make a difference.

As shown in the WGV case study in Chapter 8, it is possible to implement infill redevelopments that are highly sustainable through an integrated strategy that incorporates urban design, energy, water, waste and biodiversity. Such innovations are essential moving forward, and consumers will come to expect such features as standard in new developments to reduce running costs. There is strong merit in supporting the scaling up of demonstration projects such as WGV from a niche to mainstream practice that set whole-of-city targets for sustainability.

CLOSING REMARKS

Government and the housing industry recognise the importance of infill development in shaping the future of Perth and Western Australia. There is growing evidence that housing preferences are changing, moving away from the characteristics of the house itself and towards quality locations with high levels of amenity and good transport links. The challenge for industry is to deliver a diverse range of housing products in these existing locations while protecting amenity. The challenge for government is to establish the conditions for large-scale infill development to create places where a broad range of household types want, and can afford, to live.

This book has provided examples of high-quality infill developments and described how Perth can rise to the challenge of delivering diverse housing supply. There is a long way to go before the city shifts away from the current pattern of piecemeal infill development combined with some high-density residential towers towards a range of integrated housing types and tenures. However, positive shifts are certainly happening in the right direction. Innovation is taking place across Greater Perth, as shown in this book. The success stories described within can potentially be built on by government and industry to promote the delivery of high-quality infill housing at scale. It is hoped that this book will stimulate the thinking of policymakers within all levels of government, and within the housing industry, to help Perth achieve the delivery of infill housing in sustainable and innovative ways to meet its future housing needs.

REFERENCES

Dockery, AM, Duncan, A, Nguyen, H and Ong, R 2015, *Securing our future: meeting the challenges of WA's ageing population*, Bankwest Curtin Economics Centre, Focus on Western Australia Series, Issue No. 6, November 2015. Perth, WA: Bankwest Curtin Economics Centre.

Duncan, A, James, A, Leong, K, Ong, R & Rowley, S 2016, *Keeping a roof over our heads: BCEC housing affordability report 2016*. Focus on Western Australia report series, No. 7, June 2016. Perth, WA: Bankwest Curtin Economics Centre.

Housing Industry Forecasting Group 2017, *Forecast dwelling commencements in Western Australia: April 2017 update*. Perth, WA: Housing Industry Forecasting Group.

Landgate 2017, Strata reform. Retrieved from https://www0.landgate.wa.gov.au/titles-and-surveys/strata-reform.

Rowley, S & Phibbs, P 2012, *Delivering diverse and affordable housing on infill development sites*, Report No. 193. Melbourne, Victoria: Australian Housing and Urban Research Institute.

GLOSSARY

2D	Two-dimensional
3D	Three-dimensional
ABS	Australian Bureau of Statistics
AHURI	Australian Housing and Urban Research Institute
BIM	Building Information Modelling
BRM	Basic raw materials
CBD	Central Business District
CRC	Cooperative Research Centre
DAP	Development Assessment Panel
LGA	Local government area
MRA	Metropolitan Redevelopment Authority
MTRC	Mass Transit Rail Corporation
MUHC	Multi-Unit Housing Code
NATSPEC	National Building Specification
NIMBY	Not in my backyard
PIM	Precinct Information Model
PV	Photovoltaic
REIWA	Real Estate Institute of Western Australia

SDG	Sustainable Development Goals
TOD	Transit Oriented Development
UB	Unitised Building
WA	Western Australia
WAPC	Western Australian Planning Commission
WGV	White Gum Valley
WSUD	Water sensitive urban design

BANKWEST CURTIN ECONOMICS CENTRE

Tel: +61 8 9266 1744
Email: bcec@curtin.edu.au
bcec.edu.au

ISBN: 978-1-9250836-13

ADV100964