LOW CARBON LIVING CRC

Guide to Low Carbon Precincts

Acknowledgements

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Guide to Low Carbon Precincts

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Murray Fredericks

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Glossary

Agenda for Sustainable Development 2030 / SDGs
A global framework launched by the UN in 2015 to help eradicate poverty and achieve sustainable development by 2030. It aims to respond comprehensively to global challenges through 17 Sustainable Development Goals (SDGs) and 169 associated targets1.

Aquifer Storage and Recovery (ASR)
The direct injection of surface water supplies (potable water, reclaimed water, or run off) into an aquifer for later recovery and use.

ASBEC
Australian Sustainable Built Environment Council. The peak body of key organisations committed to a sustainable, productive, resilient built environment in Australia.

Biophilic urbanism
An approach to describe the functional, wellbeing and economic benefits of incorporating nature within cities.

Blockchain
An internet based decentralised (peer-to-peer), permanent and transparent virtual ledger commonly used for economic transactions. It is increasing being applied to track resource flows (e.g. energy, water, waste).

Built form massing
An architectural term referring to the three-dimensional perception of the general shape, form and size of a building.

Carbon emissions
Carbon dioxide emissions associated with the burning of fossil fuels, like natural gas, crude oil and coal. Carbon emissions can be classified as embodied, operational and transport-associated.

Distributed Energy Systems (DES)
Small-scale power generation or storage technologies used to provide an alternative to, or an enhancement of, the traditional centralised electric power network. Examples include renewable energy sources, such as small hydro, biomass, biogas, and solar, wind and geothermal power.

Green Building Council of Australia (GBCA)
A not-for-profit industry association that promotes sustainability in the built environment. Best known for developing the Green Star rating system for buildings and communities.

Greywater / blackwater
Wastewater from household use. Greywater is discarded water from washing food, clothing, dishes, showering and bathing, while blackwater is sourced from toilets.

Heliostat
A moveable device with a mirror that mimics the motion of the sun to reflect sunlight onto a predetermined target.

Infill
Redevelopment within the existing urban boundary. Infill may occur on brownfields (previously developed industrial or commercial land) or greyfields (typically aging, low density residential land that represent undercapitalised real estate assets).

Intergovernmental Panel on Climate Change/IPCC
An intergovernmental body of the United Nations dedicated to providing an objective, scientific view of climate change, its natural, political and economic impacts and risks, and possible response options.

'Living labs'
A research concept that is a user-centred and operating in a physical or territorial context. Living Labs encourage research and innovation within a public-private-people partnership.

Microgrid
A microgrid is an autonomous network of electrical infrastructure that connects homes and businesses in a specified local area.

New Urban Agenda / NUA
A vision for urban development for the next twenty years based on Sustainable Development Goal number 11 within the Agenda for Sustainable Development 2030. Australia signed up to the NUA in October 2016.

Photovoltaics / PV
PV cells allow the conversion of light into electricity. PVs are the medium for generating solar electricity.

Precinct
A unified area of urban land with a clearly defined geographic boundary. Synonymous with neighbourhood or district.

Public Private Partnership / PPP
A contractual relationship between a public oversight agency and a private company — either local or foreign, or a combination of the two – usually to build infrastructure.

Prosumers
A person who both consumes and produces a product. Derived from "prosumption", a dot-com era business term meaning "production by consumers". Recently the term has been used to describe owners of renewable energy systems where production in excess of consumption needs is sold back to the grid.

Special Improvement District / SID
A geographically ringfenced area in which funding for improvements comes from a local amenity-based levy or voluntary land tax paid by member businesses. SIDs are one of several innovative funding models increasingly used for local sustainability improvements.

Transit Oriented Development / TOD
A mixed use residential and commercial area designed to maximise access and use of public transit. TODs are generally located within a 400–800m walking radius from a transit stop.

Thermal envelope
A heat flow control layer, which is part of a building envelope, that is the primary control layer between the inside of the house and its exterior.

Urban fabric
A shorthand for urban environment (or urban morphology). The physical aspect of urbanism, emphasising building types, streets, open space, frontages etc. This guide describes three distinct urban fabrics: the walking city, the transit city and the automobile city.

Urban morphology
(see urban fabric)

Urban regeneration
Urban renewal that focuses on improving the physical structure of a declining area and its economy, with the goal of meeting the needs and aspirations of the community.

Urban sprawl
The unrestricted growth of housing, commercial development and roads over large areas, that typically results in low density car dependant sub-urban landscapes.

Emissions and the built environment

Buildings, in all their forms, have a huge impact on the environment. Globally, the United Nations Environment Program estimates they are responsible for **30–40%** of all primary energy used.

In Australia, buildings are responsible for one quarter of all greenhouse gas emissions.

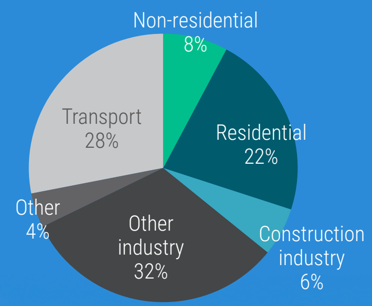
This presents a **significant challenge** as well as a **valuable opportunity** for the built environment sector to contribute to emissions abatement and mitigation.

In 2016, the Australian Government ratified the **Paris Agreement** within the United Nations Framework Convention on Climate Change, pledging to work alongside other developed nations to achieve net zero emissions by 2050 and a 26–28% reduction in emissions relative to 2005 levels by 2030.

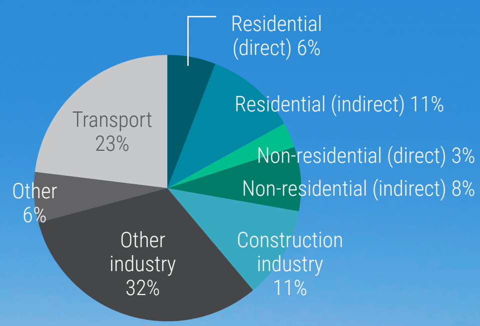
It is clear that if Australia is to achieve these targets, curbing emissions from **the built environment will play a central role**. And with more than 75% of the world's population predicted to be living in cities by 2050, the decisions and actions taken now will have effects decades into the future.

Global share of buildings and construction final energy and emissions, 2017

Energy



Emissions



Source: Derived from IEA (2018a), *World Energy Statistics and Balances 2018*, and *IEA Energy Technology Perspectives* buildings model

About the CRCLCL

The **Cooperative Research Centre for Low Carbon Living** (CRCLCL) is a national research and innovation hub for the built environment. It aims to influence policies and practices to reduce carbon emissions, improve energy efficiency and realise other co-benefits while driving competitive advantage for Australian industry. It has undertaken more than 100 research projects with industry and government partners and supported almost 100 PhD and Masters students.

Supported by the Australian Government and almost 40 industry and government participants, it links leading Australian researchers to organisations across all sectors involved in the built environment. When it ceases operations in mid-2019, the CRCLCL will leave a legacy of research outputs, policy and practice innovation, and enhanced national capacity. This Guide and others in the Low Carbon Guides series form part of that legacy.

A guide for every situation

Each Low Carbon Guide summarises best practice in various phases of the building lifecycle—construction, retrofit, operation—for a range of building types in the residential and commercial sectors and at the level of precincts. The series includes:

Guide to Low Carbon Residential Buildings – New Build
Options for homeowners, builders and designers during the planning and construction of new homes.

Guide to Low Carbon Residential Buildings – Retrofit
Retrofit solutions for existing homes, tailored for homeowners and their contractors.

Guide to Low Carbon Households
Advice to homeowners and renters on operating households using low carbon living approaches.

Guide to Low Carbon Commercial Buildings – New Build
The design and construction of low carbon commercial buildings.

Guide to Low Carbon Commercial Buildings – Retrofit
Methods for retrofitting commercial buildings to improve performance while reducing energy and carbon use.

Guide to Low Carbon Precincts
Frameworks and options to assist councils and developers with strategic planning decisions when implementing low-carbon neighbourhoods.

Further Guides cover Landscape, Urban Cooling, Value-chain and other topics.

For further information go to: builtbetter.org/lowcarbonguides

Introduction

Gen Y house,
White Gum Valley.
Photo: Acorn Photo

This document is a resource for anyone planning or assessing new low carbon precincts. Its advice complements existing policy and may be of use to developers, planners, policy makers and the community—anyone who is seeking to understand how to create sustainable urban outcomes.

Truly sustainable precincts provide high-quality urban lifestyles that benefit residents and simultaneously help to meet Australia's international commitments to tackle climate change and other sustainability goals. Precincts are big enough to allow for integrated approaches yet small enough to create cohesive communities. Their scale allows for the aligning of local needs with global goals.

The challenges inherent in delivering these sustainable neighbourhoods are great, but the risks of not trying are greater. Rapid population growth is stretching our big cities to breaking point. A warming world is exposing our urban environment to climate shocks and resource scarcity is threating quality of life.

Because of these threats, positive change is building momentum: we are witnessing a moment in time in which there is an unprecedented convergence of need (as reflected in high-level government policies), desire (increasing market and community interest) and technology to strive for sustainable urban environments. All the required elements of an urban sustainability transition—structures, culture and practice—are aligning.

Much of the advice in this Guide is sourced from the seven-year program of the Cooperative Research Centre for Low Carbon Living (CRCLCL). As such, it values the known over the speculative and avoids any particular branding, rating system or political agenda.

It is not an exhaustive analysis of the subject matter, nor does it seek to answer all questions that arise when trying to balance complex and often competing urban development considerations. Instead, the Guide introduces key terms, a set of 'sustainable precinct principles' and case studies to inspire better visions and introduce ways to *think* about achieving sustainable precincts.

While Australia is a leader in the application of certain sustainable technologies—such as solar energy and storage—recent developments in sustainable precinct design particularly in northern Europe provide exemplars that can inform the Australian experience. Case studies show there is no one-size-fits-all approach—like all built environment projects, sustainable precinct design is ultimately a creative act that varies according to location, community and the delivery team.

Finally, numerous books and guides offer general advice on good practice for urban design at the precinct scale; however, nothing offers specific advice to decision-makers in the Australian context to help them plan for low carbon, sustainable neighbourhoods. This guide aims to fill that gap.

How to use this guide

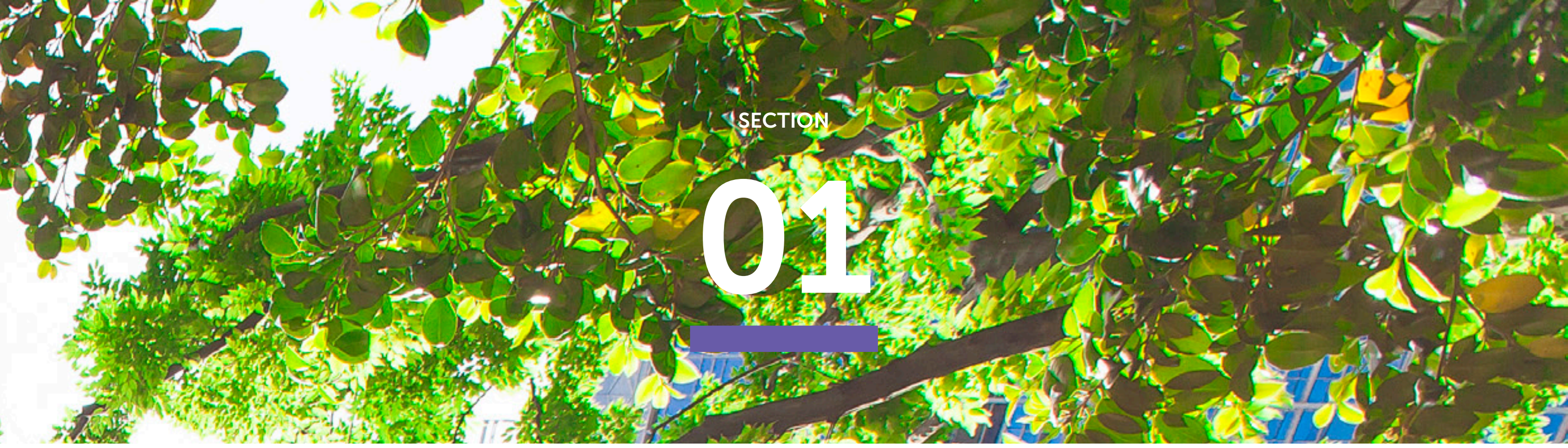
The resource is structured into four main sections:

Background – provides an overview of drivers and definitions that are useful for discussing sustainable design approaches. This includes a brief introduction to relevant global agreements, the challenges faced by Australian cities and the advantages that precincts offer for delivering sustainable urban outcomes.

Sustainable precinct themes – outlines the approaches to sustainable built form and infrastructure and categorises them into themes to be considered when planning for a sustainable precinct. Each theme includes a general discussion followed by a series of related principles to achieve more sustainable outcomes. The themes cover transport, harnessing the natural world, the optimisation of structures, and the creation of precinct-scale systems for energy, water and waste.

Delivering sustainable precincts – the processes required for the delivery and ongoing management of sustainable precincts. The emphasis is on the human processes that drive change and shape and manage new systems and business models.

Checklist – a collation of all the principles to assist with project planning, development briefs and development assessment.



Background

Before embarking on a discussion of low carbon precinct creation and management, it is helpful to understand the drivers and definitions of sustainable urban design and the challenges it addresses.

Global agreements

Australia has committed to numerous international frameworks to achieve increased sustainability, including urban sustainability. These include the United Nations Sustainable Development Goals (SDGs also known as Agenda 2030, September 2015)[1], the New Urban Agenda (NUA, October 2016)[2] and the Paris Climate Change Agreement (COP21, December 2015)[3].

The need to decarbonise is mandated in many of these agreements. Foremost is the Paris Agreement, which commits Australia to reduce greenhouse gas emissions across the economy to between 26 and 28% below a 2005 benchmark, by 2030. Several state and territory governments have also introduced ambitious greenhouse gas emissions reduction targets1 that align with or go beyond the Paris target, including net zero emissions by 2050 in South Australia, ACT, Victoria, NSW, Tasmania and Queensland[4].

Beyond decarbonisation, the United Nations Agenda for Sustainable Development calls on countries to begin efforts to achieve 17 Sustainable Development Goals (SDGs), also by 2030. The goals "address the needs of people in both developed and developing countries, emphasising that no one should be left behind". Sustainable Development Goal 11 can offer direction for sustainable precinct planning as it relates to Sustainable Cities and Communities.

The most recent framework and also the most relevant to urban development is the New Urban Agenda (NUA). Based on goal 11 within the SDGs, it calls for a "new paradigm" that will "redress the way we plan, finance, develop, govern and manage cities and human settlements, recognising sustainable urban and territorial development as essential to the achievement of sustainable development and prosperity for all …"[2]. The NUA suggests that to achieve this outcome requires "integrated urban … planning and design … to optimise the spatial dimension of the urban form and to deliver the positive outcomes of urbanisation"[2].

However, despite being a signatory to these aims, Australia has no clear national plan that sets out how its urban development will help meet these commitments. Indeed, at the SDG summit in May 2018, Australia was identified as lagging other nations in this area[5].

Figure 1.1 The 17 Sustainable Development Goals (SDGs) of Agenda 2030. Source: un.org

Challenges for Australian cities

In 2018, Australia's population reached 25 million, representing a net annual population growth of around 1.6%[6]. In the year to December 2017, this saw the nation's population grow by 388,000 people, which is roughly the equivalent of the combined populations of Hobart and Darwin. Sydney and Melbourne (our largest urban centres) are growing even faster, at more than 2% per annum[6], a rate that will see a doubling of their populations in around 35 years.

Nine out of **ten** Australians live in cities

Australia's population will reach **40 million**[7] by 2050

Based on these trends, Australia's population will reach 40 million[7] by 2050, with the majority of that growth (almost 10 million new residents) living in the major cities. City planning is struggling to keep pace with this growth and it is becoming clear that conventional urban development approaches are no longer appropriate.

Typical low-density subdivisions and housing are both land and resource inefficient. In addition, sprawling fringe development compounds societal problems such as obesity, social isolation and transport congestion. Infrastructure and urban planning need to become even better coordinated to ensure ordered city expansion that optimises the economic benefits of agglomeration while minimising the social and environmental impacts[8]. Australia's cities need to absorb growth, reduce sprawl and create sustainable, liveable and low carbon environments. In short, a new model of urban development is required.

Yet progress in this area has been slow. According to the Green Building Council of Australia (GBCA), retail and commercial buildings with a low carbon rating represent only 27% of the new floor space added to Australia's built environment over the past 12 years. In the residential sector the record is even worse— less than 1% of new buildings achieved a zero-carbon footprint over the same time period. Extrapolated over the entire built environment in Australia—about 361 million square metres of floor space—only around 0.1% of building stock in 2018 achieved a low carbon standard[5].

Liveable cities

Australian cities are renowned for the high quality of life they afford their residents. The 2016 OECD Better Life Index, ranked Australia a close second to Norway for quality of life across 11 indicators[9], while the Economist Intelligence Unit in 2017 ranked Melbourne the most liveable city in the world (Adelaide was 5th and Perth 7th[10]).

But this liveability comes at a cost. Research shows there is a clear correlation between higher city liveability and larger ecological footprint, especially for low density cities in Australia, New Zealand and North America[11,12]. Decoupling ecological footprint from the high consumption patterns currently associated with liveability is one of the key challenges of the 21st century[13–15]. The task is not so much what to do, but rather how to mobilise action at speed at scale.

At the same time, there are indications that quality of life performance of Australian cities is slipping. The Mercer Quality of Living Survey ranks Australian cities very highly, but observes a risk for reduction in quality of living in the four most populous and fastest growing cities (Sydney, Melbourne, Brisbane and Perth) as a result of population growth outpacing investment in lifestyle-enhancing infrastructure such as public transport[16].

Therefore, the challenge for sustainable urban development in Australia is twofold: the need to decouple liveability from high ecological footprint (which measures resource use and emissions); and to do so while accommodating urban growth through the provision of infrastructure and development in a way that creates liveability and sustainability[17].

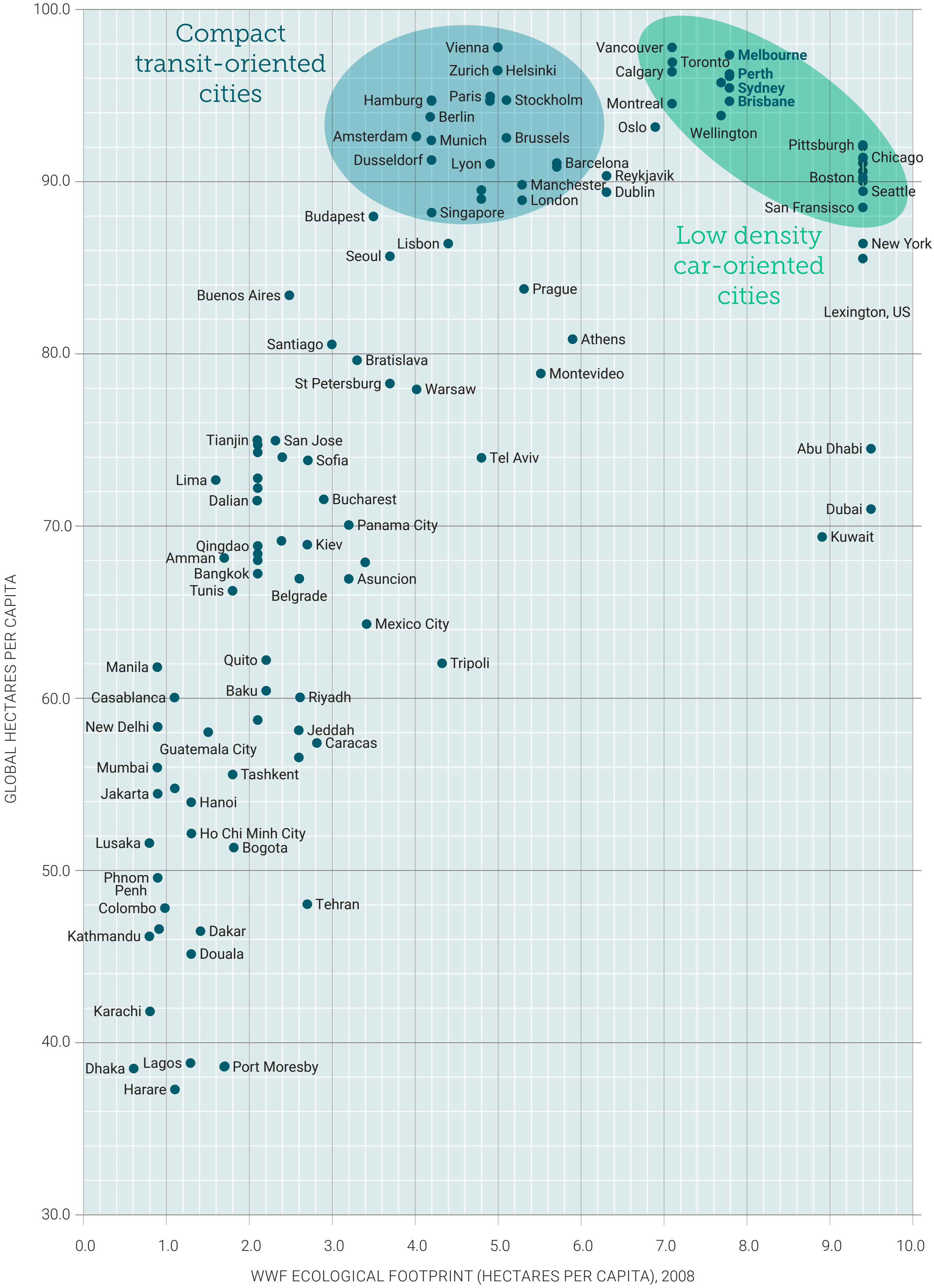


Figure 1.2 Sustainable and Liveable Cities.
Source: Newton[11]

Sustainable cities

Decarbonising our cities is critically important. In Australia, the building sector accounts for about 36% of overall carbon emissions[18].

However, this guide goes beyond considerations of low carbon to address broader interlinked sustainability factors, such as the integrated outcomes required by the global agreements (SDGs, NUA etc). These factors include energy, water, waste and biodiversity in a holistic approach that covers most of the material flows into and out of cities.

Generally, modern cities have been designed as extractive engines drawing resources from natural systems, processing these resources to generate value and in the process producing wastes. Wolman[19], in the 1960s, was the first to liken this process to the metabolism of an organism. This notion of 'material flow accounting' within human settlements is commonly referred to as 'urban metabolism'[20–23].

Urban metabolism can be explained as either linear or circular. Linear metabolism extracts material inputs from the biosphere and expels them as substantial wastes into the biosphere, at rates that often exceed what can be absorbed by nature (leading to the accumulation of greenhouse gasses in the atmosphere, for example). Circular metabolism cities, in contrast, are designed to use waste as a resource. This makes them more efficient and can greatly reduce their environmental impact because they require fewer inputs from nature and produce fewer waste outputs[21,24,25] (see Figure 1.3).

Conventional cities, particularly in wealthy countries like Australia, tend to have linear metabolism with high resource inputs and large waste outputs—hence Australia's large ecological footprint. A sustainable resource-efficient city that is more in line with the circular metabolism model is significantly decoupled from resource exploitation and ecological impact and is socio-economically and ecologically sustainable in the long term[15]. Australian cities with all their climatic and geographic advantages should be leaders in sustainable urbanism through harnessing renewable energy flows, recycling waste and pollution reduction.

The urban greenery bordering Sydney's CBD both enhances liveability and provides ecosystem services to support the adjacent high density developments.

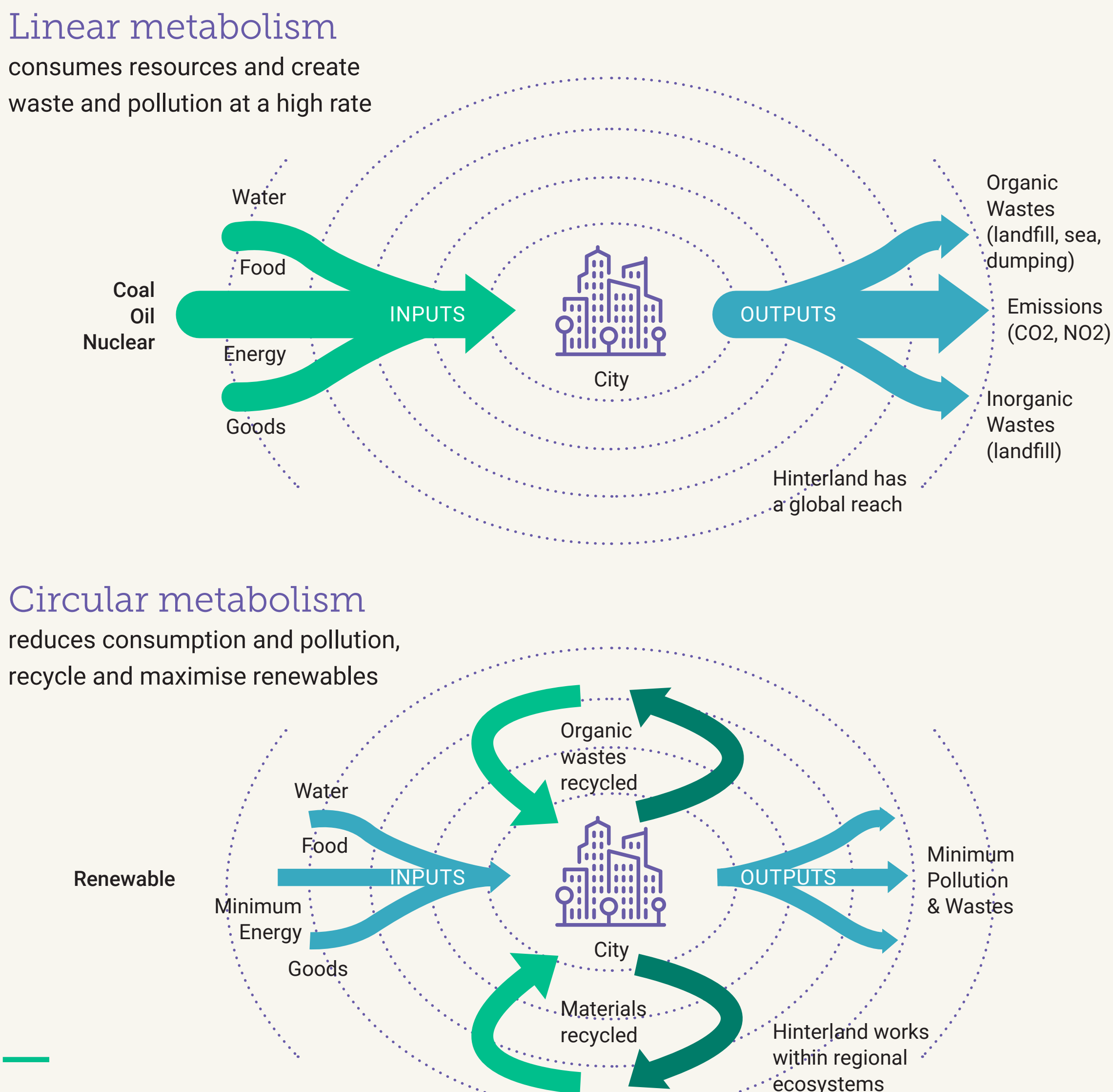


Figure 1.3 The metabolism of cities.
Source: Girardet[24]

To become more resource efficient, Australian cities must improve the monitoring of:

- water, electricity and energy consumption
- interventions to improve the efficiency of resource use
- renewable energy generation
- amount of waste generated and recycled per type
- greenhouse gas emissions per sector
- urban food flows and food security
- and identification, conservation and management of biodiversity and ecosystem services[26].

Improved monitoring can reveal leverage points for sustainability performance enhancement through approaches such as those described in this guide.

What is a sustainable precinct?

A precinct is a unified area of urban land with a clearly defined geographic boundary[18]. In the context of this document, a precinct is a synonym for neighbourhood or district. A typical precinct will contain private and public land with shared infrastructure.

Larger sustainable precincts are typically characterised by:

- medium- to high-density development (to optimise the use of the land);
- mixed-use zoning (residential mixed with retail, services and employment to reduce daily travel needs);
- the provision of good public transport (to reduce car dependency);
- access to high-quality urban greenery and an emphasis on integrating pedestrian and public spaces to create a 'village' feel in a city context (to enhance quality of life)[27].

A defined boundary is critical to the notion of a sustainable precinct because many of the low carbon precinct concepts involve distributed infrastructure that requires clear boundaries from a legal ownership and management perspective. A well-defined boundary, with a clear governance structure, allows for the precinct to be managed and monitored at the local level, permitting it to function as an autonomous or semi-autonomous piece of the city where local managers drive ongoing and iterative improvements (see Section 04).

From this perspective, defining a precinct's boundary is more important than its scale. Precinct size can vary considerably; for example, the well-known sustainable precincts BedZED in London and Hammarby Sjöstad in Stockholm are 1.7 hectares and 250 hectares respectively. This does not mean that size is irrelevant. Precinct efficiencies tend to have physical thresholds and the size of the land parcel available or the desired technology will influence the sustainability approach. Precinct Information Modelling (PIM) systems now provide a flexible digital platform for precinct design and assessment that permit their boundaries, spatial contexts and associated attributes to be defined and re-defined in real time to support scenario assessments in urban planning and development projects[28,29].

Precincts also need to be considered in relation to their wider geographic context. While a precinct approach is relevant for a neighbourhood or even a small town, far greater benefits play out at the city scale where multiple precincts interact. In this regard, **precincts are building blocks for cities**. This is especially true when they are designed with the discipline of a cellular structure—that is, clustered around the local needs of a community such as shops, services and recreational space. Linking the centres of precincts via public transport corridors greatly reduces private vehicle use and therefore carbon energy, while improving connectivity between neighbourhoods.

Hammarby Sjöstad in Stockholm. Photo: Giles Thomson

In 2011, the Australian Government published *Creating Places for People: an urban design protocol for Australian cities*[30], which clearly illustrates the relationship between precincts and the various scales of urban design, strategic and statutory planning in Australia. (See Figure 1.4)

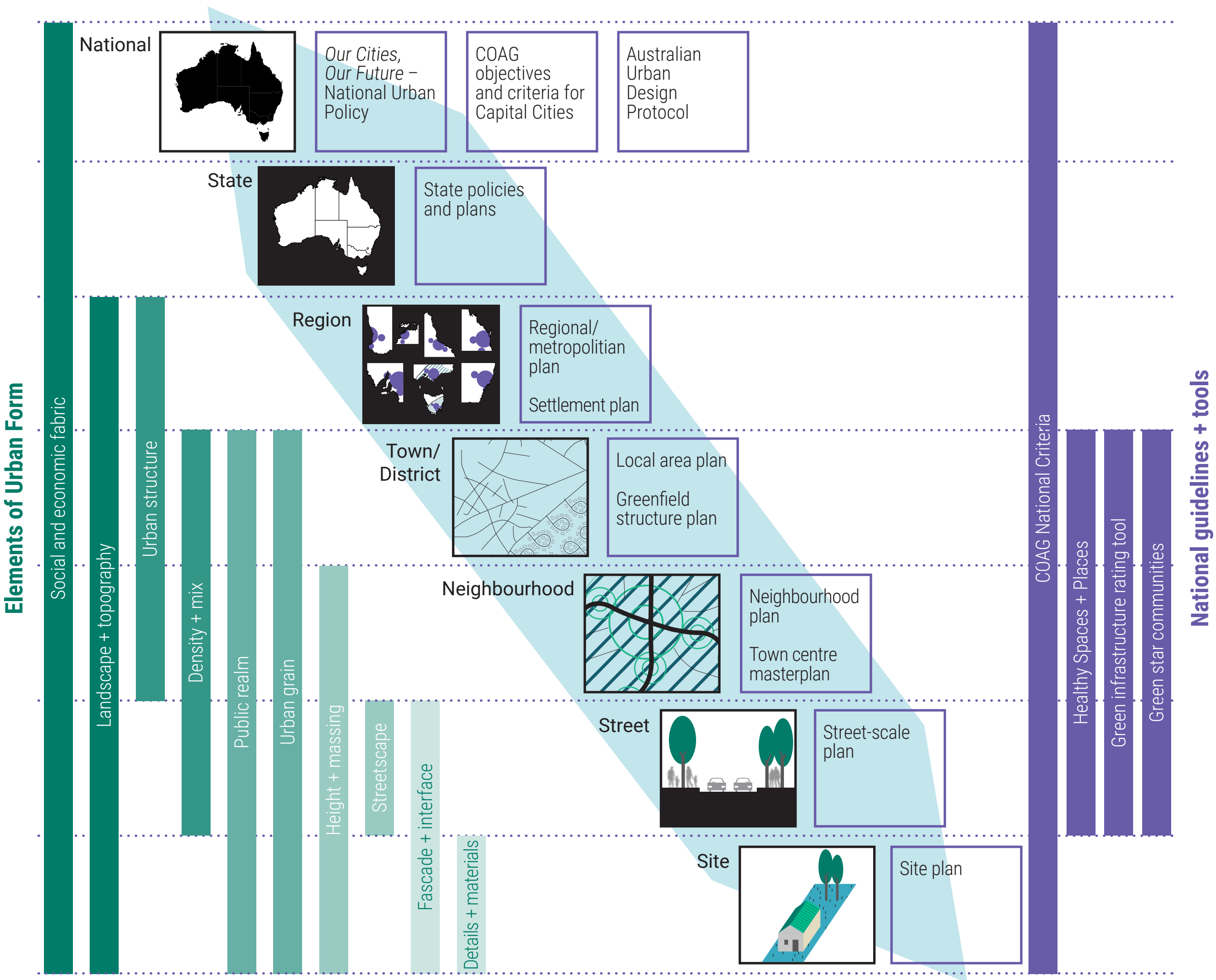


Figure 1.4 Various scales of urban design, strategic and statutory planning in Australia.
Source: Creating Places for People: an urban design protocol for Australian cities (Australian Government, 2011)

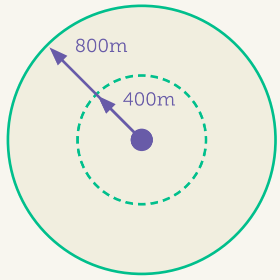
Sustainable precincts are building blocks of a sustainable city

It is well established that different cities have different environmental performance: it is also true that different parts of a city have different sustainability performance[31].

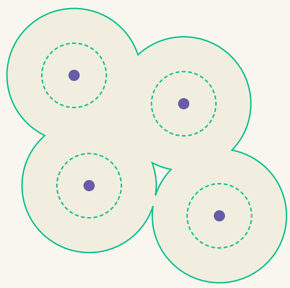
Therefore, every sustainable precinct delivered within a city has the potential to function as a discrete urban geography that cumulatively assists the transition towards an overall sustainable city. This notion is particularly relevant for decentralised precinct performance and the integration of energy, water and waste management. The sustainability advantages of precinct-scale regeneration spans numerous functions[32]:

- **Accessibility** – mixing dwelling types with other land uses reduces travel time and encourages active transport modes such as walking and cycling;
- **Energy** – carbon neutrality or zero carbon status is achieved through the introduction of distributed (renewable) energy and micro-generation technologies capable of generating energy for local use as well as for the national grid[32];
- **Water** – integrated urban water systems involving water-sensitive urban design with an appropriate mix of technologies for local water capture, storage, treatment and end use; and
- **Waste** – optimal reuse of demolished stock and minimal waste from new construction and efficient household waste disposal. This includes automated disposal and maximised recycling from occupied dwellings[33]

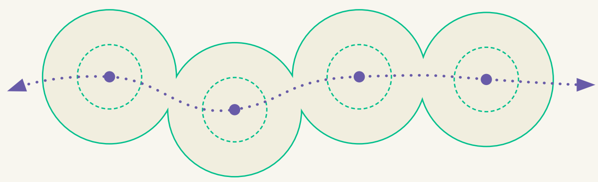
The physical characteristics of a precinct are influenced by the local climate zone as well as the dominant local transport mode. Precincts are most sustainable when served by public transit. Clustering services, housing, and jobs as transit-oriented development (TODs) encourages public transport use and reduces the need to drive. A string of sustainable precincts built along a high-capacity transit route will form a high-density sustainability corridor (see Figure 1.5), or a cluster of precincts that form a city region. The influence of transport on urban form and the role of sustainable transport in precincts is discussed in Section 02.



A. An idealised scale for a precinct is less than a 10 minute or 800m walking radius (catchment) to maximise accessibility for pedestrians from centralised services such as shops, retail and transit.



B. A collection of walkable precincts are a good cellular building block for a sustainable city. The viability of any centralised services will depend upon having a relatively high population density within the surrounding catchment.



C. A string of precincts served by transit will create a high mobility public transport corridor. Connectivity between precincts and destinations futher afield is served by mass transit.

Figure 1.5 Walkable precincts as the building block of sustainable cities.

Planning arenas

Traditionally, urban growth in Australia has occurred as **greenfield** development on previously undeveloped sites typically on the fringe of existing settlements.

This 'urban sprawl'[35] has led to the social fragmentation of cities and has had a negative impact on the agricultural and ecological land that it displaces. The trend toward building larger homes in these urban fringes has resulted in high energy use for heating and cooling and increased dependence on motorised transport. The combined impact has been increased energy-related emissions.

Attempts to contain this urban sprawl have focussed on 'infill' development, that is new development on within the existing urban boundary, either by building on left over spaces or through demolition and redevelopment. Across Australia, all metropolitan agencies have established infill targets in an attempt to redirect population and housing investment inwards as urban regeneration rather than outwards as urban sprawl.

"

Urban regeneration near existing activity centres has the greatest potential for sustainable outcomes and improved quality of life for residents.

Urban regeneration extends beyond individual buildings to a more complete re-development of adjoining land parcels and associated urban infrastructures[36–39]. For this reason, it is a higher-order process than either retrofitting or *ad hoc* redevelopment of individual properties. Urban regeneration has the greatest potential for sustainable outcomes and improved quality of life for residents.

In contrast to urban sprawl, urban regeneration takes place on either **brownfields** (abandoned or under-used industrial or commercial sites, typically larger parcels with a single government or industry owner[40]) or **greyfields** (ageing but occupied tracts of inner and middle ring suburbia that are physically, technologically and environmentally failing and which represent under-capitalised real estate assets[40]). Different development models involving planning, urban design, finance, construction and community engagement are required for each.

Brownfield urban regeneration at Claisebrook Cove in East Perth. Photo: Giles Thomson

Urban fabrics

Urban fabric is a shorthand for urban development patterns that result from different underlying transport infrastructure.

Urban fabric includes transport infrastructure such as road or rail technology, building setbacks, and road patterns and widths, which in turn shape the form of the more localised infrastructure of buildings, open space and utilities.

The Theory of Urban Fabrics developed by Newman, Kosonen and Kenworthy[41] posits three dominant city types from history: **walking cities**, **transit cities** and **automobile cities**. Most cities today have a mixture of all three urban fabrics (Figure 1.6).

Walking cities are dense, mixed-use areas of generally more than 100 persons per hectare. This is the oldest urban typology which dominated until the 1850s. Many modern cities, including Australia's 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[42,43]. Reacting to this competition, many modern cities are now attempting to reclaim the fine-grained street patterns associated with walkability[44,45]. The (US) National Association of City Transportation Officials (NACTO) has commissioned a major global study to create a series of manuals that balance human needs and transport considerations. These provide useful context material taken from global best practice. Particularly relevant to urban precincts is the *Global Street Design Guide*[46].

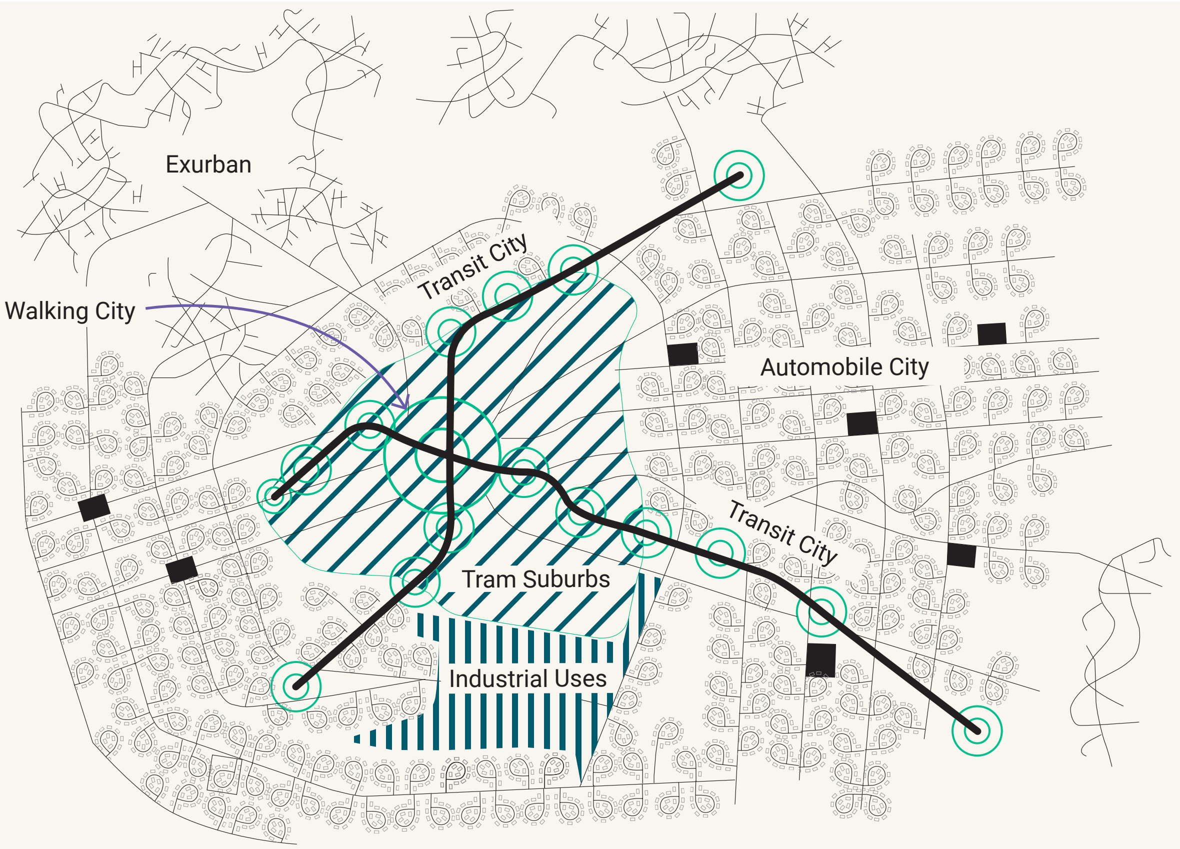


Figure 1.6 Automobile city, transit city and walking city: A mixture of three city types.
Source: Newman and Kenworthy 2015

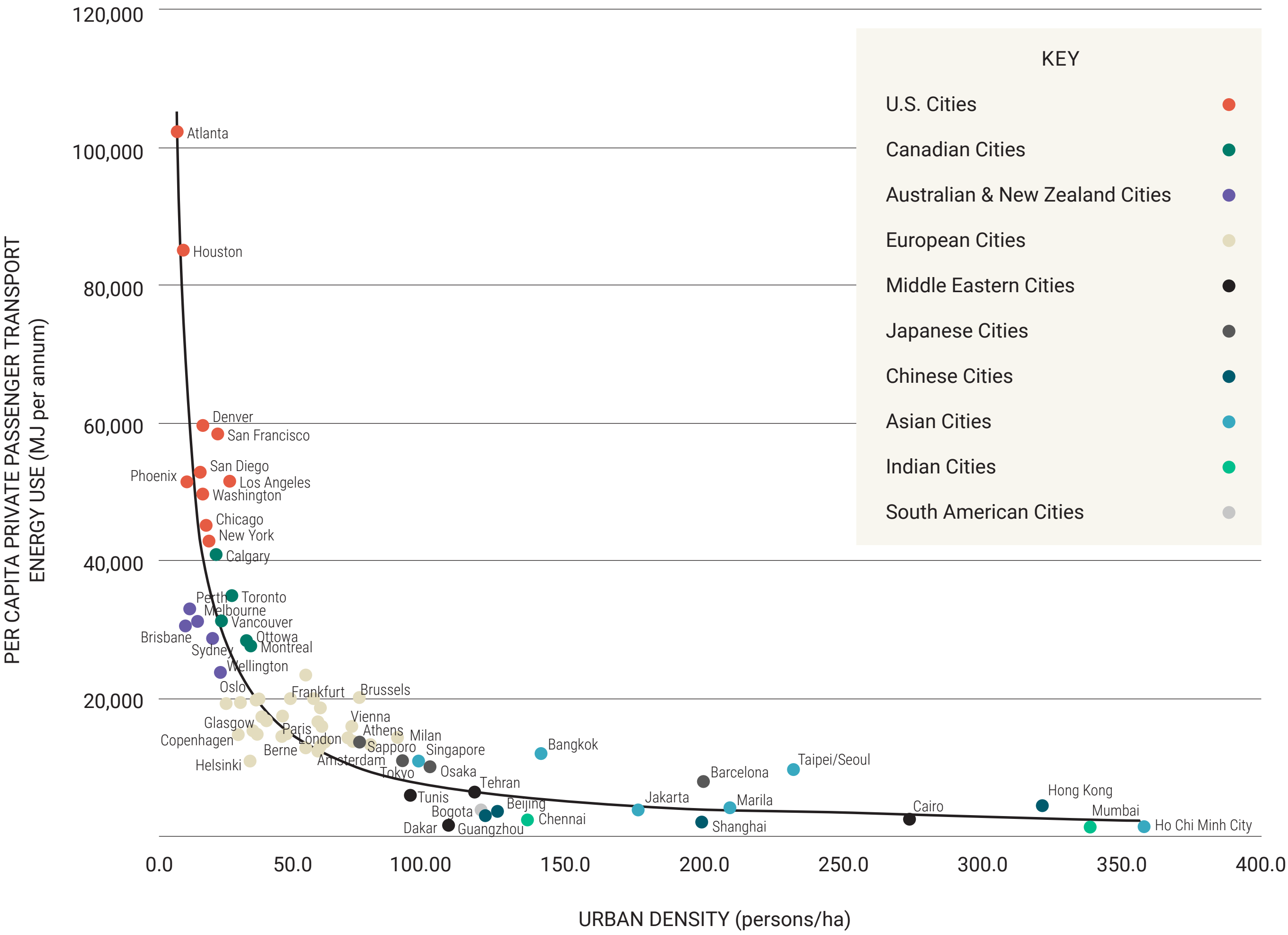


Figure 1.7 Urban Density and transport fuels in global cities.
Source: Newman and Kenworthy 1999

Transit cities are extensions of the old walking city made possible by the introduction of trains and then trams between 1850 and 1950. 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 city centre. Transit city fabric has had a considerable revival in recent decades and is a preferred location for knowledge economy jobs such as education, hospitals and health professionals, and consulting services.

Automobile cities emerged from the 1950s onward with the advent of mass automobile production. With accessible motor transport, city growth was no longer constrained to fixed transit corridors. In these new kinds of cities, population densities fell to less than 35 persons per hectare (low density sprawl) because the flexibility and speed of cars (average 50-80 km/h on uncongested roads) allowed residents to live well beyond a 20 km radius from the city centre.

The term 'automobile dependence' was developed in the 1980s to express how cities are increasingly being built around the car[47]. A fundamental problem with 20th century town planning has been the belief that there is only one type of city: the automobile city; as cities grow the negative aspects of designing cities predominantly for automobile use, such as congestion and emissions, become increasingly apparent. Low urban density reduces the potential for cost-effective transit and as a result, sprawling suburbs become

Automobile dependent planning approaches reduce the liveability and sustainability of our cities.

the basis of automobile dependence[47]. The result is far greater per capita consumption of energy use and corresponding emissions (see Figure 1.7).

The low density automobile city is the most resource-consumptive type of urban fabric, due to its inefficient use of land and associated increases in basic raw materials for building longer roads, pipes and wires to service an increasingly dispersed population[48]. In addition, low densities have significantly worse economic and social outcomes, such as obesity, social isolation, reduced amenity etc., than other city types[49]. Substituting conventional cars with electric vehicles will reduce automobile emissions, yet it has little impact on other issues associated with the dominance of automobile urban fabric, especially where it extinguishes the best features of walking and transit fabric[41]. It is this recognition that is driving the previously mentioned strong re-urbanisation of Australia's cities. Despite this demand, the automobile city fabric remains the main urban development focus post 1950[43] and continues to erode walking and transit fabrics. That it continues to do so in the face of overwhelming evidence of the social, environmental and economic problems it causes[47,50–52] is a failure of policy and planning.

SECTION

02

Sustainable precincts – themes

When planning and designing a sustainable precinct it is helpful to consider a range of thematic areas to ensure holistic outcomes. This guide considers themes such as prioritising public transport, designing with nature, optimising the urban structure, promoting precinct-scale energy systems, and integrating water and waste systems.

West Village, UC Davis.

Photo: UC Davis

Prioritise sustainable transport

Evidence shows that communities with greater public transport and active transport (walking and cycling) produce lower emissions and have healthier residents[22,53,54] and improved living environments[22,47,50]. The CRCLCL has developed a co-benefits calculator to help understand these interrelationships.

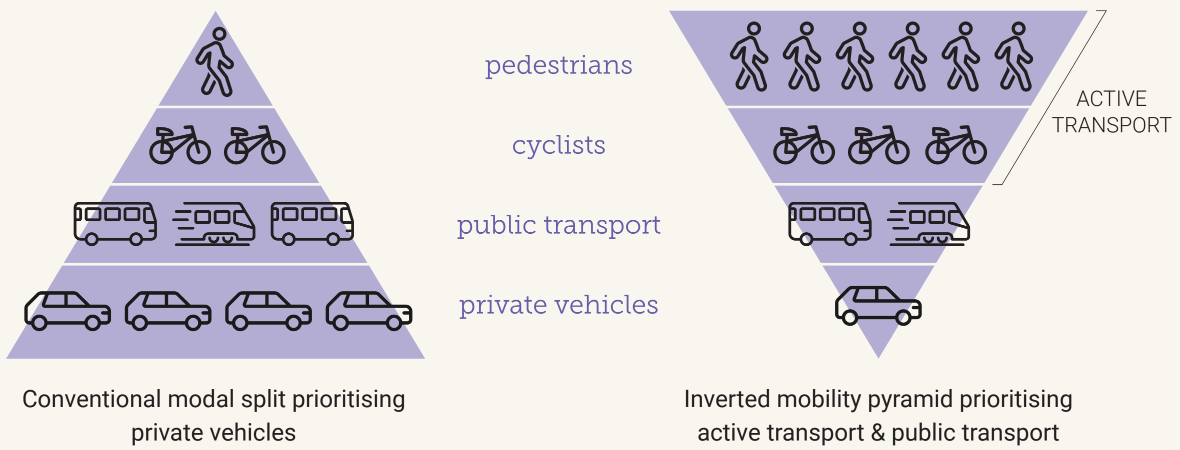


Figure 2.1 Conventional versus Sustainable transportation priorities.
Source: after Gehl

Sustainable precincts should:

Prioritise active transport

The overall objective, according to Danish architect and sustainable design proponent Jan Gehl[44], is to 'invert the transport hierarchy' to prioritise planning for pedestrians, cyclists and mass transit over cars.

Cars moving at 60km/hr are incompatible with pedestrians who, even when running, rarely exceed 15km/hr, and cyclists who travel at around 20-30km/hr[46]. Being aware of these speed differentials allows planners to design safer road environments. Reducing vehicle speeds and giving priority to pedestrians and cyclists in precinct centres creates safe environments. When vehicle speeds are below 30km/hr most commuting cyclists feel comfortable on the street and dedicated cycle lanes are not necessary, although cycling experiences vary and options should be provided for less capable and less experienced cyclists including children. Designing supportive infrastructure with cycling in mind, such as the provision of undercover cycle storage in buildings and end of trip facilities (eg. showers, lockers etc.) at cycle parking facilities further invites greater cycling participation. Location also matters, parking facilities should be provided where people want to be, for example in retail hubs or major public transport hubs.

Reduce private vehicle use

Reducing car use requires a shift in thinking from an emphasis on high levels of **mobility** to high levels of **accessibility**. High levels of accessibility means locating services, facilities, activities and open spaces

Table 1 Calculations of Transport patronage capacity per hour per kilometre of lane space.

Transport Mode	People per hour per km of lane space	Multiples of car capacity in a suburban street
Car in suburban street	1000	1
Car in freeway lane	2,500	2.5
Bus in traffic	5,000	5
Bus in freeway lane (BRT)	10,000	10
Light Rail	10,000-20,000	10-20
Trackless Tram	12,000-30,000	12-30
Heavy Rail	50,000*	50

* Hong Kong has a new service that provides 86,000 passengers per hour per direction, based on 12 car trains with a capacity of 3750 per train every 2.5 minutes. Source: MTRC 2018. Based on Newman and Kenworthy[22,43]

close to housing and with good cycle and walking links[55]. It also requires ensuring a sufficient population to support the services. Shops for example, need a viable economic catchment, so a high density of residents and workers nearby (eg. less than a 10-minute walk), will encourage people to walk or cycle. Walking and cycling accessibility is therefore intrinsically linked with urban structure and site planning.

A further step is to provide safe, convenient and accessible **alternatives** to private car use[56]. Globally, people are turning to rail to bypass inner city congestion. Designing new city precincts in response to this trend will 'future proof' neighbourhoods and make them more competitive as urban travel becomes increasingly slow for cars. Congestion is itself a function of the spatial limits of urban streets. A freeway lane can handle around 2500 passengers per lane per hour, in comparison, rail-based solutions offer ten times that movement in the same space (Table 1).

Design for transit

Precincts can be designed around transit as Transit Oriented Developments (TODs). Transit should be integrated into locations where residential and employment uses are concentrated, but also link to destinations such as retail centres, institutions (schools, universities, hospitals etc), sports stadiums and other large transit generators. High-volume, high-frequency transit such as rail or light rail is preferable. The benefits of rail are summarised by Newman, Kenworthy and Glazebrook as:

- lower per capita private passenger transportation energy use
- lower per capita traffic congestion costs
- lower per capita emissions from the transportation sector
- lower per capita traffic fatalities
- lower per capita consumer transportation expenditures
- higher per capita transit service provision
- higher per capita transit ridership
- higher transit commute mode split
- lower transit operating costs per passenger kilometre
- higher transit service operating cost recovery
- lower CBD parking per 1000 jobs
- better overall urban design especially through Light Rail Transit systems[56].

To support ridership and ensure service frequency is maintained, high-density residential development should be concentrated within a 10-minute walk (800 metres) from rail stations. A major difficulty with rail infrastructure is the disruption that results from retrofitting it into existing urban areas; much of the rolling stock used in Australian cities was developed decades ago. However, advances in technology have expanded the possibility of mass transit. Exploratory studies suggest Australian cities could greatly benefit from an emerging transit technology, electric propulsion with storage and recharging (Guided Electric Transit System – GETS), and the replacement of metal tracks with rubber tyres, which transforms the current type of light rail into what is commonly referred to as 'Trackless Tram'[57]. This technology that has emerged from Europe and is now being trialled in China. While many light rail projects take years to build, this form of transit does not require digging up roads and lengthy

Trackless Tram technology in China. Source: CRRC Zhuzhou Institute

delays; rather it can be installed virtually overnight (with stations prefabricated for rapid onsite erection). The technology also lends itself to driverless guidance systems (Autonomous Rail Technology – ART).

There is a trend in some Australian cities toward building parking facilities next to rail stations, particularly for heavy rail, to encourage ‘park and ride’ behaviour. This should be avoided. Car parking adjacent to a station encourages vehicular traffic, which in the process destroys the quality of the pedestrian environment. The highest and best use for land in a station precinct is mixed use, medium to high-density development, as this type of land use can provide high ridership volumes within the walking catchment and create a more vibrant, attractive and pedestrian-friendly place to live[58].

Provide good transit feeder systems

Accessibility through well serviced transit—shuttle services to feed rail or other mass transit—can widen the catchment areas of mass transit systems, making them more economic in lower density suburban areas, or in cities where activities are highly dispersed. In the future, this is likely to involve the use of autonomous feeder services (see Figure 2.2).

Minimise car parking

Car parking takes up space, and space in urban environments is a limited resource. Due to typical minimum parking standards, the higher the density the more space must be allocated to car parking. However, mandatory car parking standards reduce quality of place, encourage car dependence and reduce site yield. Loss of site yield impacts developers (fewer dwelling units to sell) and local Councils through a reduced rate base (fewer residents to tax). There is an argument that car parking is seen as a ‘market requirement’ but there are examples of high-density areas, built prior to the advent of cars, for example the suburb of Paddington in Sydney, that command strong house prices despite little available car parking. This high value can be attributed to proximity to services and sense of place: less parking allows more space for amenity creating open places, plazas and greenery.

Parking is also a hidden cost of our current car-based systems. In Sydney, it has been estimated that car parking occupies at least 100 square kilometres of land, worth in the order of $100 billion if put to other uses (land values in Sydney have recently reached $1,000/m^2). The oversupply of parking, particularly free parking in the suburbs, is effectively a subsidy for

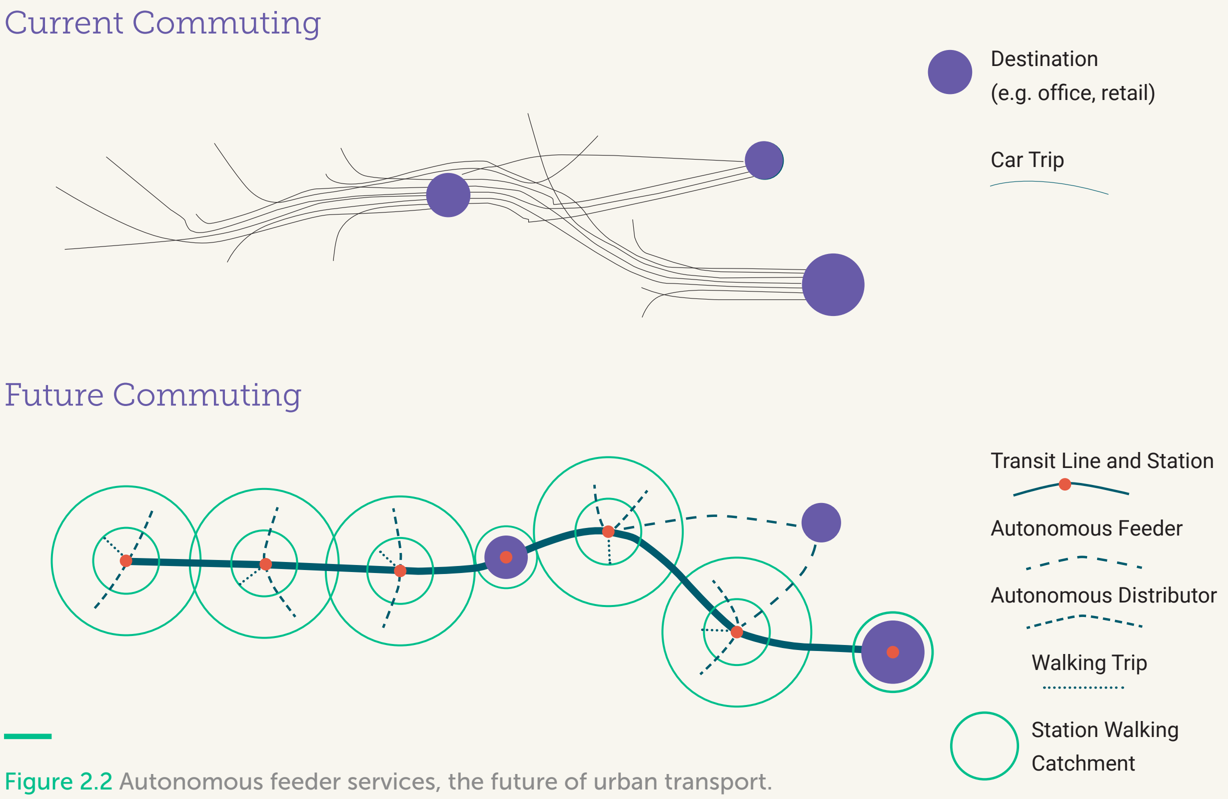


Figure 2.2 Autonomous feeder services, the future of urban transport.
Source: Glazebrook and Newman 2018[59]

drivers that makes driving a cheaper alternative than it should be, and often results in more time spent in cars 'cruising' for a car park. In the US, a study of 160 drivers at UCLA's Westwood Village, a popular activity centre, found that the average cruising time per driver in search of a park was 3.3 minutes during the day and nearly 10 minutes in the evenings. The cumulative impact was a major contributor to greenhouse gases[61]. Similar scenarios would play out in Australian cities.

All great urban environments have a parking 'problem', because as a place becomes more vibrant, active and walkable, more people want to drive to it from other less lively places[62]. The solution, perhaps counterintuitively, is to offer less parking not more. To reduce or remove parking requires the provision of comfortable and convenient public and active transport alternatives. Where public parking is provided it should:

- Attract a fee
- Generate revenue that is diverted, at least in part, into a local 'parking benefit district' rather than absorbed into the city's coffers. Parking revenue is then invested to improve transport and community amenities[61] such as landscaping, storefront facades, and bicycle and walking paths. In the greater Perth region in Western Australia, parking revenue funds the free Central Area Transit (CAT) buses, which loop through the city centres of Perth, Fremantle and Joondalup, allowing pedestrians to hop on and off anywhere on the route. The establishment of parking benefit districts also helps make metered parking more palatable to shop owners and residents who see a clear link between the fee for parking and improvements in the precinct.
- Be unconnected to buildings to encourage drivers, once they leave their cars, to become pedestrians who experience the advantages of people-activated streets.
- Be screened from view to prevent unpleasant streetscapes and avoid footpath interruption which can increase potential driver-pedestrian conflict[58].

Encourage car sharing

Community-based car shares or car clubs are a form of 'collaborative consumption', that allows customers access to a car on a pay for use basis, thereby avoiding the cost of buying their own vehicle, or for car maintenance and storage costs. Unlike car rental companies, car sharing allows people to rent vehicles for short periods of time, often by the hour, making the service particularly attractive in highly connected urban areas where residents need access to a vehicle only occasionally. The benefits to the community include freeing up car parking spaces for other uses such as urban greenery.

Because each hire event is a conscious expense, car sharing motivates residents to utilise alternative transportation modes such as walking, cycling and transit, whereas the sunk cost of car ownership encourages greater car use. The net benefit is fewer people in private cars, lower demand for parking and ultimately reduced greenhouse gas emissions (especially if the car share fleet consists of electric vehicles)[27]. In certain locations, with good walking proximity to services and transit, car share has the potential to completely replace private vehicle use in residential accommodation, especially when the ratio of car share bays to dwellings is high, for example between 1 in 4-12.

Promote Electric Vehicles (EV) and build charging stations

The Australian Energy Market Operator (AEMO) forecasts that, by 2036, electric vehicles will comprise around 20% of vehicles on the road[63]. The overall impact on electricity demand is expected to be minor (around a 4% increase), while fossil fuel use will be significantly reduced (especially if electricity is drawn from renewable sources). However, demand for EV at the precinct scale is likely to be higher, with one study predicting increases in energy demand of up to 40% above average household electricity use[64]. As such, it will be essential to balance loads between household demand, household batteries and EV batteries. EVs are a good complement to rooftop solar, because they can be charged during the day when energy demand (and cost) is low and draw on energy stored in batteries in the evening when household electricity demand (and costs) increase.

E-bikes and E-scooters, whether privately owned or as part of community share schemes, are emerging as viable forms of sustainable transport that contribute to the urban mobility transition away from private hydrocarbon fuelled vehicles and with much lower energy consumption than electric cars.

In precinct developments, charging stations should be provided for EVs in anticipation of increased demand.

Electric Vehicle charging points in public spaces. Photo: Giles Thomson

Sustainable transport principles

- Reduce private vehicle use by improving accessibility to services, minimising car parking and providing safe, comfortable and convenient movement alternatives
- Plan for pedestrians, cyclists, transit and cars in that order
- Design precincts with a 'centre': this should include transit co-located with shops and services of a scale to suit the economic catchment. Higher density developments create more viable centres
- If high-frequency transit is not provided, consider future proofing the site through the provision of potential future transit corridors
- Design precincts around transit as Transit Oriented Developments (TODs)
- Create good feeder routes to transit stops to maximise ridership and reduce car use
- Create an attractive and inviting public realm with cycle and pedestrian routes linking key destinations such as transit, schools, shops
- Reduce vehicle speeds and give priority to pedestrians and cyclists in town centres. In low speed environments (< 30km/hr), cyclists do not need dedicated cycle lanes
- Provide undercover cycle storage and end of trip facilities in buildings and at destinations
- Encourage car and bike share schemes (including EV, E-bike and E-scooters)
- Provide EV charging stations in anticipation of projections that EVs will forming 20% of road vehicles in 2036

Design with nature

Cities exist within a broader natural landscape. They are artefacts of human culture, yet their citizens are subject to the same natural laws that apply to all living things. Urban environments displace natural habitats but there are ways to design with nature in mind.

Harnessing the intrinsic resources of the development site, including working with the existing development form, underlying geology, site drainage, landscape, and solar and wind potential will enhance the sense of place but also achieve more sustainable development outcomes[65].

Climate change poses a massive risk to urban environments. In addition to carbon reduction measures, it is also wise to plan for the major climate change induced risks to urban areas, particularly in terms of those aspects of natural risks that are compounded by climate change such as:

- **sea level rise** – most major Australian cities are located in low-lying coastal areas making them highly vulnerable to climate change, be it sea level rise or flooding related to extreme rainfall events
- **extreme heat events** – which may be amplified by urban heat island effects (where an increase in urban density and canopy loss can lead to increased temperatures due to heat retention); and,
- **bush fires** – as suburban expansion moves into naturally flammable areas and is compounded by a drying and warming environment[66].

Each of these risks needs to be mapped and managed before any planned (re)development. Ideally, this should occur at the regional scale, but this is not always done. Therefore, each project should conduct its own due diligence relating to potential climate change risk. This would include assessing the suitability of the site for development as well as any appropriate adaptation measures to reduce climate change risk.

At the precinct scale, the following design with nature approaches are relevant.

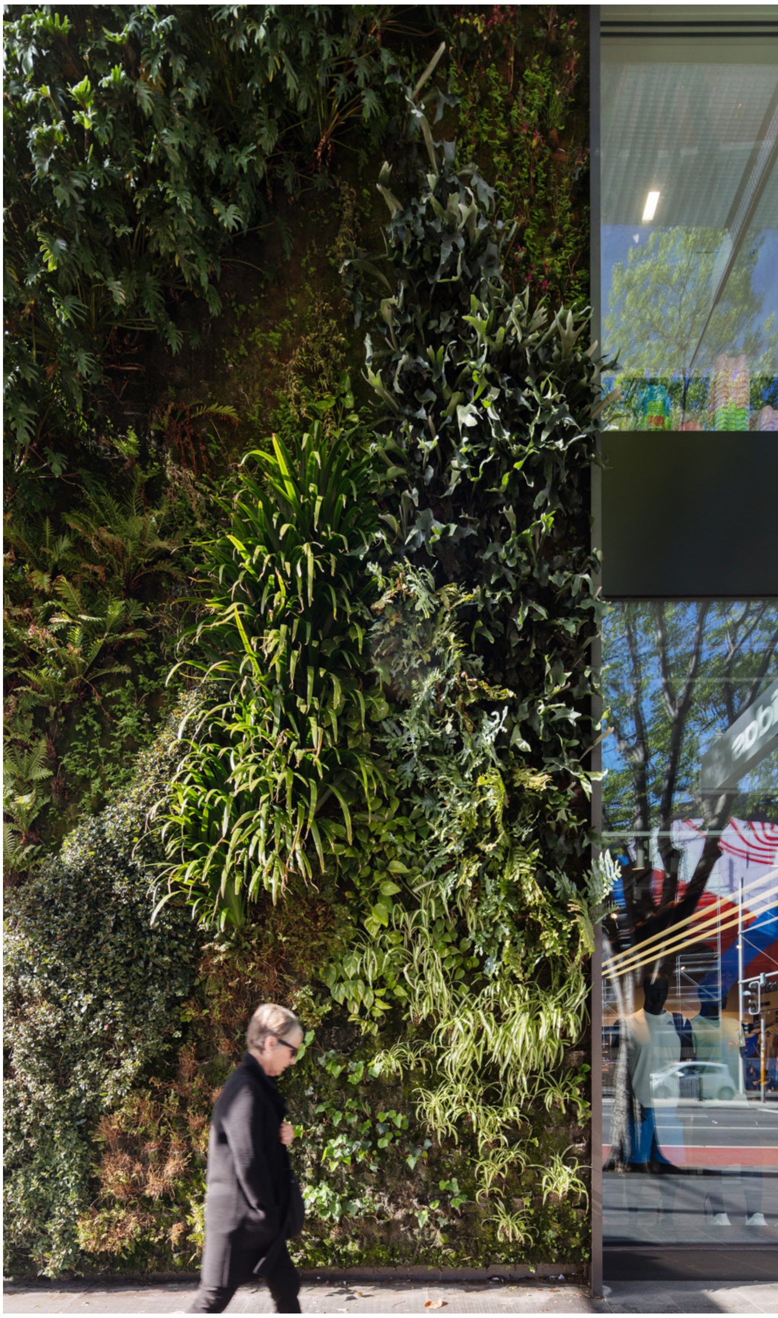
Contextual landscape assessment

A good place to start is to understand the existing ecological, topographic and other landscape assets of a precinct site. Mapping the underlying topographic and natural features as part of a landscape assessment will identify development opportunities and barriers. A landscape assessment will help determine the development footprint, that is, the amount and location of land to be (re)developed or preserved at any given site. This process should seek opportunities to use the existing natural assets to the site's best advantage. Drainage patterns should be identified and the site considered in terms of 'city as catchment'[67], involving water-sensitive urban design at the precinct scale to enable an appropriate mix of technologies for local water capture, storage, and treatment (see integrated water systems in the next section). Drainage and urban water should be considered in close association with urban greening.

Preserve remnant vegetation and seek opportunities to increase urban greenery and habitat

Ideally, this would be in the form of interconnected urban wildlife corridors to enhance biodiversity networks. Wildlife corridors can be co-located with pedestrian and cycle links. Urban greenery is an investment; it increases property values as well as performing ecosystem services (for example urban cooling and reductions in storm water peak flows) and providing psychological relief from stress. Areas with limited access or low development potential make good locations to create wildlife corridors—examples include water courses, or residual spaces such as railway embankments.

There will always be pressure on urban greenery in highly built up areas. For this reason, it becomes necessary to actively seek opportunities to increase urban greenery. Examples of biodiverse habitat that fits easily into urban environments include isolated 'spot' habitats such as 'living' (green and brown) roofs and green walls. Such environments, while not as beneficial as ecological corridors, provide vital habitat for birdlife and insects and protect them from feral predators like



An extensive green wall on the Central Park development in Sydney. Photo: Katherine Lu

cats and foxes. They also provide other ecosystem services such as shading, cooling and slowing the rate and speed of stormwater runoff to reduce urban flood risk[68]. Planting guidelines should specify climate-appropriate vegetation to reduce maintenance needs and reduce irrigation demand. Gardens can be encouraged through the introduction of rear building setbacks and the mandating of 'deep soil zones' to provide environmental conditions to support trees with larger canopies (for an explanation of deep soil zones see NSW SEPP65[69]).

Maximising planting in the public realm—for example dense and layered street tree and shrub planting—will help increase urban greenery. Areas with high car use tend to have less greenery because street tree planting opportunities are limited by driveway crossovers and car parking. Small and apparently insignificant green areas can play an important role in providing ecosystem services, biodiversity and amenity to an urban area. To be most effective green corridors, drainage lines and other natural systems should be co-ordinated to link to similar environments beyond the precinct boundary. Ecosystem services are defined as benefits that humans obtain from ecosystem functions, or as direct and indirect contributions from ecosystems to human well-being. Urban ecosystems are especially important in providing services with direct impact on health and security such as air purification, noise reduction and urban cooling effects to mitigate against urban heat islands and rising temperatures resulting from climate change (See the CRCLCL Urban Cooling Guide). Which ecosystem services are most relevant varies greatly depending on the environmental and socio-economic characteristics of each site[13].

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 for climate change resilience and urban comfort in periods of hot weather. The urban heat island effect has an impact that is greater than just thermal comfort and its related energy costs.

High temperatures also negatively affect health and are closely correlated to increased mortality[70]. Recent research by the Nature Conservancy and C40 Cities demonstrated that leafy trees are the only cost-effective solution for addressing both air quality and rising urban temperatures[71]. Yet, strangely, the benefits of urban greenery and the ecosystems services they provide are often overlooked as areas are redeveloped with infill. WGV in Perth is a positive example, where urban greenery was a central component of the redevelopment from the outset and a factor in its multiple awards for demonstrating best practice.

Utilise green space factors and green plot ratios

Green space factors and green plot ratios are two novel ways to quantify and encourage green space within urban environments. The green space factor was

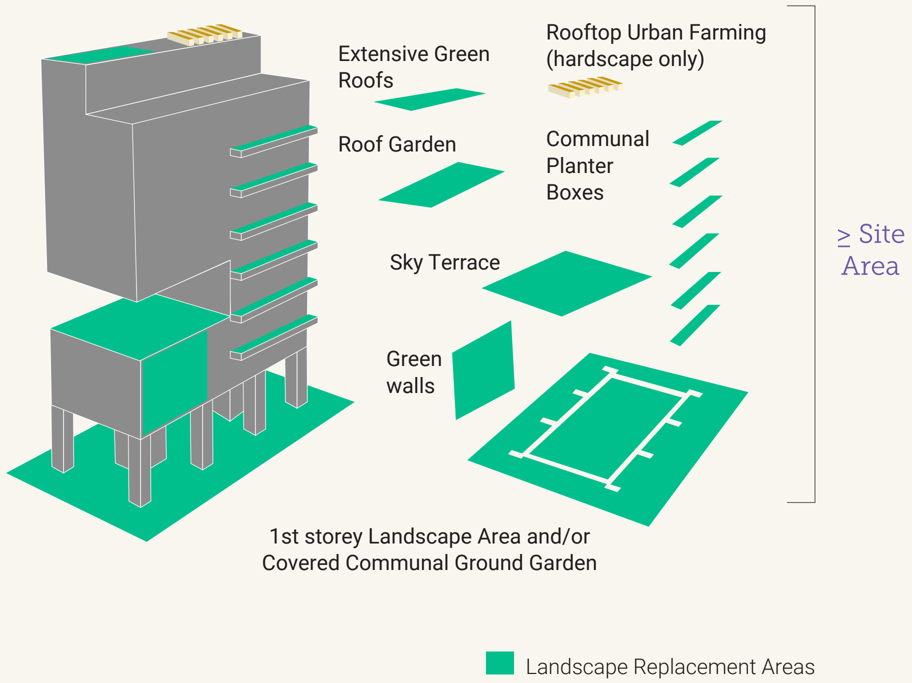


Figure 2.3 Landscape Replacement Areas as part of the Landscaping for Urban Spaces and High-rises (LUSH) programme (LUSH). Source: Singapore Urban Redevelopment Authority[74]

developed in the European Union and uses a points system (checklist of green and blue infrastructure options for developers) to achieve a minimum level of compensation habitat for birds, biotopes in parks and the layout of an open stormwater system[72].

Under their Landscaping for Urban Spaces and High-rises (LUSH), Singapore's Urban Redevelopment Authority imposes green space replacement requirements for new buildings and offers incentives for green space provision in developments. This is to encourage accessible urban greenery. One component of the green space replacement requirements, known as the Landscape Replacement Area scheme (see Figure 2.3), is the Green Plot Ratio (GnPR). This is a proxy of greenery density presented as a ratio similar to a building plot ratio which is commonly used to control maximum allowable built-up areas in a development. Floor area bonuses are also given to developments which provide high quality green spaces. Overall, the LUSH programme encourages a minimum quantity of green space and minimum density of greenery within a development site without necessarily excluding land area from building development. It provides flexibility to the designer while simultaneously protecting the green quota in the design (Ong, 2003). With the combination of incentives and requirements, the LUSH program has been successful. Two in three new residential developments and one in two new office blocks, shopping centres and hotels have taken up at least one LUSH incentive (Urban Redevelopment Authority, 2017).

Case Study

WGV

Location White Gum Valley, Fremantle WA

Climate Mediterranean

Scale/Typology 2.3 ha mixed typology residential precinct (approx. 100 dwellings)

Lead LandCorp

Status Commenced 2013; Forecast for completion by end of 2020

Image: Landcorp

Urban greenery — Capturing and enhancing a sense of place

As a LandCorp 'innovation through demonstration' project, WGV demonstrates design excellence on many levels including urban greening strategies. The landscape design at WGV aims to provide an environment that captures and enhances the suburb's sense of place, while strengthening biodiversity, local food production and community cohesion. Community consultation in the planning of WGV identified the retention of trees as a key objective in order to retain the neighborhood character, provide for wildlife and mitigate the impact of the Urban Heat Island Effect (UHIE).

Design features include:

- **Tree retention**: Road verges have been widened in key areas to retain existing trees, and the use of rear vehicle access lots enables verge flora to be maximised. The road design responds to retained trees, which combined with new planting recreates the historic canopy cover.
- **Water Sensitive Urban Design**: Sustainable stormwater management has been integrated with the streetscape and landscape design. This approach means that vegetation and habitat are doubly valued for their service to the function of the precinct as well as to biodiversity.
- **Revegetation**: To revegetate the site after development, a diverse range of native and exotic trees and shrubs have been incorporated within the public open spaces and road reserves to support the local ecology. These species provide habitat and food for native animals, birds and insects. The tree canopy target for the site is 30% at 15 years post construction, with a tree canopy diameter of 6m. This target matches the tree canopy coverage measured prior to the re-development in 2014.
- **Native wildlife**: To help preserve and restore native wildlife species, an intensive fauna survey was undertaken prior to site clearing. Habitat boxes have been included in mature trees within the development and adjacent road reserves and are the subject of a two-year study to monitor their use. Design guidelines encourage private owners to develop native verge gardens, frog-friendly gardens and include fauna habitats with landscaped areas.

Read more at: landcorp.com.au

Design with nature principles

- Start with a landscape assessment to understand existing landscape and landform assets that may be used to the site's best advantage. For example, drainage patterns can dictate stormwater collection potential, topography affects solar access or can be used to conceal underground car parking
- Set aside low-lying parts of the site for water storage or soaks; this can be incorporated with vegetation or open space
- Aim to preserve remnant vegetation and seek opportunities for urban greenery planting to create interconnected urban wildlife corridors to enhance biodiversity and for green pedestrian and cycle links
- Maximise urban greenery, it is an investment that increases property values, performs ecosystem services (particularly urban cooling and reductions in storm water peak flows) and provides psychological relief from stress
- Maximise urban greenery in the street and encourage green gardens through rear building setbacks
- In highly built-up areas, consider green roofs and green walls and ensure minimum deep soil zones for trees
- To be most effective, green corridors, drainage lines and other natural systems should be co-ordinated with locations outside the precinct boundary
- The green plot ratio and other policies can quantify and encourage greater green space particularly in denser urban areas.

Optimise the urban structure

The urban structure relates to the arrangement of the blocks, streets, buildings, open space, landscape and other features of an urban area[65].

Getting the urban structure right is critical to the overall sustainability performance of a precinct due to its influence on site density, walkability, solar access, green space and so on.

Plots, blocks and street grids

Subdivision patterns and site planning set the foundations for the potential of a site. For this reason, a holistic and integrated approach (comprehensive planning) at the precinct scale is preferable to ad hoc development at the smaller plot scale.

To encourage walking and cycling, the development footprint should be designed with a 'permeable' street grid; that is, with good connections and small blocks (and this pattern should respond to the surrounding street networks beyond the site). Block size will impact upon the potential for private green space. Smaller blocks are more walkable but larger blocks allow greater opportunity for private gardens[65].

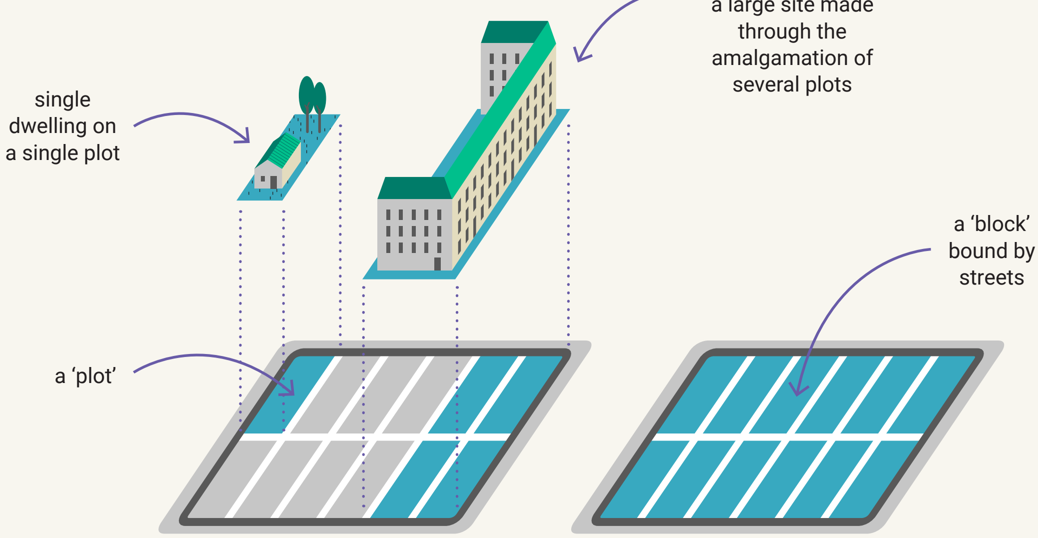
Passive design

Site design should emphasise low cost 'passive' sustainability elements; for example, narrow buildings with high ceilings allow more daylight to enter and reduce artificial lighting needs, operable windows allow through ventilation for heat purging. General principles to consider at the design stage include:

- The streets, blocks and buildings should be arranged to maximise good solar access
- Maximise the amount of sunshine penetrating north facing windows between 9am and 3pm in mid-winter
- East-west blocks will provide the greatest opportunity to orient buildings to maximise the number of north facing windows
- Living areas should face north where ever possible
- Site buildings to the south of a plot to permit a sunny yard
- Topography influences solar access — shorter shadows on north facing slopes permit higher density with better solar access than on the equivalent south facing slope[75].

In dense urban environments, solar access for daylighting and solar photovoltaic potential will require

Figure 2.4
Plot, block and street grids.



* several blocks and the surrounding public realm (e.g. streets and open space) make a precinct.

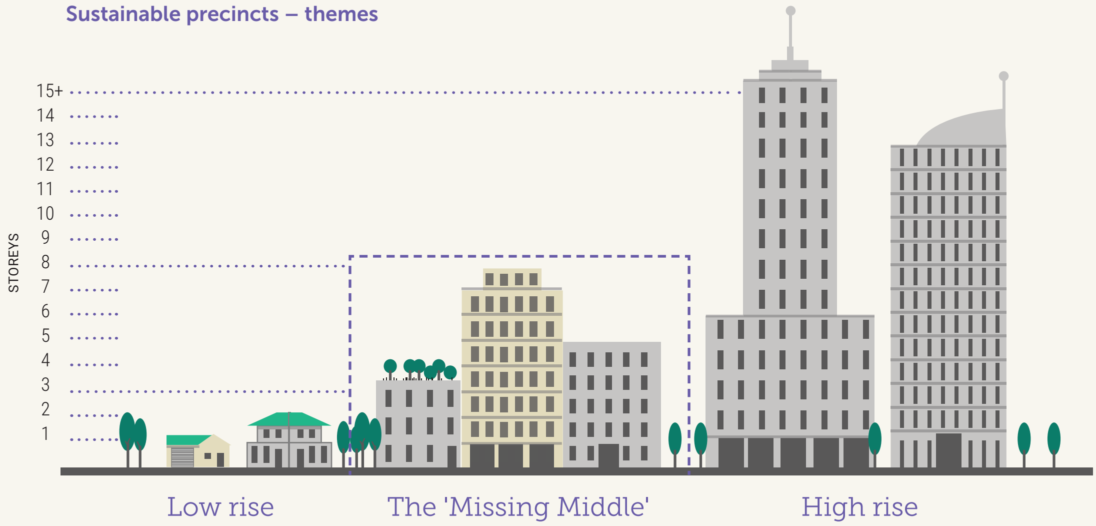


Figure 2.5 The 'missing middle' is well suited to precinct development, offering a good combination of density and amenity.

compromise, so it should be modelled as a standard component early in the design concept phase. Built form massing arrangements should take solar access into account; such modelling capability is standard in most 3D architectural modelling packages and easily achieved. Buildings should be modelled to maximise the potential for energy production through roof orientation and inclination to support solar PV ('solar ready roofs') (Figure 2.6). Consideration for a solar-ready roof would include maximising a north-facing aspect at the optimal solar angle and minimising obstructions such as chimneys or elements that overshadow the roof space.

Height, scale, mass and orientation

The interplay between building forms is what creates spaces, defines the public realm and is particularly important in shaping the passive performance of living spaces —access to daylight, solar potential, ventilation and so on. Site massing and other modelling during the concept design phase allows testing for solar access to living spaces (internal and garden), and rainwater harvesting potential. Overshadowing garden space should be minimised and narrow building depths (i.e. façade to back wall) with high floor-to-ceiling heights will allow maximum daylight penetration to living areas.

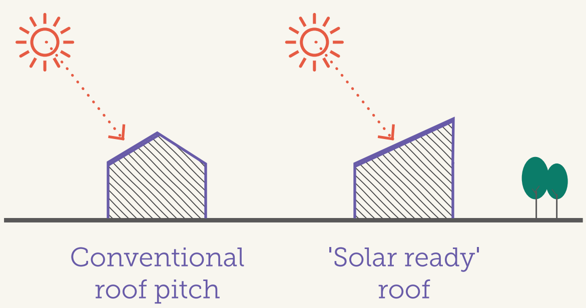


Figure 2.6 'Solar ready' roofs optimise roof pitch and inclination creating far greater solar potential than a conventional roof.

Land use

The design of robust and flexible buildings that can be adapted over time is more important than trying to get the land use mix 'right'. Adaptive reuse stems from building stock that has flexible floor plans. Common examples include historic warehouse structures that can be repurposed for a range of uses from retail to residential. Similarly, some older terraces in inner city suburbs have been retrofitted as bars, cafes, shops or even apartments. Low-density, purpose-built housing does not offer the same flexibility. Designing flexibile floor plans increases the chance for future adaptive reuse saving energy and costs when a change of use is desired.

Missing middle

Australia's cities are becoming taller and wider. Urban sprawl is reducing amenity and the quality of the tallest buildings in our urban centres is coming under question; it has been noted that high-rise apartment towers in central Melbourne are being built at four times the maximum densities allowed in Hong Kong, New York and Tokyo[76]. At the same time planning agencies are routinely failing to meet their infill targets and opting instead for low-density villas or duplex housing[77]. The conspicuous absence of

Prefabrication has benefits for infill developments. It can cut costs, takes less time and is less disruptive to surrounding uses. A modular approach was used in the Adara apartment complex by the WA Department of Communities with Hickory. Photo: WA Department of Communities

medium-density development is being referred to as 'the missing middle' and recent policies by planning authorities (particularly in Melbourne and Sydney) include plans to encourage more of this typology[78]. While definitions vary, the general consensus is that the missing middle needs to be upwards of 30 to 50 dwellings per hectare. This equates to terraces, multi-dwelling townhouses and residential apartment buildings, with building stock between three and eight storeys high—the type of density commonly seen in European cities and in Australia's older urban areas. In addition to medium density, the concept of 'missing middle' also needs to encompass the scale of the development project, especially in greyfields areas where projects above the typical 'knock down rebuild' (2:1 to 4:1) are largely absent[77].

Delivery of higher-density built form is challenged by small plot size. Larger plots provide greater flexibility and, in locations where land parcel sizes are small, opportunities should be sought for site amalgamation through incentives or the involvement of redevelopment authorities as facilitators for land packaging.

Building prefabrication

Technological advancements in housing construction can assist in the delivery of higher density development and the missing middle. Off-site prefabrication has been demonstrated to deliver 40% faster construction times, with fewer on-site delays. Off-site fabrication also results in reduced waste due to streamlined factory production lines; reduced site spoilage and clean-up costs; and improved performance—factory precision creates better thermal envelopes to reduce operating energy costs[79]. In short, manufactured assembly presents economies of scale which, along with reduced construction times and less material waste, translate into lower costs.

Complete streets

'Complete' streets are designed as places for everyone, not just vehicles. They emphasise safety and comfort for people of all ages. In sustainable precincts, they are important spaces for the coordination of service infrastructure to support energy, water, waste and urban greenery. A complete street is designed to be a multifunctional space. A typical complete street:

- Is safe for cyclists and pedestrians while providing for the safe movement of vehicles, albeit at a slower pace and lower volume
- features street trees and inviting places that encourage social interaction and physical activity
- incorporates water sensitive urban design elements
- minimises driveway 'cross overs' to avoid interrupting the pedestrian environment.

Street design should also consider where and how to coordinate services. Although uncommon in Australia, some countries particularly in Europe are creating 'combined utility corridors' which group together pipes (water, gas, vacuum waste collection, district heating and cooling) and cables (electrical, optic fibre). Grouping pipes and cables together improves access to service corridors, creates greater service location certainty and minimises disruption during maintenance work.

Ultimately, the urban structure should ensure buildings, spaces and streets and designed together to create places people want to be.

Sustainable urban structure principles

- Develop a permeable street grid with short block lengths to actively increase walkability
- Block size will impact upon the potential for private green space. Smaller blocks are more walkable but larger blocks allow greater opportunity for private gardens
- Design in low-cost 'passive' sustainability elements e.g. Narrow building footprints, with high floor to ceiling heights allows for maximum daylight penetration, and with operable windows allows cross ventilation for heat purging and fresh air
- Use modelling at the design stage to optimise solar access and PV rooftop potential e.g. arrange the street grid, building alignment and roof inclination to maximise solar orientation
- Building form should reflect the street pattern, energy consumption and the potential for energy production (e.g. solar ready roofs)
- The design of robust and flexible buildings that can be adapted over time is more important than trying to get the land use mix 'right'
- Design 'complete' streets as places for everyone, not just vehicular movement corridors; emphasise safety and comfort for people of all ages. Minimise driveway 'cross overs' and instead use rear lanes for parking access to car parking spaces
- Coordinate services through combined utility corridors, to improve access, ensure greater service location certainty, and to minimise disruption during maintenance work

For more information on designing streets for people, excellent guidance is available from the National Association of City Transportation Officials (NACTO) in the *Global street design guidelines*[46] and from Austroads in its guidance for streets in activity centres.

Precinct-scale energy systems[i]

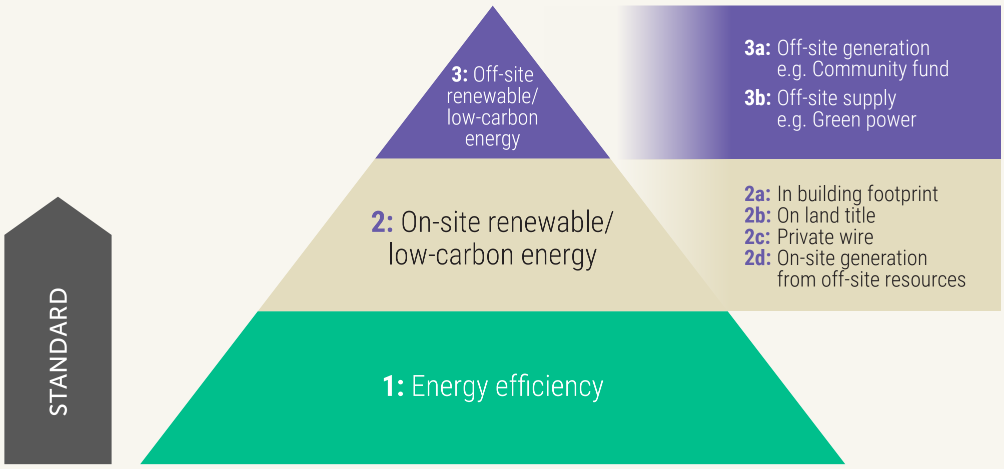


Figure 2.7 Recommendation for Australian standard zero carbon building emissions.
Source: ASBEC[80]

There are numerous methods for sustainable energy generation at the precinct scale; however, this guide focusses on those with the greatest potential in Australian cities. The following section describes some of the key aspects of solar-with-storage generation and also a brief introduction to trigeneration, also known as 'district heating and cooling with energy'. The Australian Sustainable Built Environment Council (ASBEC) recommends a three-step energy hierarchy for the introduction of a zero or low carbon urban environment in Australia:

1. Improved energy efficiency
2. On-site renewable energy (including distributed systems)
3. Off-site renewable or low carbon energy[80].

Given that energy demand is intrinsically linked to building stock, decisions made at the building and site design stage will determine the thermal efficiency of buildings, how much daylight is received and the solar potential for photovoltaics (PV).

The next section looks at precinct-scale approaches to sustainable energy systems.

Demand reduction

The most important step toward energy sustainability is demand reduction, including low carbon, climate responsive building design strategies (see also the **Guide to Low Carbon Residential Buildings – New Build** and the **Guide to Low Carbon Commercial Buildings – New Build**). The foremost consideration is the development of a good thermal building envelope that acts as a dynamic environmental filter to insulate internal temperatures and protect the household environment from large fluctuations in daily and seasonal temperature variations. Buildings should be designed with thermal envelopes that can be sealed during extreme weather to minimise energy demand for heating and cooling. Windows should be placed to allow heat purging and internal cross ventilation for passive cooling and internal air quality.

Knowing the energy demand profile of buildings enables renewable energy supply to be tailored to suit, saving developers money by not over-investing in surplus infrastructure.

[i] The concepts in this section have been developed by Rod Hayes and Matt Rule from Balance Services Group and James Eggleston from Powerledger

West Village UC Davis

Location: Davis, California, USA

Climate: Mediterranean

Scale/ Typology: 75 ha mixed use 'village', 662 Apartments, 343 single family homes, ca. 4000m2 commercial space surrounding a 'village square'

Lead: LandCorp

Status: Built, completed 2014

University of California Davis 'West Village' is the largest sustainable precinct in the US.. Photo: UC Davis

West Village — maximising energy efficiency

The 75-hectare West Village site is the largest net zero carbon development in the USA and is the result of a partnership between UC Davis (as the land owner) and several energy companies under the leadership of a multidisciplinary advisory committee. This 'living lab' draws upon expertise of the university researchers, was built without subsidy and designed to be replicated.

The site is trialling a number of sustainable energy and transport initiatives including the 'Honda smart home demonstration' (launched in 2014) which links EV technology with housing PV. All initiatives are required to be delivered 'at no higher cost to the consumers or developers'[105]. Noteworthy is the site's urban structure and built form which, although simple, greatly aids the overall sustainability performance to allow technology supplements to perform to their maximum effect.

Other features include:

- A regular street grid with strong north-south and east-west blocks
- Centred around a mixed-use 'village square'
- High-performance building envelopes with an average U-value of <0.33
- Natural cross ventilation and shading on the building exterior
- Solar-optimised roofs on all apartments to maximise PV capacity
- PV panels on all parking spaces.

PV provides all the site's electricity, with excess fed to the grid during the day and energy drawn back off the grid in the evenings. Surplus energy from biogas, derived from agricultural and food waste, is exported off site to the adjacent main university campus.

Read more at: westvillage.ucdavis.edu

Distributed energy system (DES)

Small-scale power generation or storage technologies enhance—or provide an alternative to—traditional electric power systems. DES typically provides up to 10,000 kW and lend themselves to integration in the urban environment. DES can include:

- solar PV
- wind turbines
- biomass generators
- geothermal
- solar thermal
- fuel cells (Hydrogen)
- natural gas turbines
- microturbines
- trigeneration units
- battery storage
- electric vehicles chargers
- demand response applications

DES can be designed with energy monitoring and control solutions to meet specific network and user requirements including cost reduction, energy efficiency, security of supply and carbon reduction. Precinct-scale DES can be designed as a standalone microgrid, an embedded network (grid-tied microgrid) or a VPP (see below).

Solar Photovoltaics (PV)

Distributed rooftop solar is popular in Australia. According to the Green Energy Market, the rate of growth in solar PV installations increased by a record 60% in the year to April 2018[81]. In WA, PVs are now installed on 28% of all homes and this could increase to 50% by 2050. The electrical output is so great that rooftop solar is now the "biggest power station" in the state[82].

While solar PV uptake is growing for individual premises, the situation is more complicated in higher-density areas due to multiple ownership of residential buildings (i.e. strata). Strata has difficulty managing PV, particularly the arrangement of an equitable fee structure for the use of the generated energy among residents[83]. However, research and policy changes around strata governance are helping to unleash the potential for far greater market penetration of solar energy in higher-density areas[84,85]. In July 2016, the WGV development in Fremantle, became the first strata development in Australia to offer solar and battery storage. The Sustainable Housing for Artists and Creatives (SHAC) cooperative at WGV is testing its solar PV system along with a shared electric vehicle. Other states, too, are investigating the potential of such schemes. In Victoria, the CRCLCL has produced policies in conjunction with the Victorian Government to promote community energy schemes.

The addition of battery storage to household PV systems has allowed consumers to redistribute their energy load. PVs create the most energy when exposure to the sun's rays is highest, usually midday and early afternoon. Yet in most households, peak energy demand is in the early morning and early evening. Batteries help to rectify this mismatch between energy generation and demand. Given the increasing demand for solar, it is important to optimise solar generation potential. In new precincts developers should:

- Maximise north-facing roof access (some west-facing or flat roofs also allow relatively high solar gain; optimal outcomes can be achieved through 3D solar modelling at the design stage)
- Appropriate roof design to maximise solar gain and minimise overshadowing and to ensure roof structures are strong enough to support PV
- Ensure ease of access to panels for cleaning and maintenance, including safety provisions for working at height
- Allow space for batteries, controllers and inverters (sheltered from the weather, hazards, rodents etc.) and secure them for safety
- Keep in mind that, with current technologies, buildings over five storeys have insufficient roof area for solar panels to meet their energy demands by PV alone.

In June 2018, ASBEC prepared recommendations for amendments to the building code of Australia to assist with the transition to a zero-carbon built environment. This follows other jurisdictions, including the State of California, that have already introduced specific on-site renewable energy requirements to building codes[4].

Microgrids

In the urban environment, microgrids — smaller autonomous grids that can operate with or without connection to the main grid — are increasingly relevant for sustainable precincts because they enable the integration of local distributed energy generation. By connecting multiple household PV arrays into microgrids, for example, energy resilience and load balancing can be improved, and energy bills reduced, among households that rarely maximise their energy demand at the same time.

Microgrids are either publicly owned or privately operated as an 'embedded network'. With increased uptake of microgrids it will become possible to integrate multiple 'smart' microgrids into a cluster of connected 'cellular' networks that enable a large-scale network. Each microgrid automatically defaults to its specific locality if others fail.

Embedded networks

Embedded networks are alternative electricity networks that are owned, controlled and operated by a party other than a network service provider, and have the ability to integrate and optimise distributed generation (and potentially peer-to-peer trade), storage and load, while maintaining interaction with the main grid. A distributed network of smart microgrids offers cost benefits to precincts and increased energy security compared to centralised energy systems, which can be vulnerable to transmission failures.

Virtual Power Plants

Precincts are ideal locations for virtual power plants (VPPs) for multiple distributed renewable energy resources e.g. solar PV. A VPP connects flexible power consumers (i.e. households) to batteries to give a reliable overall power supply. The interconnected system is dispatched through a central control room, but nonetheless VPPs remain independent in their operation and ownership, typically through an energy service company.

> "
>
> White Gum Valley is a rare jewel of… willingness to experiment, to innovate, to ask: How can we make it better?
>
> Geoffrey London – Professor of Architecture University of Western Australia

Hybrid systems

A hybrid energy system harnesses two or more energy sources to provide increased system efficiency as well as better balance in energy supply. In an urban setting, a hybrid system might consist of a combination of solar PV, battery storage and the main grid supply. The combined benefit of solar PV with battery storage is that households and businesses begin to both produce and consume electricity — thus becoming 'prosumers'.

Planning considerations

Australia's electricity market is becoming increasingly decentralised and distributed; however, there is a lack of regulatory oversight that governs the connection of distributed energy to the grid. Currently, state legislation confers the responsibility to individual electricity distributors, resulting in inconsistencies in connection standards and requirements around the country[86]. Several bodies, including Standards Australia, the National Energy Market, Energy Networks Australia, ClimateWorks and ASBEC, are all investigating the policy implications of this rapidly evolving area of energy policy. Any reforms must be evidence-based, consistent across different networks and balance the interests of disparate market participants to create better outcomes for the economy and the grid[86].

Introducing on-site renewable energy requirements into Australia's building code would provide greater certainty about the speed of distributed renewable energy uptake and support planning for future electricity network upgrades. In addition, distributed renewable energy paired with battery storage may help address grid stability issues, reduce transmission and distribution losses, increase the resilience of the grid during power outages and assist with the broader transition to a zero carbon electricity sector[87].

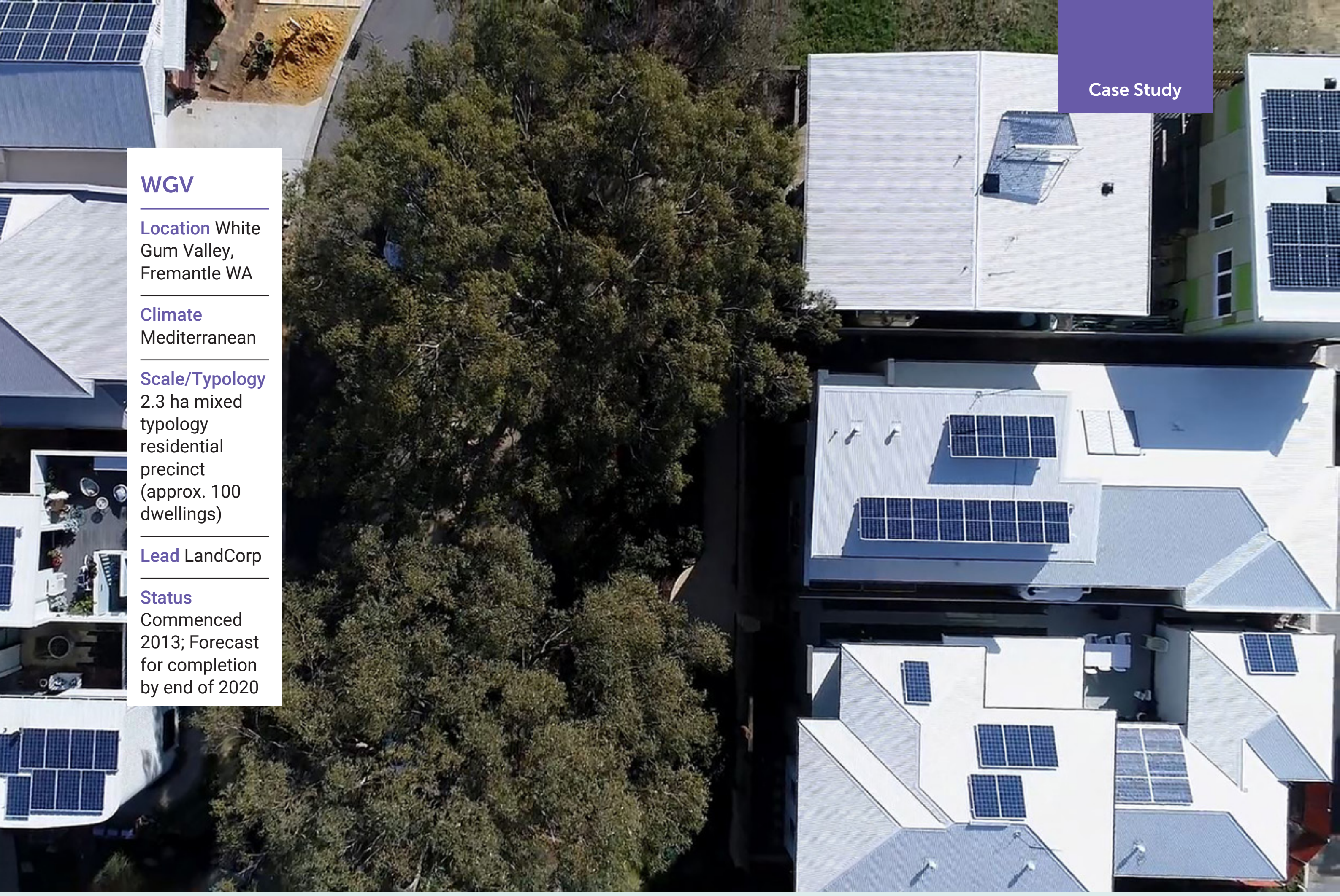


Photo: VAM Media

WGV

Location White Gum Valley, Fremantle WA

Climate Mediterranean

Scale/Typology 2.3 ha mixed typology residential precinct (approx. 100 dwellings)

Lead LandCorp

Status Commenced 2013; Forecast for completion by end of 2020

WGV – energy management

One of the aims of WGV is to achieve 'net zero energy' status, meaning the precinct will generate as much energy as it uses, balanced over the year. This will be achieved through a combination of energy-efficient buildings and rooftop solar energy generation. Several apartment buildings are installing solar energy storage which will see grid energy reliance reduced by up to 80%. The project also includes a shared electric vehicle and a planned peer-to-peer 'across the grid' energy trading trial. Through these initiatives the project is at the forefront of testing new technologies and governance models to support the greater uptake of renewable energy and low-carbon built form outcomes.

The precinct's features include:

- **Energy efficiency**: Design guidelines were prepared for the single residential dwellings to facilitate the building of energy efficient homes. Requirements include minimum 7-star NatHERS performance, solar passive design including provisions to limit overshadowing of neighbours, a minimum 1.5kW roof top solar PV system, and the installation of efficient hot water systems and heating, ventilation and air conditioning (HVAC). Development tenders for the apartment sites required proposals to demonstrate innovation in energy efficiency and provision of renewable energy.
- **Sustainability package**: LandCorp made available a $10,000 Sustainability Package to all single residential lots that complied with the Design Guidelines. The funds provided for the upgrade of the minimum PV system (1.5kW) to 3.5kW allowing the capacity for homes to operate at net zero energy. The package also covered the cost of a rainwater tank, pump and controls to support improved water management (refer WGV – Urban Water Management), as well as the supply and installation of an advanced shade tree to contribute to the precinct tree canopy target (refer WGV – Urban Greening).
- **Solar storage**: Three apartment buildings are participating in a solar storage trial to test battery storage technology and a novel governance model designed to enable equitable sharing of renewable energy by occupants in multi-residential buildings. The apartment buildings range in scale (three units to 24 units) with mixed tenure, both social housing

Figure 2.8 Projected annual dwelling energy demand by load, plus energy sources for the dwellings at WGV, alongside Compliance case. Modelling data source: Kinesis, 2019

and private ownership. Residents are provided with real-time access to their energy consumption data to help them optimise the utilisation of renewable energy.

- **Peer-to-peer trading**: Key stakeholders, including the local network operator, will trial a peer to peer trading environment across the precinct, where surplus solar energy from one building can be traded across the meter to another to utilise this power locally. Conceivably, this trading concept can be applied to other utilities such as water e.g., a community bore (refer WGV – Integrated Water Management).
- **Compliance**: The precinct has shown it can meet the objectives of the Paris Agreement as well as all the Sustainable Development Goals[114].

Read more at: landcorp.com.au

Low carbon energy principles

- Focus on reducing building and transport energy demands
- Monitor energy demand and supply simultaneously. Reductions in energy demand will have considerable economic and environmental benefits
- Consider virtual power management to balance precinct energy generation with demand
- Maximise efficient forms of on-site renewable energy production. Each technology will have its own spatial requirements
- Integrate storage systems to manage renewable energy variability. (e.g. daily solar fluctuations in PV electricity generation). A community battery is likely to offer cost benefits through economies of scale
- Maximise rooftop solar orientation and minimise overshadowing at both the building and precinct scale
- Design buildings with good thermal envelopes that can be sealed during extreme weather to minimise energy demand for heating and cooling
- Provide operable windows to allow passive heat purging and to maximise cross ventilation
- Develop a facility management (site and equipment) strategy where the assets are owned collectively 'behind the meter'
- Consider connection to the grid for the sale of excess energy and purchase of energy shortfalls
- Integrate energy and transport systems, renewable energy generation should be considered in conjunction with electric vehicle infrastructure
- Consider emerging technologies, while solar and battery are likely to dominate renewable energy provision in urban Australia there is potential for other sources e.g. cogeneration fuelled with biogas

Integrated water systems

The stormwater detention sump at WGV has been landscaped to also double as a biodiversity pocket and useable open space when dry. Photo: Josh Byrne & Associates

The ideal scale for water management is the catchment scale, but this can be difficult in urban areas.

However, the precinct lends itself to managing fresh, storm and waste water in a far more integrated fashion than single plots[88]. Natural hydrological water cycles are significantly altered by urban landscapes[89]; therefore, to restore the integrity of the system, the sustainable management of urban water needs to mimic natural approaches.

Water Sensitive Urban Design (WSUD)

WSUD involves the integrated management of urban water cycles. In urban environments, large areas of impermeable surfaces increase rainfall runoff and can result in flooding after high rainfall. Impervious surfaces also reduce groundwater infiltration which, in combination with ground water extraction for irrigation, can significantly reduce water table levels. WSUD measures can mitigate these factors through:

- Integrated management of groundwater, surface runoff (including stormwater), drinking water and wastewater to protect water related environmental, recreational and cultural values
- Storage, treatment and beneficial use of runoff
- Treatment and reuse of wastewater
- Use of vegetation for treatment purposes, water efficient landscaping and enhanced biodiversity
- Water saving measures within and outside domestic, commercial, industrial and institutional premises[90].

Each Australian state prepares guidance on WSUD measures based on local conditions. These measures include:

- swales: linear channels that collect and transfer stormwater and which are vegetated to slow waterflows, reduce erosion and absorb nutrients
- retention ponds
- raingardens
- biofiltration strips, and
- wetlands.

In addition to natural water flows from rainfall and site runoff, urban environments have significant inflows of potable (drinking) water and significant outflows of waste water. These combined factors are known as the 'site water balance'. Piped water not only generates a large water demand from external sources, but also requires high energy inputs for pumping large volumes of water over long distances.

Across much of Australia, all mains water provision is potable even for use in parks and gardens. Potable water demand can be greatly reduced through water efficiency measures, water harvesting from rainwater and stormwater collection for use in laundries and toilets, and recycling wastewater for use in gardens. Water can be fully collected at source within a city, as well as being recycled from greywater and blackwater, and used to help regenerate aquifers and water bodies in the bioregion[17]. Research by the CSIRO[89] looked at the potential for integrated urban water management to reduce water demand at an urban infill site in Perth. It concluded that implementation of water efficiency and reuse strategies, groundwater abstraction and roof runoff capture was sufficient to supply projected in-house uses. Further, if wastewater was reused for irrigation demands the need for mains supply could be eliminated altogether and wastewater discharges halved[89].

The collection and storage of rainwater within precincts is possible from roof and land surfaces; indeed, land surfaces can be sculpted to maximise runoff catchment. Rainwater harvesting is an option to be considered when planning a community-oriented water supply system[27] and typically requires rainwater tanks. Small tanks are most useful in locations with regular annual rainfall. In southern Australia, larger tanks take advantage of high winter rainfalls to store and supply water during long dry summers.

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 geology permits. ASR has been used with considerable success in Playford, South Australia, where water is channeled through the street network to the Munno Parra urban wetland. The wetland filters and reduces the nutrient content of the water and the clean water is then actively injected into the aquifer to be recovered during periods of low rainfall[91].

Water retention

In areas where ASR is limited by the local geology and the absence of a suitable aquifer, below-surface storage enables runoff during high-rainfall months to be captured for re-use during periods of low rainfall. One of the best precinct-scale examples of this is the water retention system at the high-density urban development at Central Park, in inner city Sydney.

More information on Australian water research can be found at the CRC for Water Sensitive Cities.

Case Study

Biophilic design: the green walls of Central Park. Photo: Katherine Lu

Central Park

Location Chippendale, Sydney

Climate Warm Temperate

Scale/Typology 5.8ha mixed-use precinct, comprising 2,400 apartments, 400 hotel rooms, 1,000 student accommodation beds, 6,000 m^2 commercial space and 20,000 m^2 retail.

Lead Frasers Property Group & Sekisui House

Status Commenced 2008; Precinct forecast to be complete by 2018

The city of the future

Central Park in inner-city Sydney is a mixed-use precinct that provides a glimpse of the ‘city of the future’. It features exciting architecture and biophilic design across a 5.8 hectare, rehabilitated industrial site that, when finished, will yield around two hectares devoted to public open spaces.

The project incorporates the flagship One Central Park Tower, designed by French architectural firm Ateliers Jean Nouvel (with PTW Architects). The tower features an iconic heliostat and extensive ‘green’ facade. There is also cutting-edge precinct-scale utility infrastructure including a trigeneration plant which provides power, heating and cooling energy, and a wastewater treatment plant that processes sewage and stormwater. The onsite wastewater system is a ‘circular system’ that captures and reuses wastewater at source. It is also the world’s largest membrane bioreactor. It treats wastewater (rainwater, stormwater, sewage) through several steps including, screening for solids, disinfection through bioreactor treatment (anaerobic and aerobic tanks), membrane tanks, UV filtration and chlorination.

Treated water is used for various non-potable uses such as irrigation (across the seven kilometres of planter boxes that comprise the building’s iconic green walls), for toilet flushing, and in washing machines. The impact of the water recycling is to reduce per capita residential water consumption by between 40 and 50%. This improves the ecological footprint of the building and enhances its aesthetics and thermal performance.

Read more at: centralparksydney.com

WGV

Location White Gum Valley, Fremantle WA

Climate Mediterranean

Scale/Typology 2.3 ha mixed typology residential precinct (approx. 100 dwellings)

Lead LandCorp

Status Commenced 2013; Forecast for completion by end of 2020

Diagram of the community bore network at WGV. Photo: Josh Byrne & Associates

WGV – integrated urban water management (IUWM)

Perth's WGV is targeting a 60 to 70% reduction in mains water consumption across all buildings. This equates to 30kL to 40kL of water used per person per year, compared to the Perth average of 106kL. Key water saving initiatives include advanced water efficiency measures in homes, lot-scale rainwater harvesting systems for toilets and washing machines, a community bore irrigation supply for use in both public and private gardens, and a range of water sensitive landscaping features integrated across the development site. Performance data is being collected to verify if the water use targets are being achieved.

- **Water efficiency**: The efficient use of water is the primary foundation upon which all other IUWM initiatives at WGV build. This ensures that the maximum potential from each individual water source is achieved, as well as minimising the resulting volume of 'wastewater' which has cost and greenhouse gas emission implications at a water utility level. Within the precinct, internal household water efficiency measures are typically one step up from those stipulated within the National Construction Code (NCC), while outdoor water use measures include specific considerations relating to landscaping and irrigation efficiency. In addition to the above measures, smart metering is employed with real-time data logging for leak detection, as well as providing user feedback to support efficient water-use behaviour.
- **Rainwater harvesting**: the WGV Design Guidelines require dual plumbing to allow rainwater supply to provide internal non-potable water demands. The supply and installation of a rainwater tank, pump and controls is supported by a developer Sustainability Package. The water savings for the single residential dwellings has been estimated as 10 kL per person per year where a plumbed 3000L rainwater tank (minimum) has been installed. Modelling was undertaken based on recent rainfall data, 3kL rainwater tank, a minimum roof catchment area of 70m^2 and typical residential toilet and washing machine consumption.
- **Community bore**: The community bore is a precinct-scale, non-potable water supply scheme for the irrigation of public and private green space

Water Sensitive Urban design incorporating native plants as a vegetation understory at WGV. Photo: Josh Byrne & Associates

and is key to the overall mains water savings for the development. The community bore scheme supplies groundwater from the superficial aquifer via a third (purple) pipe system to both public areas and private lots via metered connections. The development Design Guidelines mandate connection to the community bore and the use of an irrigation controller with weather sensor capability to optimise efficiency. The community bore scheme is based on a net positive groundwater recharge water balance to ensure sustainable management of the aquifer.

- **Water-sensitive landscaping and stormwater management**: Comprehensive on-site infiltration of stormwater has been achieved through a combination of drainage cells, flush kerbs, ephemeral winter wet depressions (a typical geomorphological element of the Swan Coastal Plain), and the use of damp-land native plants as a simple and effective WSUD solution to minimise stormwater runoff and improve localised infiltration. Micro-swales and vegetated basins have also been incorporated into the design to slow runoff events and maximise on-site infiltration. The redevelopment of a large historical drainage sump (which receives inflow from the surrounding suburban catchment) has resulted in an attractive, biodiverse, publicly accessible greenspace.

Read more at: watersensitivecities.org.au

Integrated water system principles

- Reduce water demand
- Design the site using Water Sensitive Urban Design (WSUD) principles
- Harvest water from rainfall and waste water (both grey and black water)
- Design the site to maximise the capture of runoff rainwater for reuse
- Create gardens and open spaces with low or no irrigation demands
- Design water harvesting structures as multi-purpose spaces — sumps and storage ponds can be designed as landscape features
- Co-ordinate urban water with the natural hydrological cycle. Where appropriate incorporate elements such as urban wetlands and/or aquifer storage and recovery.

Integrated waste systems

An integrated waste system encompasses the collection, transportation, processing, recycling and disposal of waste, as well as strategies that aim to reduce the likelihood of waste being produced in the first place[27].

Waste production is intrinsically linked with consumer choices, whether the selection of construction material or daily consumer goods. Some wastes are benign while others have a cumulative negative impact in the environment. By eliminating potentially adverse materials at the front end of the design process it becomes possible to reduce waste at the end.

This process is known as 'cradle to grave' and it is synonymous with life cycle assessment. Reframing waste as a resource in a circular system is a process labelled 'cradle to cradle'[92]. Waste in this scenario becomes an input for another system; for example, waste food for compost, or 'sewage mining' as a source for biogas and water recycling.

The Australian National Waste Report[93] prepared for the Department of Energy and Environment offers a snapshot of Australian waste activity. It reports on three main waste streams (excluding fly ash, a by-product of coal burnt for electricity production). These are listed below with waste recovery rates shown in brackets:

- households and local government activity (51%)
- offices, factories and institutions (57%)
- construction and demolition waste (64%)

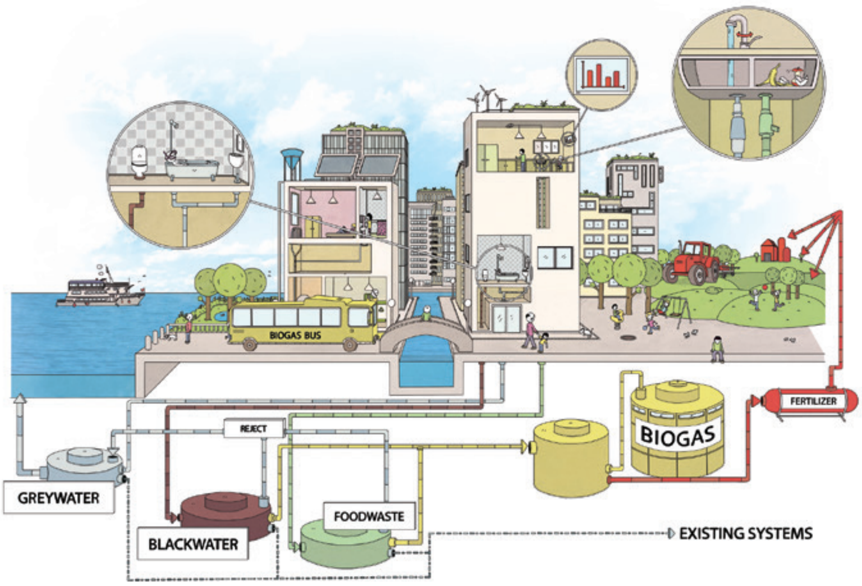
Per capita generation of waste is high at around 2.7 tonnes of waste per capita (2015). If fly ash is excluded, this rate reduces to around 2.25 tonnes per person. Regardless, only around 60% of this is recycled. Per capita waste volumes (excluding fly ash) has increased approximately 1% a year since 2006[93]. Fly ash is produced at around 460 kilograms per capita. Increased uptake of renewable energy will help reduce this waste stream. The integrated waste system approaches relevant to sustainable precincts include:

Pneumatic waste conveyance systems in Wembley Green UK. Manual sorting of waste streams occurs at the discreet central bins, with the conveyance system hidden underground.
Photo: Envac[94]

Improved waste separation processes

Separation of household and commercial waste streams in Australia usually occurs manually and is dependent upon local municipality requirements. Collection involves large garbage trucks which use considerable resources in terms of labour, hours and fuel. In addition, they are noisy and in dense urban areas they can be difficult to manoeuvre. Waste accumulation and collection puts pressure on urban spaces as densities increase. These pressures range from the aesthetic (streets lined with overflowing bins), the practical (a lack of on-site storage at many dwellings) to serious issues of public health (vermin and disease).

An emerging waste technology that overcomes this problem and is suitable for high-density areas is the underground pneumatic waste conveyance system.



Waste to energy system of H+, Sweden. Source: Helsingborg Municipality

This technology resembles a vacuum powered 'sewer' for solid waste. The system replaces the need for garbage trucks through the introduction of a network of pipes that appear above ground as collection points resembling regular street bins. Such systems greatly reduce the visual presence of waste, reduce vermin, lower health risks, and reduce noise and traffic by negating the need for street-side waste collection. Waste is conveyed under pressure to a central collection point where it is recycled, converted into energy or otherwise disposed.

In 2016, the Sunshine Coast Council in Queensland announced that it would become the first municipality in Australia to introduce a pneumatic waste conveyance system, to manage waste in the Maroochydore city centre. In June 2018, Singapore, a global leader in urban waste management, made pneumatic waste conveyance systems compulsory for developments of over 500 dwellings, as well as mandating dual chutes for refuse and recycling in new residential developments over four storeys.

Waste as a resource in circular urban systems

Unlike other renewables such as wind and solar, waste flows occur in relatively constant volumes and the potential of waste as an energy source is underrepresented in the energy mix in Australia; however, numerous international examples exist for inspiration.

The advantages of using waste for energy are multiple. First, the removal of waste is a significant cost for cities, involving time and effort from citizens and waste service organisations. Redirecting user activities and financial resources that would otherwise go into waste disposal changes attitudes to waste and turns waste into a valuable resource. In Sweden, where waste to energy ('energy recovery') has been common practice since the 1970s, less than 1% of the nation's waste goes to landfill. Energy recovery utilises 48.5% of household waste[95] (compared to around 9% in Australia). Combustible waste is used as a 'fossil fuel replacement' in incineration centres that provide energy and heat through district heating networks. The program has been so successful there is a shortage of combustible waste and the country has begun to import waste from neighbouring countries. Swedish examples, Hammarby Sjöstad and Helsingborg, are described below.

The new precinct-scale sewage to energy system of H+, in Helsingborg Municipality, is the 'star' of the Swedish 'waste to energy' systems. In this model, sewage, food waste is converted to biogas for cooking, heating and transport fuel (e.g. biogas bus). Biogas is gas consisting mainly of methane produced by anaerobic digestion of organic waste. Like regular gas, biogas can be used as a fuel for heating or cooking, to power vehicles, or it can be converted to electricity.

Residual organic waste is used as compost for agriculture and in parks. Greywater is pumped into the existing effluent pipes. Household food waste disposers are incorporated into the kitchen sink to increase food waste volumes and biogas and compost production[96].

It is easy to see how such a system would be beneficial in a dry Australian context, where reclaimed water could be used as a reliable resource for toilet flushing and irrigation for urban greenery.

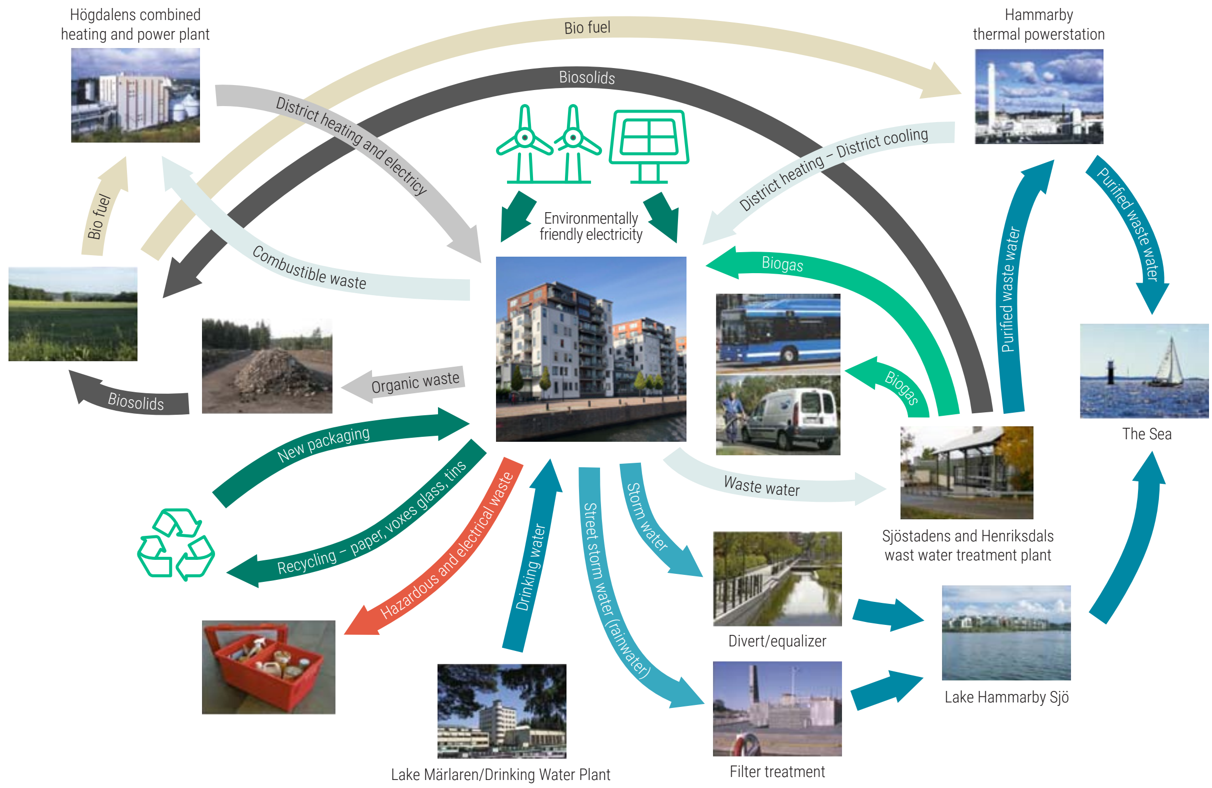


Figure 2.9 The Hammarby Model integrating energy, water, waste.
Source: GlashusEtt[116]. Reproduced with permission.

Hammarby Sjöstad – integrated sustainable systems

This showcase central Stockholm sustainable neighbourhood was developed on a brownfield site (former naval yard). The redevelopment is highly integrated, with the mixed-use neighbourhood well serviced by public transport, cycle and walking routes (car ownership is low at 210 cars per 1000 residents). It features a high-quality public realm, with around 20% of the site reserved as green space and with maximum access to existing site assets (water, forest).

The development uses around 20% less energy (118kWh/m²) than the Swedish average (150kWh/m²)115. The origin of this energy is 80% renewable, largely generated as part of the 'integrated sustainable systems' as summarised in the 'Hammarby (metabolic) model'.

The Hammarby model recognises that 'everybody who lives in Hammarby Sjöstad is part of an eco-cycle' that includes energy, waste, sewerage and water for both housing and offices. This model reuses waste streams as resources in a circular 'metabolic loop'.

For example, sewage is converted into biogas and treated wastewater. The wastewater is used in the district heating network and the biogas is used along with combustible waste to produce both electricity and district heating in the precinct-wide district heating network[116].

A waste vacuum system (Envac) allows for waste collection and separation. There is a target of 50% reduction in waste, 90% reduction of landfill waste and 40% reduction of all waste produced. There is also a target to reclaim 50% nitrogen and water, and about 95% of phosphorus to use as local agricultural fertiliser.

Read more at: hammarbysjostad.eu

Hammarby Sjöstad

Location
Stockholm, Sweden

Climate
Continental Climate (warm summer)

Scale/Typology
250ha medium to high density mixed-use neighbourhood, comprising 10,000 dwellings, office, retail, restaurants, cafes and community space.

Lead City of Stockholm

Status: Built

Integrated waste system principles

- Reduce waste volumes
- Design out harmful substances that accumulate to cause harmful impacts upon the environment such as hydrocarbon fuel sources, heavy metals etc.
- Consider alternative waste collection processes such as energy efficient pneumatic waste conveyance systems to avoid the high labour and energy cost of large waste collection vehicles
- Integrate energy, water and waste systems to reduce environmental impact while improving local resilience
- Design circular systems that seek to utilise wastes as resources, for example nutrient cycling, biogas production, recycled goods and reclaimed building materials
- Look for opportunities for new green enterprises involving waste recovery or conversion
- Minimise water and energy use in transporting and treating human waste (sewage)

SECTION

03

Delivering sustainable precincts

Delivering sustainable precincts is not straightforward, particularly because it is new territory for many urban planning authorities. The scale of work required, deficiencies in the regulatory framework and rapidly changing technology all create barriers to precinct-scale delivery. Nevertheless, processes and methods exist that can assist delivery of sustainable precincts.

Photo: Corey Roberts

Barriers to delivering sustainable precinct delivery include:

Scale – It is generally far easier to manage most aspects of energy efficiency and technology solutions on a building by building basis where the governance issues are far simpler

Regulation – The framework around regulated assets such as distribution networks currently inhibits efficient management of local infrastructure across property boundaries

Collaboration – Participatory processes involving stakeholders deliver higher-order results; however, collaboration is difficult when most processes develop organically

Physical limitations – Roof space availability is a major constraint on the adoption of solar resources at a medium density or existing precinct scale

Vision – Significant investment of time is required by the private sector to inspire a transition without any certainty of potential payback

Investment – The technology landscape is moving so fast that large capital investments are difficult without significant future proofing, yet it is difficult to envisage what that future proofing looks like.[97]

Plan for people

It is easy to jump to technical solutions when attempting to improve sustainability performance of urban environments. However, it is important to remember that the primary purpose of cities is to support human endeavours and lifestyles.

To avoid failure, it is therefore essential that a sustainable precinct is grounded in human-centred design.

The best way to plan for people is to plan with them. While, conventional 'consultation' is often about informing people after the event, genuine and deep involvement of end-users can only occur through participatory or co-design processes.[98] This benefits the individuals who will inhabit the space, but also the wider system because designing a desirable and attractive product (in this case the urban environment) benefits market uptake. The 'pull' of market demand is always more effective than the 'push' of legislation and other blunt policy instruments which may not elicit the desired market response.

"

There are two trains of thought about how government can best provide leadership in the area of sustainability. The encouragement approach and the stick approach. In Bowden, the two have been a powerful mix.

Paul Davey – GBCA Green Star Assessor and Project Consultant

Bowden Park, the main public space within the Bowden development. Source: ASPECT Studios

Case Study

Bowden, Adelaide

Climate
Mediterranean

Scale/Typology
16-hectare mixed-use precinct

Lead
Renewal SA (Govt Agency)

Status
Commenced 2008 – forecast completion 2026.

The development comprises 2500 residential dwellings, 10–12,000 m² of retail space, and approximately 15–20,000 m² of commercial office space.

Bowden – this lifestyle focussed 'green village' on a former brownfield site incorporates its industrial heritage. Photo: Corey Roberts

Bowden – Lifestyle focussed 'green village'

The 16-hectare Adelaide brownfield redevelopment at the former Clipsal factory site in Bowden on the city's fringe is being developed as a new medium to high density "green village" under the leadership of the South Australian government agency, Renewal SA. Bowden demonstrates significant leadership in urban planning, with carefully considered design guidance and review processes. All buildings must be assessed by an architectural review panel. The project demonstrates a range of building typologies, from terraces to apartment buildings, and has been rated at a precinct level using the Green Star Communities tool.

The precinct demonstrates excellent sustainability credentials including:

- a minimum 5-star green star rating and rooftop solar for all buildings
- alternative water sources and recycled water; terraces have 2050L rainwater tanks
- integrated transport with excellent public transport links and a focus on active transport to reduce car use.

On top of these excellent credentials, Bowden sells sustainability through the lifestyle it offers: One of its credos is: "It's the people that make the place". With mixed-use initiatives such as traffic calming, shared streets, train and tram connections, cafes (where bikes can be borrowed for free), restaurants, gym, community gardens, a warehouse conversion into an artist-run not-for-profit space, a renovated historic pub, a photographic studio, and a co-working space, the redevelopment attracts people from well outside its immediate residential catchment.

The strategy is working well five years after construction commenced; the site has transformed into one of the city's most sought-after suburbs. The average price for a two-bedroom apartment has risen from low-to-mid $300K to between $450K and $600K. Similarly, the first three-bedroom townhouses at Bowden sold for just over $500K; today they sell for upwards of $800K (April 2018).

Read more at: renewalsa.sa.gov.au

Demonstration projects, living labs and sustainable policy

Many of the early sustainable precincts, including some of the case studies mentioned in this Guide, are demonstration projects.

Others are 'living labs' and some are the result of built environment policies or 'transitions' supported by local or state consent authorities. It is useful to distinguish between these processes to understand the drivers behind pioneering sustainable precincts.

Demonstration projects showcase a particular approach and often become a 'flagship' for their sponsor. They demonstrate what is possible; while often being best practice they tend to be subsidised 'one-offs' in the hope that industry or marketplaces will self-manage and learn from the demonstration. Typically, demonstration projects are funded by government or another benevolent organisation.

Living labs are sophisticated projects that experiment and prototype new ideas. They typically involve cross-sectoral collaboration with a research body from academic, industry or government sectors. Living labs differ from demonstration projects in that systematic monitoring and testing of new products and approaches are designed into the process, with the expressed intention of advancing knowledge, testing policies and developing new markets.

Urban sustainability transitions require policy change to scale up niche projects (such as demonstration projects and living labs) to become mainstream practice. Policy by its very nature is reactionary and policymakers require an evidence base before shifting policy. In this sense demonstration projects and living labs are essential steps in a larger process of transition. The lag between demonstration of a concept and policy change is often considerable and requires leadership. In Australia, the process of policy change is slowed even more due to no clear bipartisan position on urban sustainability goals. This is further compounded by three to four-year electoral cycles that don't align with the long-term planning horizons of sustainability[99].

What is needed is a 'process of state-sanctioned intervention in the means and processes of designing the built environment in order to shape both processes and outcomes in a defined public interest'[100]. This requires leaders who can think long term and governments who use assets in innovative ways and offer sufficient stability to give business the confidence it needs to invest[101]. Government redevelopment authorities are assisting this process, but more can be done. The national Building Better Cities Program, created through federal government investment between 1991 and 1996, facilitated a national wave of medium density mixed-use precincts on former brownfield sites. These include iconic projects such as Pyrmont-Ultimo-Darling Harbour in Sydney, Southbank in Melbourne, and East Perth among others[102].

Government-owned redevelopment authorities are best-placed to lead large-scale projects. They can complement local urban revitalisation programs (which may or may not operate under the auspices of local councils) and lead to the formation of legally recognised not for profit urban redevelopment entities that build partnerships around an agreed vision and that deliver projects on the ground[103].

The Darling Harbour precinct in Sydney has been the subject of significant government-led redevelopment and revitalisation.

Integrated urban systems need integrated planning

Going about things as they have always been done won't lead to sustainability outcomes. Urban Sustainability Transitions result from 'the enactment of sustainable ways of organising (structures), thinking (culture) and doing (practice)'.[104]

There are two ways to facilitate this: a top down government approach or partnership.

Government approach

Government agencies can help produce a coherent vision and integrated plan for a precinct or precincts. This can be done for demonstration projects (WGV, Bowden, Hammarby Sjöstad) where innovation is required to achieve sustainability outcomes like zero carbon, water sensitive urban design, zero waste or transit systems. The risk inherent in this approach is that the market is distorted and demand for the product is overestimated and/or the product is rejected by the community. These risks can be largely overcome by encouraging partnerships and facilitating community engagement early in the precinct design process.

Partnership approach

The other approach to integrated precinct planning is through partnership. This should begin at the design stage to ascertain the community's vision and long-term goals for the project, including any local sensitivities. It continues through procurement where private sector bids are sought that build sustainability outcomes into the process from its beginning. The advantage of this approach is a more financially viable project that has funding from public and private sources and which has market, agency and community support. Most integrated precinct developments follow a continuum of government and partnership processes[57].

Inter-agency collaboration

Successful sustainability transitions require interdisciplinary and interagency collaboration. No single agency has the expertise to fully understand the complex interrelationships of the systems that make up cities[105] and a new co-designed model is required. Such a model necessitates the participation of institutional actors with 'hard power' (governments who create structures) and civil actors with 'soft power' (industry and community) who ensure a shared vision and provide hesitant governments with a mandate to act.

An example of where hard and soft powers came together can be found in the City of Växjö, Sweden, where a cross-sectoral alliance of actors with an interest in driving an urban sustainability transition created a simple policy statement that clearly outlined a shared vision and manifesto. The two-page Växjö Agreement was signed in 2015 by the municipality (City of Växjö), academia (Linnaeus University) and a regional environmental network (Sustainable Småland) (see Figure 3.1). It called for sustainable energy, sustainable transport, sustainable buildings, sustainable consumption and greater collaboration and leadership. The City of Växjö was named the European green city of 2018, three years after the agreement was signed.

Announcing a collaborative partnership is the first step, agreeing on direction and then working together is more difficult; it takes time and many conversations between stakeholder groups. Figure 3.1 illustrates the steps required in a cross-sectoral co-design process involving policy makers and researchers[106].

A collaborative co-design process is needed to allow equal consideration to the needs and expertise of each stakeholder[105], and to provide the environment in which new ideas can develop. An integrated approach that considers the interrelated components of a complex urban system maximises the efficiencies of urban design. Achieving this requires urban governance and management practices to shift from 'silo' planning (i.e., each sectoral management or department planning in isolation) to an integrated planning that optimises synergies between sectors and manages trade-offs. This is done through innovative integrated and cost-effective planning, collaborative decision making and implementation[107].

Linnéuniversitetet
Linnaeus University

SUSTAINABLE SMÅLAND

Växjö kommun
The Greenest City in Europe

Växjö Declaration

Växjö urges the Swedish Government and European local authorities to take meaningful action to go fossil fuel free.

In close collaboration between public and private actors, Växjö, the Greenest City in Europe, has been putting words into action since the 1970s in its environmental work and can proudly show the world that it is possible to work locally towards a global sustainable future. Växjö has set the goal of becoming a fossil fuel free city by 2030, but we cannot do it alone. Växjö therefore urges the Swedish Government and European local authorities to take meaningful action to go fossil fuel free.

Energy supply

In the past 20 years the people of Växjö have almost halved their fossil carbon dioxide emissions. Växjö has already built a combined heat and power plant that produce fossil fuel free heating, cooling and electricity. Household organic waste are collected and made into biogas for buses and cars. The proportion of renewable fuels in the transport sector must increase. We already know that it is technically possible to produce renewable vehicle fuel in our combined heat and power plant, but it is a major financial risk for one individual actor.

Växjö urges the Swedish Government to form an economic structure that makes investments in the production of renewable energy profitable.

Växjö urges European local authorities to switch to fossil fuel free energy systems.

Sustainable travel

Växjö is investing in sustainable travel on foot, by bicycle and by public transport. Our buses run on renewable fuel and we plan to lay cycle superhighways for quick and easy travel within the municipality. Växjö will lead the way in sustainable travel with the implementation of 52 identified measures by 2020. Växjö is part of a region and we need a simple and attractive regional infrastructure that provides accessibility without fossil fuels. We need high-speed trains via Växjö to open up national and international travel possibilities.

Växjö urges the Swedish Government to invest in double tracks on existing railways and in a high-speed track via Växjö and other regional centres.

Växjö urges European local authorities to design towns in a way that promote sustainable transport systems.

Buildings

Växjö builds in wood. We build passive houses, low-energy houses and energy plus houses in close collaboration between the municipality, private sector and academia. Together with industry and other local authorities in Europe, Växjö is carrying out extensive and innovative energy efficiency improvements in its housing stock. We are finding it difficult to make sufficiently progressive energy requirements due to the national building regulations being too weak and the law preventing municipalities from setting specific requirements. Växjö also feels there is a lack of satisfactory methods and procedures to ensure compliance with the building regulations laid down by the Swedish National Board of Building, Planning and Housing (Boverket).

The City of Växjö, together with Linnaeus University and private actors, is prepared to lead the way in ensuring that energy requirements are actually complied with.

Växjö urges the Swedish Government to give Boverket the task of substantially sharpening the energy requirements of current building norms by prioritizing renewable district heating before electricity as a heating source and ensuring that energy requirements are actually complied with. Växjö also urges the Swedish Government to once again let Swedish municipalities go first in line in making special environmental and energy demands for land sales.

Växjö urges European local authorities to make long-term sustainable investments to reduce the energy consumption of buildings.

Consumption

Växjö will also take responsibility for its own indirect climate impact, i.e. from our own consumption. A growing world population and limited natural resources demands a change in the raw material flows. We will switch from being a society that continuously seeks new resources, utilises them and then discards them, to a society based on sustainable cycles. Extending the life cycle of products, enhancing the quality of newly manufactured products and facilitating re-use saves enormously on resources. Växjö will establish a knowledge transfer centre for circular economy, a reuse village and draw up local control measures for promoting circular economy.

Växjö urges the Swedish Government to draw up control measures that favour circular economy.

Växjö urges European local authorities to promote circular economy.

Collaboration and leadership

In Växjö we work transnationally to achieve our goal of becoming free from fossil fuels. Växjö has earned the reputation of being the Greenest City in Europe and was one of the first European local authorities to sign the Covenant of Mayors. Växjö leads the way in creating a fossil fuel free society and does it in broad collaboration. To make it possible to achieve the goal, clear decisive leadership is required at national and international levels that lead to a more innovative private sector with great economic development potential.

Växjö urges the Swedish Government to set a goal of becoming the world's first fossil fuel free nation and to urge the European Commission to decide on binding climate goals for the European Union.

Växjö urges European local authorities to push development in the right direction by signing and living up to the Covenant of Mayors.

Stephen Hwang
Rector
Linnaeus University

Niklas Nillroth
Chairperson
Sustainable Småland

Bo Frank (M)
Chairperson
Executive board, City of Växjö

The Växjö declaration will be handed over on the 25th of March 2015, during Earth Week, to the Swedish Minister of Environment Åsa Romson, and also the Executive Director of Energy Cities, Claire Roumet.

Figure 3.1 The Växjö declaration outlines the vision of a cross-sectoral alliance to deliver a sustainable city. Source: City of Vaxjö

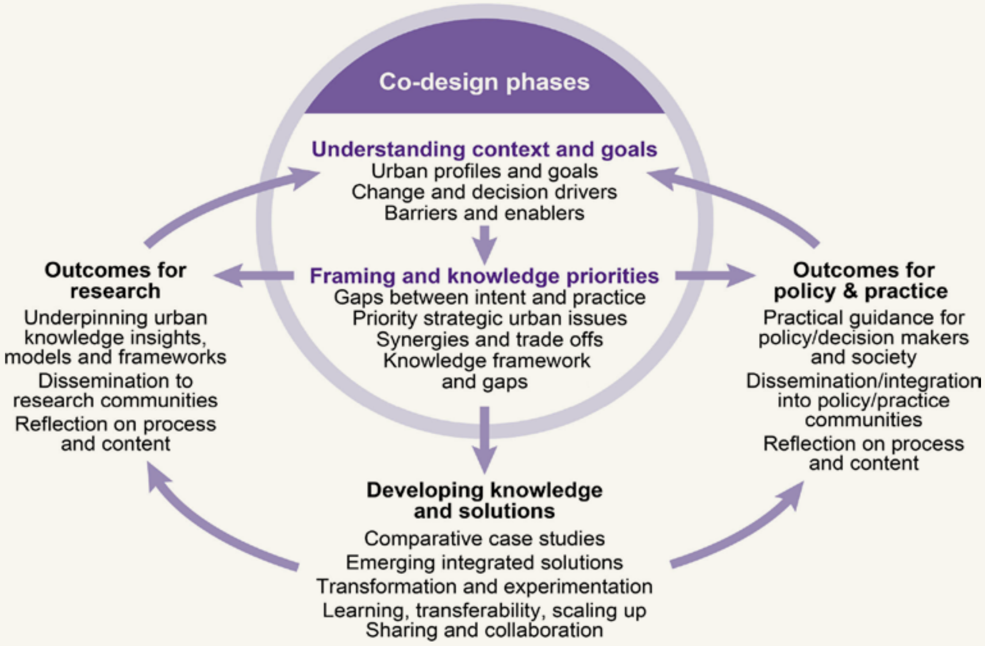


Figure 3.2 Overall Knowledge co-production process for sustainable urban development.
Source: Webb et. al.[106]

The Hammarby model developed for the Hammarby Sjöstad precinct (as described in the integrated sustainable systems case study on page 47) is exceptional in that it shows how it is possible to integrate multiple urban services and functions including waste to energy, biogas fuelled co-generation, water, transport and so on. This was made possible through collaboration between agencies and innovation in project delivery. The demonstration Hammarby project is being replicated across other Swedish cities. It has shown what is possible and has led to structural reorganisation and iterative improvements within urban delivery agencies and organisations. These have had ripple effects heralding the broader mainstreaming of an urban sustainability transition (see, for example the Swedish sustainable precincts BO1, Stockholm Royal Seaport, and H+ Helsingborg).

Vision and metrics

Sustainable precincts require strong vision and commitment to sustainability; sustainable outcomes require a whole-of-system approach[105]. A shared, and ideally co-designed, vision will ensure all stakeholders are working for the same outcomes. Clarity comes from strong leadership which may be from the bottom up or the top down. A shared vision permits coordination by ensuring the alignment of key stakeholders, institutions and businesses.

The role of an assessment authority is important to ensure development approvals adhere to the vision. Rating tools and other metrics must be applied to track performance against any agreed goals. The most legitimate form of tracking is to monitoring a sustainable precinct is to have specific and regularly monitored goals ('as performed') to ensure the outcome meets the aspirational targets set out at the planning stage ('as designed').

There are many rating systems that can assist in the creation of precinct plans, each with different strengths and weaknesses. Some rating systems prescribe targets to meet as a form of quality assurance (GreenStar Communities, LEED, BREEAM); others provide a framework within which to develop a custom action plan (e.g. One Planet Communities); others still provide a framework for building an alliance of actors to help develop a vision and build collaboration (e.g. EcoDistricts). Links to some common tools used to help with the delivery, rating or management of sustainable precincts are provided in the Appendix.

Asset and place management

Once a precinct has been designed it requires ongoing maintenance of the various assets in common ownership.

Traditionally, management of the public realm has been led by local government; however, in precincts that have systems such as microgrids 'behind the meter' (i.e. on private land and not the responsibility of the centralised utilities company), or specialised assets such as high quality public realm or community gardens that are either outside the responsibility of the local council or beyond their typical service levels, then localised place management can perform this role. There are a number of precedents for this approach, namely in the form of in **Business Improvement Districts (BIDs)** and **Special Improvement Districts (SIDs)**[57].

In BIDs, businesses tax themselves for the good of the infrastructure or amenity that they create for their own gain and the gain of the public. In the BID model, local governments collect the funds and manage the disbursement and the ongoing investment processes. Each BID will have its own constitution developed by the stakeholders. The motivation behind most BIDs is security, heritage conservation or simply to provide better spaces that attract businesses and residents and hence create value in the area[42].

SIDs are geographically ringfenced areas, such as precincts, that receive levies to fund district improvements and amenities, they are bespoke to the location and focussed around stakeholder needs. More common in the US than in Australia, SID levies are now being extended into whole corridors and even into creating urban rail and urban regeneration in Transit Oriented Developments (TODs[57]) – intense mixed use residential and commercial areas designed to maximise access and use of public transit.

The BID model is already quite common in Australia and could be adapted to have a concerted sustainability focus tailored to the needs of each precinct and community. Tailored BIDs and SIDs have the potential to:

- Create a legal framework for a coordinating body to manage and guide implementation of a sustainable precinct
- Design the strategy, goals, financing, monitoring and management of eco-infrastructure and other community needs
- Create a framework to coordinate stakeholders for the design of appropriate delivery mechanisms
- Establish long-term value and long-term management structures for a region
- Coordinate long-term plans that bypass the short-termism of elected officials
- Establish an ongoing neighbourhood governing entity responsible for ensuring environmental, economic and social benefits
- Establish an organisation for the management of precinct scale eco-infrastructure
- Ensure data collection and reporting against agreed targets
- Create a legal entity responsible for loans and revenues associated with capital costs and maintenance of eco-infrastructure
- Improve community participation and economic development/job creation for local businesses
- Integrate management of a collection of individually financed projects to meet goals
- Manage decisions to strategic direction.

Such models could also be used to facilitate funding for:

- organisational administration, assessment and monitoring
- small-scale projects, initiatives and scoping studies
- the financing of district utilities (e.g. district energy, large scale renewables, water, waste, energy efficiency programs etc)[108,109].

Smart cities and smart systems

Several European countries have participated in the creation of Smart Sustainable Districts (precincts) funded through ClimateKIC, Europe's main climate innovation initiative. Typically, these involve precinct-scale projects and innovations such as smart grids, district energy and heating, drainage and water management, rainwater harvesting, green streets, zero waste programs, district composting, waste-to-energy, car sharing, biking and

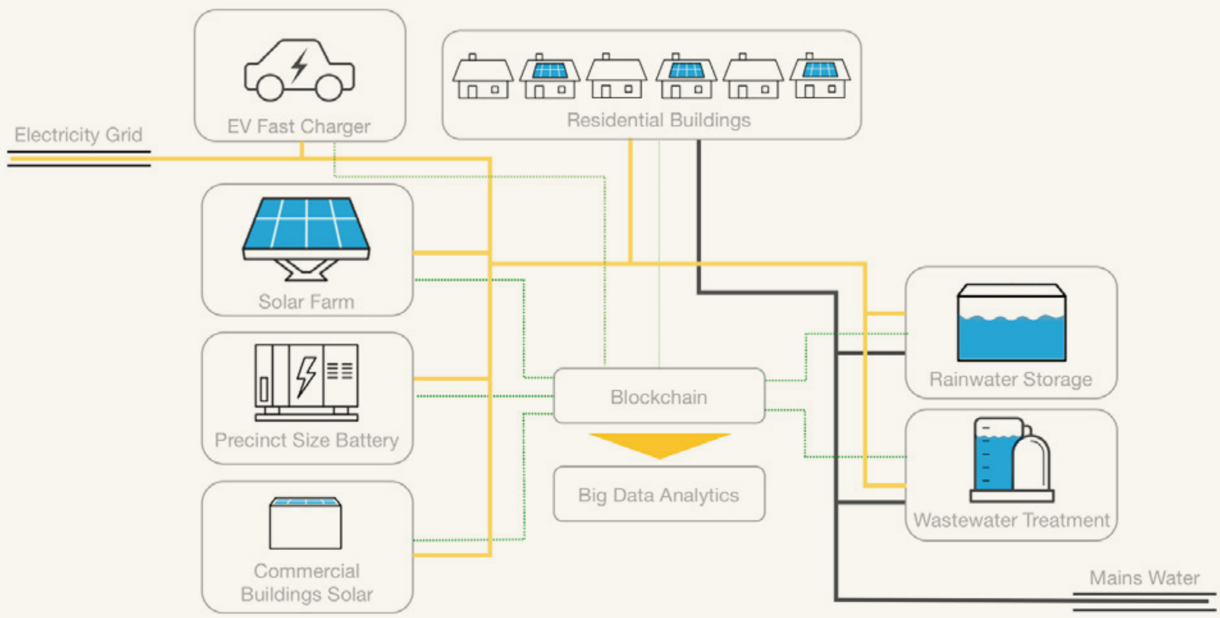


Figure 3.3 Integrated electricity and water services with P2P trading using blockchain technology.
Source: Curtin University (2017)

bike lanes, urban agriculture, culture and events, local maps and data interactions. The ClimateKIC's research found that precincts are the most effective unit of scale to test integrated systems and infrastructure to accelerate sustainability[110]. Its Smart Sustainable Districts program goal is 'factor four' or an 80% reduction in resource intensity. The program shifts the focus from a conventional master developer or agency, to a network of policy makers, municipalities, utilities, developers, innovation experts, sustainability specialists, and citizen groups, enabled by digital tools. This 'smart' network has huge potential for asset management within cities, particularly for monitoring and managing decentralised infrastructure systems at the precinct scale.

Smart city strategies can use technology as an enabler for efficient use of resources and governments have learned that top-down initiatives are not a prerequisite for success. Increasingly, the drivers required for success are collaborative and participative human-centric approaches[111]. The role of citizens has been recognised in the emerging concept of citizen utilities, an approach in Australia that is most advanced in Perth where blockchain is being used to manage utility transactions between households that were previously not possible[85]. Blockchain support systems enable 'peer to peer' trading of excess rooftop solar energy, water or other resource between producers and other consumers. Residents thus become prosumers (both producers and consumers of resources) (Figure 3.3)[85]. This innovative application of technology to local trading of renewable resources is being trialed in Fremantle through the Australian Government's Smart Cities and Suburbs program. It has the potential to rapidly accelerate the use of distributed technologies within sustainable precincts.

Local shared systems

Precincts form an integral part of a whole-city approach to energy, water, waste and transport—each sharing the benefits and opportunities created with others. This system is considered to be the way of the future[112] in which energy, utilities and mobility are shared by 'the internet of things' and blockchain. Internet-based communication channels facilitate the sharing economy and this is rapidly moving beyond social networks. These diverse and distributed networks and systems enable each part of the city to fit together and function seamlessly. The distributed infrastructure is also more resilient. Precinct-scale infrastructure, combined with digital networks, offer the potential for a new wave of urbanisation which is highly liveable, affordable and sustainable.

Checklist

Designing and delivering low carbon, sustainable precincts is no easy task. In Australia, there are regulatory hurdles to navigate and a culture of business as usual to overcome. However, solutions do exist to create liveable and sustainable precincts— it is people who enable or hinder their application.

Photo: Josh Byrne & Associates

Summary checklist

For this reason, transforming urban design requires leadership, not just from government or industry but everyone. To help achieve this transition, this Guide has outlined a series of principles and themes that will help drive sustainable outcomes. These principles are collated as a summary checklist below.

Sustainable transport principles	
Reduce private vehicle use by improving accessibility to services, minimising car parking and providing safe, comfortable and convenient movement alternatives	
Plan for pedestrians, cyclists, transit and cars in that order	
Design precincts with a 'centre' this should include transit co-located with shops and services of a scale to suit the economic catchment. Higher density developments create more viable centres	
If high frequency transit is not provided, consider futureproofing the site through the provision of potential future transit corridors	
Design precincts around transit as Transit Oriented Developments (TODs)	
Create good feeder routes to transit stops to maximise ridership and reduce car use	
Create an attractive and inviting public realm with cycle and pedestrian routes linking key destination such as transit, schools, shops	
Reduce vehicle speeds and give priority to pedestrians and cyclists in town centres, in low speed environments (< 30km/hr) cyclists do not need dedicated cycle lanes.	
Provide undercover cycle storage and end of trip facilities in buildings and at destinations.	
Encourage car and bike share schemes (including EV, E-bike and E-scooters)	
Provide EV charging stations in anticipation of projections that EVs will forming 20% of road vehicles in 2036	

Design with nature principles	
Start with a landscape assessment to understand existing landscape and landform assets, that may be used to the site's best advantage (e.g. Drainage patterns can dictate stormwater collection potential, topography affects solar access, or can be used to conceal underground car parking)	
Set aside low-lying parts of the site for water storage or soaks, this can be incorporated with vegetation or open space	
Aim to preserve remnant vegetation and seek opportunities for urban greenery planting to create interconnected urban wildlife corridors to enhance biodiversity and for green pedestrian and cycle links	
Maximise urban greenery, as it is an investment increasing property values, performing ecosystem services (particularly urban cooling and reductions in storm water peak flows) and providing psychological relief from stress	
Maximise urban greenery in the street and encourage green garden through rear building set backs	
In highly built up areas consider green roofs and green walls and ensure minimum deep soil zones	
To be most effective green corridors, drainage lines and other natural systems should be co-ordinated with locations outside the precinct boundary	
The green plot ratio and other policies can quantify and encourage greater green space particularly in denser urban areas	

Sustainable urban structure principles	
Develop a permeable street grid with short block lengths to actively increase walkability	
Block size will impact upon the potential for private green space. Smaller blocks are more walkable but larger blocks allow greater opportunity for private gardens	
Design in low cost 'passive' sustainability elements e.g. Narrow building footprints, with high floor to ceiling heights allows for maximum daylight penetration, and with operable windows allows cross ventilation for heat purging and fresh air	
Use modelling at the design stage to optimise solar access and PV rooftop potential e.g. arrange the street grid, building alignment and roof inclination to maximise solar orientation	
Building form should reflect the street pattern, energy consumption and the potential for energy production (e.g. solar ready roofs)	

The design of robust and flexible buildings that can be adapted over time is more important than trying to get the land use mix 'right'	
Design 'complete' streets as places for everyone, not just vehicular movement corridors, emphasise safety and comfort for people of all ages. Minimise driveway 'cross overs' instead use rear lanes for parking access to car parking spaces	
Co-ordinate services through combined utility corridors, to improve access, ensure greater service location certainty, and to minimise disruption during maintenance work	
Design buildings and streets as places people want to be.	

Low carbon energy principles	
Focus on reducing building and transport energy demands	
Monitor energy demand and supply simultaneously. Reductions in energy demand will have considerable economic and environmental benefits	
Consider virtual power management to balance precinct energy generation with demand	
Maximise efficient forms of on-site renewable energy production. Each technology will have its own spatial requirements	
Integrate storage systems to manage renewable energy variability. (e.g. daily solar fluctuations in PV electricity generation). A community battery is likely to offer cost benefits through economies of scale	
Maximise rooftop solar orientation and minimise overshadowing at both the building and precinct scale	
Design buildings with good thermal envelopes that can be sealed during extreme weather to minimise energy demand for heating and cooling	
Provide operable windows to allow passive heat purging and to maximise cross ventilation	
Develop a facility management (site and equipment) strategy where the assets are owned collectively 'behind the meter'	
Consider connection to the grid for the sale of excess energy and purchase of energy shortfalls	
Integrate energy and transport systems, renewable energy generation should be considered in conjunction with electric vehicle infrastructure	

Consider emerging technologies, while solar and battery are likely to dominate renewable energy provision in urban Australia there is potential for other sources e.g. cogeneration fuelled with biogas	

Integrated water system principles	
Reduce water demand	
Design the site using Water Sensitive Urban Design (WSUD) principles	
Harvest water from rainfall and waste water (both grey and black water)	
Design the site to maximise the capture of runoff rainwater for reuse	
Create gardens and open spaces with low or no irrigation demands	
Design water harvesting structures as multi-purpose spaces (e.g. sumps, storage ponds can be designed as landscape features).	
Co-ordinate urban water with the natural hydrological cycle (e.g. Where appropriate incorporate elements such as urban wetlands and/or aquifer storage and recovery).	

Integrated waste system principles	
Reduce waste volumes	
Discourage harmful substances from entering the system, e.g. hydrocarbon fuel sources, heavy metals etc.	
Consider alternative waste collection processes such as energy efficient pneumatic waste conveyance systems to avoid the high labour and energy cost of large waste collection vehicles	
Design circular systems that seeking to utilise wastes as resources, for example nutrient cycling, biogas production, recycled goods and reclaimed building materials	
Look for opportunities for new green enterprises involving waste recovery or conversion	
Minimise water and energy use in transporting and treating human waste (sewerage)	

The Guide has also emphasised the importance of getting the broad brushstrokes right: **Prioritise** sustainable transport; **optimise** the urban structure, and; **design** with nature to maximise site assets, particularly water and biodiversity, to build a strong sense of place and to enhance the calming effects of connection to the environment.

These are big moves. They put in place the fabric of success that will persist for decades.

Woven into these good bones is the flesh of eco-efficient infrastructure to support high-quality lifestyles for inhabitants: Precinct scale energy systems, integrated water systems, and integrated waste systems.

Appendix

PRECINCT RATING TOOLS

GreenStar Communities, LEED ND and BREEAM Communities are the three leading international precinct rating tools commonly used in Australia to measure the performance of a precinct 'as planned'.

GreenStar Communities – developed by the Green Building Council of Australia (GBCA) to assess the planning, design and construction of large-scale development projects at a precinct, neighbourhood and/or community scale. It is a comprehensive assessment across five themes; governance, liveability, environment, prosperity and innovation.

LEED ND – born out of the US Green Building Council's Leadership in Energy and Environmental Design building rating system, LEED ND has a broader range of targets for Neighbourhood Developments. While, LEED ND is used outside the US, in Australia the GBCA's GreenStar is more aligned with Australian regulatory systems.

BREEAM Communities – this rating system is managed by the UK Building Research Establishment (BRE) which first prepared an Environmental Assessment Method (BREEAM) for buildings in 1990. This has since been expanded to include whole master-planned communities as BREEAM Communities.

Rating tools are useful for helping to drive urban sustainability transitions. But the ability to efficiently and effectively assess urban sustainability performance is in its infancy, and significant variations in terms of what indicators and how they are measured, do occur between tools. A scoping study by the CRC LCL entitled 'Performance Assessment of Urban Precinct Design' covers some of these variations in detail by way of example it shows that just over 20% of the GreenStar Communities indicators relate to energy and carbon, this focus is considerably higher in BREEAM Communities at around 35%.

OTHER COMMON MODELS

Other rating tools and models exist and some are receiving increased attention in Australia. These include:

Living Community Challenge (LCC) – was developed through the International Living Future Institute. The LCC is an aspirational rating system that aims for regenerative development. There are seven 'petals' covering place, water, energy, health and happiness, materials, equity and beauty. The goal of this rating system is to drive excellence in the built environment that is 'socially just, culturally rich, and ecologically restorative'. The GBCA manages LCC in Australia and to meet the stringent requirements is, as the name suggests, a 'challenge'. The first LCC-endorsed project in Australia is a rural property in Castlemaine Victoria.

One Planet Communities – are certified by the not-for-profit environmental charity Bioregional in the UK. This model was developed for the now famous BedZED sustainable precinct in Beddington, UK. It was developed in conjunction with the World Wildlife Fund and comprises 10 simple One Planet Principles against which a community prepares a Sustainability Action Plan with occasional or annual sustainability reports to track progress against some or all agreed sustainability objectives.

EcoDistricts – the EcoDistricts Protocol is a model based on innovative work around sustainable community development from Portland USA. EcoDistricts takes a different approach to rating systems in that the focus is upon building collaborative communities who develop and implement a vision from concept to outcome. The three 'imperatives' are climate, resilience and equity. It avoids a top down approach and, in a similar manner to One Planet Communities, the stakeholders codesign the goals. EcoDistricts is managed by the GBCA in Australia.

On the following page is a comparison of the main ratings tools.

Comparison of rating tools

Framework	Section J Australian Construction Code	NatHERS	NABERS	Green Star	LEED	One Planet Living	Living Building Challenge	IS Tool (ISCA)
General	The energy efficiency req's of the building code	Section J compliance method for houses and multi-res	Rates office energy, water, IEQ and waste. Only energy is common	Established in Australia. There is now an operational tool	USA/Euro Green Star is based on LEED.	Light on design guidance, more about long term targets	Targets restorative design.	For infrastructure projects.
Metric	Pass or fail	0 – 10 Stars	0 – 6 stars (higher is possible)	4, 5 or 6 star	Certified, Silver, Gold, Platinum	'OPL certified'	'Petal Recognition' (partial) or 'Living' status	Commended, Excellent, Leading
Type of project	Buildings (classes 3-9)	Buildings (class 1&2)	Offices only (fitout, base building or whole building)	Any building type, interior fitouts, now also for Communities (precincts)	Any building or precinct	Involves operational and behavioural, so can be a community or a corporation	Renovations, buildings, precincts	Transport
Water	361	179	179	179	179	179	179	0.50
Communication	149	266	266	266	266	266	266	1.79
Energy	223	828	828	828	828	828	828	3.71
Mandatory?	Yes	Yes	If over 2000m2, then energy rating must be on ads	Sometimes req'd (e.g. all MRA sites, all Freo sites, PCA grades for offices)	Emerging in Aust. Firms with US parent companies often prefer LEED	No	No	Rarely (sometimes part of brief req's)
Energy Modelling required?	Deemed-to-satisfy OR Energy modelling can be used (JV3)	A special software platform is used (AccuRate or FirstRate)	Rating is based on actual energy use, but modelling common in design	Yes (as per JV3 modelling) plus daylight and comfort modelling	Yes (as per JV3 modelling) plus daylight and comfort modelling	Probably	No (based on operational figures)	Basic estimates only.
Technical difficulty	Standard practice	Standard practice	Specialised assessors	High. Certified practitioners req'd	High. Certified practitioners req'd	Low. Rarely used to achieve certification; used as a guide.	Very flexible in how rating achieved but very tough on what is not allowed.	Lower levels are almost standard practice.
Cost	$3K - $8K	$350-$650	$2K/year	$22K to GBCA plus ~$100K consultants	$18K to USGBC plus ~$100K consultants	Cost of certification by BioRegional $?K	$500 registration costs beyond this depend on project	$26K - $55K plus ~$100K consultants

Source: Josh Byrne & Associates

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