



**LOW CARBON LIVING  
CRC**

## **RP2003 Scoping Study: (Phase 1: Interim Report)**

A Review of Low Carbon Precincts to Identify  
Pathways for Mainstreaming Sustainable Urbanism  
in Australia



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### Peer Review Statement

This scoping study has been approved by CRC RP2003 project leader Peter Newman.

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## Acronyms

CHP	Combined Heat and Power (co-generation)
CRC	Australian Co-operative Research Council for Low Carbon Living
IPCC	Intergovernmental Panel on Climate Change
GHG	Green House Gas

## Executive Summary

### CRC Context

As part of the CRC for Low Carbon Living this scoping paper focuses on the Low Carbon Precincts (Program 2) however, it also examines aspects of how the Engaged Communities (Program 3) can help with the implementation of low carbon precincts e.g. through leadership, governance, construction and real estate, and community / consumer attitudes and action. The research also touches on the importance of Integrated Building Systems (Program 1) as essential infrastructure for achieving a low carbon precinct.

### Background and Key Recommendations

Decades of global research point to the social, economic and environmental imperative to decarbonise the world's cities e.g. the Brundtland Report (1987) and more recently the IPCC Fifth Assessment Report (AR5), (2013). Today it is the basis of a new competitive innovation process called the Green Economy or Sixth Wave of Innovation. Many precinct scale low carbon innovations are being developed globally but they are not part of any coherent or accredited process.

Most countries have oriented towards decarbonisation through the front end of the economy by pricing carbon as it enters through power plants and big industries. The built environment, where most carbon is used, is at the back end of the economy, where end users make use of the energy. Thus precinct scale innovations are not considered to be eligible for carbon accreditation and the regulatory regime surrounding the built environment remains highly dispersed and hardly coherent.

The new Australian Government has a Direct Action policy that focusses on end users and includes the built environment; this may indeed break new ground in finding ways to reward low carbon urban development. The CRC in Low Carbon Living may be able to provide a research basis for how the Direct Action policy can be implemented in urban development.

Decarbonising the built environment will require retrofitting existing building stock to reduce energy demand; it will also require new sustainable buildings and infrastructure. This scoping study is concerned with the second category of new build, at a precinct scale. In particular it focuses on how new build, mixed use and primarily residential projects (greenfield, brownfield and greyfield) might be built to standards that help meet agreed emissions targets and to benefit from the associated economic (less expenditure on energy) and environmental (less pollution) benefits. It will be necessary to address both direct emissions related to the construction of buildings and indirect emissions associated with the operational energy demand of buildings, transport, waste and other urban services.

Precinct (neighbourhood or community) scale development will prove useful as we transition toward genuine mainstreaming of low carbon urbanism. Precinct scale development has a number of advantages over the individual building scale (Newton, 2009, Rauland, 2013) with the important factors including:

- A precinct is the scale of community – and can allow comprehensive planning with mix of uses within walkable distance and a distinct sense of place.

- Precinct scale eco-infrastructure becomes feasible - localisation solutions versus centralised solutions (eg distributed energy, sustainable transport, water sensitive urban design) are a major issue in future planning as many low carbon solutions are local scale.
- Precinct scale development allows for the integration of social infrastructure (schools, parks, shops) allowing for greater liveability and a more community-based way of life.

As a means of transition, low carbon precincts can function as decentralised, semi-autonomous, cellular components that cumulatively work toward the aspirational end state – the low carbon city – whilst simultaneously achieving a range of other urban development goals. It should therefore be a major focus of the Federal Government's new Direct Action Plan.

A recent submission by ASBEC (Roper 2013) to the Government suggested this could be achieved through the following measures :

- *A clear focus on maximising abatement to achieve Australia's 2020 abatement target*
- *Preference to be given to abatement which has certainty of being achieved*
- *Independent verification of abatement*
- *Weighting to be given to abatement which continues beyond 2020*
- *Transparency (eg, disclosure of bid prices and report on ERF abatement outcomes)*
- *Certainty for participants and government*
- *Minimise transaction costs*
- *Fairness and equity.*

While the Direct Action Plan will play an important role ASBEC go on to note that 'complementary measures' – both financial and non-financial incentives will be required to encourage the built environment towards better practice and reduced emissions. Complementary measures would include measures 'such as; discounts for lower emissions properties, training opportunities to upskill the workforce, R&D incentives to support innovation, community education to change occupant behaviour etc.' (Roper, 2013)

The question becomes: how best does a precinct scale urban development proceed to take advantage of the local carbon technologies and systems that are becoming available?

Looking globally numerous examples demonstrate that industry has the technological capability to deliver low carbon precincts (see Appendix 1) – however, the reality is that uptake of low carbon sustainable urbanism everywhere is scattered and incoherent. In Australia it is sluggish at best, with few innovative low carbon developments making it to market over the last two decades. Even recent literature cites only a handful of *bone fide* Australian low carbon precincts (see Bunning, Beattie, Rauland, Newman, 2013). The home buying market has not demanded a shift toward more sustainable products and industry and government-led uptake has been inhibited due to a number of major barriers including:

- the 'sustainability cost premium' (Sustainability Victoria, 2011) whereby the additional costs associated with integrating

sustainability into an urban development makes the product uncompetitive against conventional designs,

- the split incentive whereby the financial incentive to invest in sustainable technology (by the developer) is split from the beneficiary (the occupant) (see: UNEP, 2009; McKibbin, Evens, Nadel, Mackres, 2012),
- the short termism of 3 to 4 year electoral cycles and difficulty of meeting the long term planning horizons of sustainability (Rogema, 2012).

Through a combination of Direct Action and complementary measures it may be possible to catalyse a transition toward sustainable urbanism, but in order to fast track this process and lessons learn from other successful case studies will be essential. This paper identifies a wide range of national and international low carbon precincts from which to learn

Following a literature review, a 'long list' of 78 possible low carbon precincts was identified (listed in Appendix 1) from these a 'shortlist' of 20 are described in greater detail.

In terms of geography there is an obvious skew toward Europe which seems to be leading the world in delivery of low carbon precincts. However, there is an emerging push from other regions over recent years, especially in Asia with only a few projects in the world's biggest economy North America. To remain competitive Australia should aim to stay abreast of these trends.

This low carbon precinct review considers both the component parts of precincts and in particular if and how they have addressed the following key precinct carbon emission sources (Bunnings et al, 2013):

- Embodied carbon in materials
- Construction processes
- Energy production and management
- Transport
- Water management
- Waste management.

Criteria for elevation from the 'long list' to the 'exemplar' low carbon precincts 'short list' was discretionary based upon the number of key carbon emission sources (listed above) addressed by the project, the frequency of the project being cited in the literature, and development status (only projects completed or underway were considered).

Conclusions and recommendations are provided based upon observations from the case study reviews. Recommendations are provided in terms of **product**, structured around the six categories identified by Bunning et al (2013), and **process** which includes a series of recommendations around potential delivery mechanisms observed in the case studies.

An overall conclusion from the processes would be that no such overall approach exists that is fully accredited and certified by government. Many innovations are happening but eventually they need to be part of a mainstreamed government process. The new Direct Action Plan of



the Australian Government offers an opportunity as it is seeking certified carbon credits for end use actions which include built environment innovations. If a precinct-based process can be developed it may be possible to create innovative low carbon urban developments that can earn carbon credits.

### **Overall Recommendation.**

R1: The precinct scale of urban development is an obvious and useful scale on which to conduct built environment research. Precincts enable most aspects of built environment innovation to be trialled as an integrated system, thus if the total carbon involved is significantly lowered the demonstration project can be replicated quickly in other parts of the city and indeed across the world. Precinct scale low carbon urban development should be examined closely as innovations in this area are becoming globally competitive and the CRC for Low Carbon Living can help Australia to achieve multiple benefits in the built environment sector.

In particular the creation of a process that can enable claims of carbon accreditation for Low Carbon precinct development should be developed in close consultation with the Direct Action plan of the Australian Government. Following endorsement by the CRC leadership this approach will be expanded in Phase 2 of this work.

NB. It is envisioned that a holistic approach informed by the conclusions of this scoping study and findings from further research related to the detailed recommendations below would form the basis of such a framework.

### **Detailed Recommendations**

R2. A research project should be instigated with government and industry partners to establish an accreditation process for low carbon precinct development. All six of the key precinct carbon emission areas (as outlined by Bunnings et al 2013) covered in this report should be considered in the framework developed.

#### *Emissions related to embodied carbon*

R3: Explore opportunities for low embodied energy materials (to complement CRC project RP1004 - low carbon concrete) that are appropriate within Australia. If considering the transport dimension, the most appropriate low embodied materials may differ between major centres therefore local studies may be required.

R4: Investigate construction waste reduction strategies and technologies, in particular the potential for building prefabrication (with an emphasis on carbon neutral or carbon negative materials) to reduce the embodied energy and construction cost of development.

#### *Emissions related to operational energy*

R5: To support existing building envelope performance benchmarking recommendations (GBCA, ASBEC and others) complementary cost-benefit analysis conduct investigations into environmentally and financially effective combinations of 'building envelope performance' and 'building envelope + renewables' will assist development of appropriate and implementable planning policy targets for aspirational energy efficient developments. Such modelling should provide recommendations on total building emissions, and variations across several Australian climatic regions (cf. seven climate zones designated by the Australian Building Codes Board).

R6: An investigation is needed into, and workshops with, urban service / infrastructure providers to find synergies to reduce the

urban metabolic loop and to reduce resource consumption (cf. Hammarby Sjostad). Such an investigation would necessarily need to include mechanisms for governance and funding and possibly new eco-infrastructure (eg. district heating and cooling pipes and /or vacuum waste collection and sorting).

R7: Study potential carbon emission savings related to water demand reduction and on-site water capture and reuse (eg on-plot rainwater tanks, sitewide water retention and detention basins, aquifer storage and recovery) to reduce energy emissions related to water pumping and potable water desalination.

R8: Study methods to reduce water heating demand including the potential of waste water heat exchange, at both the individual house level or at the precinct scale (cf. Millennium Waters sewer heat recovery).

R9: Investigate potential carbon emission reductions related to precinct scale local food production. Such a study may measure the success (or otherwise) of programs such as Malmo's sustainable food policy. Similarly does the integration of urban agriculture actually lead to behaviour change in food consumption patterns that significantly reduce greenhouse gas emissions? Are there other benefits such as improved sales (property values or clearance rates) related to the integration of urban food production as a lifestyle option?

R10: Investigate precinct scale benefits of green infrastructure for precinct scale carbon reductions through the mitigation urban heat island effect, reducing run-off peaks, cooling through shading and evapo-transpiration and even sales premiums (to offset the sustainability cost premium).

R11: Measure the success of smart meters and smart grids as tools for monitoring and improving consumer behaviour and reducing emissions. Longitudinal studies of smart metered projects can compare modelled versus actual performance (both where there is monitoring and where there is no on-going monitoring).

#### Delivery processes

R12: Phase 2 of this scoping study should seek to develop or adopt a clear vision for low carbon precincts and define some simple baseline metrics and targets influenced by best practice performance observed in shortlisted exemplar projects.

R13: Investigate innovative funding models to help offset the additional cost of eco-infrastructure (eg. value capture from zoning uplift of higher densities to finance district heating and cooling networks and other community scale energy systems).

R14: Investigate potential funding mechanisms (eg. financing, tax incentives, rezoning, development bonuses) to overcome the 'sustainability cost premium' and 'split incentive' associated with eco-infrastructure. Investigations should also explore how potential planning controls could lead to additional site yield ('planning gain mechanism') (for example a reduction of parking requirements where a site is well served by public transport could lead to increased site yield / development bonuses by the consent authority where achievement of minimum sustainability standards is demonstrated (cf. One Brighton)).

R15: Investigate the level of carbon credits that would be needed to enable low carbon urban development to become mainstreamed.

R16: Investigate options / appetite for Government Owned Development Corporations (GODCs) to work with the CRC to develop low carbon and sustainable tendering processes (including competitions) for demonstration projects (particularly major government housing projects, possibly as 'living labs'). GODCs demonstration projects will assist in the dissemination of information while also expanding sustainability skills and technologies within the built environment and engineering sectors to deliver carbon neutral precincts. Developing consistent quality benchmarks, score cards or other mechanisms to improve sustainability could help GODCs to compare products, share knowledge and compete for sustainability and built environment excellence. Investigation should also consider the role GODCs can play in trialling Direct Action certification and accreditation

R17: Investigate the role GODCs could play in identifying and assembling / amalgamating sites to unlock key locations with the greatest potential for higher density sustainable development. The most strategic locations would likely be infill sites (greyfield or brownfield) well served by public transport, with good access to open space, retail and services. Potential for low carbon energy sources (eg. Water source cooling, adjacent land uses with waste heat or combustible wastes might also be mapped).

R18: Investigate how not-for-profits or social enterprises might work to drive value-led development to deliver low carbon developments in Australia. Similarly what role might not-for-profits or social enterprises play in the on-going management and monitoring of low carbon precincts (cf. One Brighton)? This may involve collaboration with existing organisations or the potential establishment of new organisations.

R18: Investigate whether self procurement of homes and housing co-operatives might be a useful approach for delivering improved low carbon urban sustainability in Australia (cf. Vauban). A review of Australian experiences may identify any structural barriers or supportive policy changes to facilitate greater uptake of CoDesign or community co-operatives to permit an uptake of sustainable housing and increase consumer choice (cf. Christies Walk, Westwyck).

R19: The CRC might consider developing a dedicated website (cf. Zero Carbon Hub) to function as a trusted central knowledge repository for the dissemination of technical information on low carbon urban development in an accessible manner. Such a website would function as a one-stop knowledge shop for policy makers, the public and industry. The CRC may act as a knowledge aggregator to support its partner organisations and while also disseminating its own recent research. To be effective it may be necessary to provide accessible recommendation summaries to widen the audience of the technical papers.

## Introduction

Urban environments, once built, are slow to change, therefore the neighbourhoods we build today, ideally, need to meet the social, environmental and economic needs of the future.

The importance of recognising this rather obvious feature of cities is important not only because it is more efficient but because cities have always existed, thrived or declined based on their competitive advantages. The next big competition for cities is to enable the green economy (OECD, 2008). Innovations in low carbon urban development therefore are an important agenda for all cities and Australian cities need to be one of the leaders.

This scoping study involves a review of innovations in low carbon precincts and identifies a range of components common to genuine low carbon precincts as well as identifying some of the barriers to mainstreaming low carbon sustainable urbanism in Australia.

The emphasis is upon a description of the case studies and their component parts with some discussion on possible pathways for overcoming the known sustainable urbanism barriers. Recommendations, based upon information available from the surveyed case studies, are provided suggesting possible research to further clarify possible pathways for mainstreaming sustainable urbanism in Australia. A subsequent phase of research, to be conducted in the first half of 2014, will make deeper inquiries into the processes utilised by the project teams of some of the most successful low carbon precincts identified through this study.

The study focuses on precinct scale development as precincts may provide the best opportunity for incrementally decarbonising Australian cities during the transition from conventional practice to widespread low carbon sustainable urbanism.

Cumulatively, low carbon precincts have the potential to function as transitional, decentralised, semi-autonomous, cellular components of an aspirational end state – the low carbon city.

## Australia's greenhouse gas emissions

Per capita Australia produces more carbon pollution than any other developed nation. The building sector is a major contributor to Australia's greenhouse gas emissions accounting for around 12% of carbon dioxide (CO<sub>2</sub>) emissions (Australian Government, 2013a). 'The vast majority of emissions from the property sector come from indirect emissions associated with 'gas and electricity consumption for lighting, heating, ventilation and air conditioning systems, appliances and information technology, and operation of lifts and machinery' (Green Building Council of Australia, 2011 p.6). ASBEC suggest that operational demand for energy in the buildings sector (commercial and residential, not including construction) amounts to 23% of Australia's greenhouse gas emissions (GHG).

The logistics of the challenge will be compounded by high population growth which is projected to be around 50-100% (30-42 million people) by the mid 2050s (ABS, 2008) this growth will make per capita emission targets even more onerous to meet. Climateworks Australia (2013) recommend that a low emissions built environment is a key goal for success (Denis et al. 2013). But achieving this target will require a radical shift in the building sector away from business as usual towards mainstreaming low carbon sustainable urbanism practice.

Most countries have oriented towards decarbonisation through the front end of the economy by pricing carbon as it enters through power plants and big industries. The built environment, where most carbon is used, is at the back end of the economy, where end users make use of the energy. The new Australian Government has a Direct Action policy that focusses on end users and includes the built environment; this may indeed break new ground in finding ways to reward low carbon urban development.

The CRC in Low Carbon Living may be able to provide a research basis for how the Direct Action policy can be implemented in urban development.

The knowledge to deliver low emission built environments exists, but the challenge will be to find market-acceptable, cost-effective models for implementation. At present major structural and financial barriers are impeding the rapid transition from business as usual towards a low carbon sustainable urbanism.

These major barriers include:

- the 'sustainability cost premium' (Sustainability Victoria, 2011) whereby the additional costs associated with integrating sustainability into an urban development makes the product uncompetitive against conventional designs
- the split incentive whereby the financial incentive to invest in (sustainable) technology (by the developer) is split from the beneficiary (the occupant) (see: UNEP, 2009; McKibbin A, Evens A, Nadel S, Mackres E, 2012)
- the short termism of 3-4 year electoral cycles and difficulty of meeting the long term planning horizons of sustainability (Rogema, R 2012)
- Skill and knowledge barriers (COAG 2009).

The case study review below has identified a number of projects where processes and techniques enabled some of these barriers to be overcome. Phase 2 of the scoping study will investigate these processes further.

## Approach

### Project scope

The project scope is to investigate 'low carbon precincts', working definitions for 'low carbon' and 'precincts' in the context of this study are provided below.

#### What is meant by 'low carbon'?

There is a great variety in the form and definition of 'low carbon' development making direct comparison difficult (see Rauland 2013 for detailed discussion). For the purposes of this scoping study low carbon projects are those that demonstrate considerable emissions reductions relative to conventional development in the same geographic location. For this reason there may be considerable variation in the absolute performance between various projects ie. they generate *lower* carbon emissions than business as usual relative to their region. Ideally an absolute measure would be used such as a clearly defined 'carbon neutral' baseline (an absolute aspirational target) for embodied, operational and other indirect energy associated with urban habitation. Unfortunately information limits made such an approach unrealistic for this scoping study.

As a general observation most projects observed incorporated aspects of the 'Mean, Lean, Green' energy hierarchy approach (Sheffield Universtity n.d) involving:

- Mean - low energy demand in the urban environment / building performance
- Lean - improved operational efficiencies in urban systems / building service distribution
- Green - supplementing residual energy requirements with renewable technology.

If the green (renewable energy) component exceeds the energy demand the development may become a carbon negative by adding clean energy to the grid.

#### What is meant by a low carbon 'precinct'?

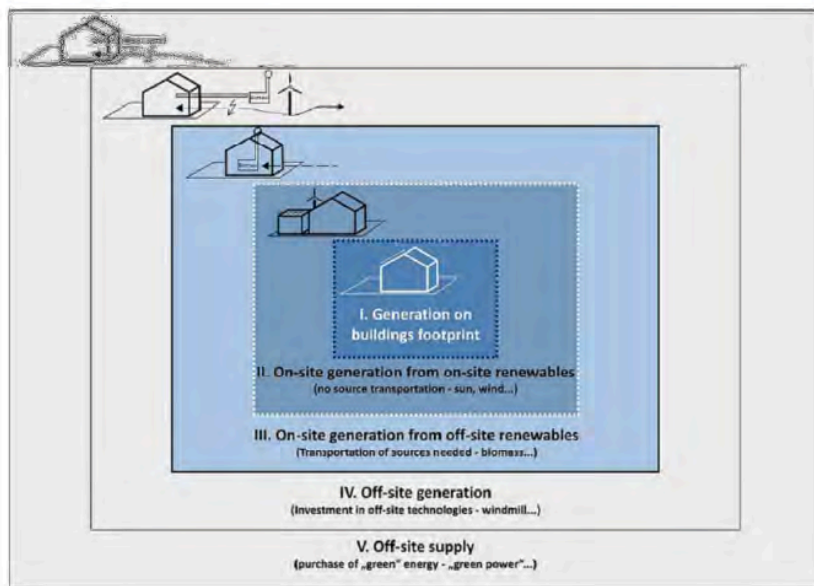
The construction of autonomous, low carbon buildings with integrated renewable energy is possible but the widespread roll-out of such a buildings is unlikely to be cost effective (Riedy C, Lederwash A and Ison N 2011).

Newton et al (2013) state that 'for resilient, sustainable low carbon urban development to be realised in the 21st century ... will require several radical transitions in design performance *beyond* the scale of individual buildings'.

Greater efficiencies can be achieved through low carbon precincts that combine integral, on-plot and site wide renewable energy, supplemented by off-site supply where required (see Figure 1). The majority of short listed exemplar projects demonstrate district energy solutions particularly co / trigeneration, solar arrays and smart grids.

Figure 1: Overview of possible renewable energy supply options

Source: Marzal et al (2010)



A precinct has been described by CRC for Low Carbon Living precinct stream leader Peter Newton as *"...an urban area of variable size that is considered holistically as a single entity for specific analyses or planning purposes, as well as in a contextual sense to represent the interactions that occur with elements of the surrounding urban area. It typically comprises land parcels occupied by constructed facilities (generally buildings), including open space, and often clustered into urban zones that share some common characteristics (uses) and supported by physical infrastructure services to manage energy, water, waste, communication and transport as well as a range of social infrastructures related to health care, education, safety, retailing and entertainment."* (Newton et al. 2013 p. 5)

Elements and processes for the delivery of low carbon precincts are worth studying because greater efficiencies can be achieved at the precinct scale than at the individual household scale due to the complex network of interaction between urban systems such as energy, water, food and transport that in combination provide opportunities for an integrated development (Newman and Kenworthy, 1999).

A well designed precinct is much more than the sum of a collection of buildings and infrastructure, it is about liveability. Good planning recognises the city as a place for people (Gehl, 2010). Failing to offer a high quality of life for occupants will reduce the market appeal of low carbon options. Interestingly several case studies (eg SolarCity Linz, GROW community, One Brighton) have been marketed as much for the lifestyle and liveability they offer than their low carbon technical attributes. A successful low carbon precinct, therefore, will need to be a sustainable (considering its full ecological footprint) and liveable precinct.

*Liv(e)ability is about the human need for social amenity, health and well-being and includes both individual and community well-being. Liv(e)ability is about human environment, thought it can never be separated from the natural environment. Thus sustainability for a city is not only about reducing metabolic flows (resource inputs and waste outputs); it must also be about increasing human liv(e)ability (social amenity, health and well-being). (Newman and Kenworthy 1999 pp.9-10).*

As we transition from business as usual to low carbon sustainable urbanism, precinct scale initiatives can help trial and test subdivision/ neighbourhood wide urban eco-infrastructure. All of the low carbon precincts case studies reviewed in this scoping study trialled some form of innovative process or technology aimed at reducing resource consumption. However it is worth noting that many of these projects received large subsidies from government and occasionally industry. Such demonstration projects are useful for showing what is possible but the key to mainstreaming low carbon sustainable urbanism will be finding processes, or sufficiently desirable products, capable of competing against (typically cheaper) conventional development.

Trialling sustainable technologies and processes at the precinct scale can help build knowledge within the built environment professions and inform future urban policies (through the analysis of case studies) with the ultimate objective of mainstreaming low carbon sustainable urbanism in Australian cities.

## Known limitations

### Lack of consistent definitions and data

The lack of consistent definitions and data on low carbon precincts made the selection of directly comparable projects difficult. To compensate for the great variation in definitions around the globe another approach was required to enable the rapid identification of projects worth considering as potential low carbon precinct 'exemplars'.

A relative approach was taken such that projects needed to demonstrate an intention to meet the additionality criterion (Bunnings et al 2013) – that is, the project demonstrated a concerted and intentional effort to achieve additional forms of abatement relative to those which would occur under a business as usual scenario.

The quality of readily accessible data available on each project varied greatly with some projects extremely well documented (eg BedZED, Hamarby Sjostad, EcoViikki, Lochiel Park, Vauban etc) while some projects claimed as exemplary seemed to be little more than concept plans being used for marketing or fundraising purposes (eg. Mentougou Eco Valley in China, Konza Techno City in Kenya).

### Differentiating between aspirational and actual achievements

In September 2013 the Economist described the phenomenon of 'urban dreamscapes' naming several highly publicised low carbon projects as 'fantastic' and with being affected by 'post (Global Financial) crisis realism' having been conceived during a more optimistic period. Some of these schemes are more akin to high Modernist utopian visions than *bone fide* low carbon projects.

There are some exceptions eg. Masdar which will be realised at least for its first phases although subsequent phases have been pushed back, and that may be built and hopefully will advance knowledge and technology improving resource efficiency and quality of life.

### English language bias

The majority of the sources reviewed were in English leading to a prevalence of projects known in the Anglosphere. Limited use of Google translate was of assistance where projects were cited with few or no good information sources in English.

This shortlist includes projects from a number of countries but the obvious majority are European and of these a large number were from the UK. Europe certainly is leading the way in terms of the scale and performance of low carbon precincts and this activity is supported by

Figure 2: Konza Techno City



Figure 3: Mentougou Eco Valley



Figure 4: Mentougou Eco Valley





the European Union. The prevalence of UK examples might be due to a number of other reasons including:

1. The limitation of conducting research in English - several case studies identified as possible low carbon precinct precedents particularly in Asia were not included because of the lack of material in English to confirm their relevance.
2. The push by the UK government since the publication of the Stern Review (2007) to take early and strong action on climate change to minimise future social and economic disruption leading to government low carbon initiatives such as *the Code for Sustainable Homes*, *The Carbon Challenge* and *EcoTowns*.
3. Several major sources of the literature/ website review originated from the UK (Eg Zero carbon hub, BREAM, One Planet Communities (Desai 2010), Westminster University Eco Cities survey) and therefore contained considerable local content.

## Approach to examining exemplary low carbon precincts

### Purpose

The purpose of this scoping study (Phase 1 and 2 - see below) is to identify and disseminate findings and recommendations (for further inquiry) from a review of successfully implemented low carbon precinct case studies. Findings and recommendations from this paper may assist CRC partners to better understand the range of possibilities for low carbon precincts in terms of products (development components) and processes (delivery mechanism). Through an understanding of what has been delivered elsewhere, and how it was achieved, it may be possible to discover triggers for mainstreaming low carbon sustainable urbanism in Australia and against which to benchmark progress.

A broad spectrum of projects were considered for review based upon a reputation for being 'low carbon' or sustainable. A range of sources (books, websites and journals – see Appendix 2 for source list) were consulted to identify projects for review.

### Method

This study will be delivered in two phases:

**Phase 1:** Literature review scoping study leading to the identification of a 'longlist' and a process for determining a 'shortlist' of best practice case studies (this report).

**Phase 2:** Several projects will be selected from the Phase 1 short list and will become the focus of a more detailed investigation in Phase 2 of this scoping study. Phase 2 will involve site visits to selected projects and interviews with key stakeholders to understand the processes behind the project delivery (to occur in the first half of 2014).

**The Phase 1 approach is set out below.**

## Long list of projects for consideration

### Criteria for Selection

Case studies were selected based upon their *reputation* for being 'low carbon' with evidence drawn from a variety of sources including:

- journal databases
- leading books on the topic of low carbon precincts

- websites drawn from interest groups and organisations.

Appendix 2 lists the sources reviewed to identify the low carbon precincts included in the 'long list'.

A 'long list' of 78 projects were considered as possible best practice low carbon precincts, the projects are listed in Appendix 1.

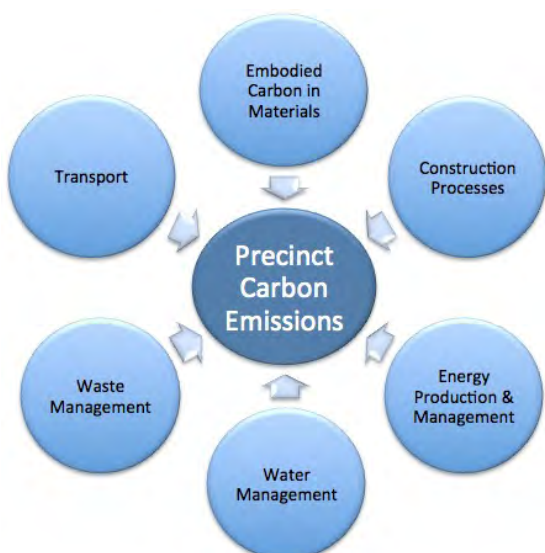
Each project has been summarised in matrix form to categorise comparable information relating to location, scale, stage and type of development using the following headings:

- Project Name
- Country
- EcoClaim (the label used by the developer or literature to describe the sustainability vision)
- Status (Constructed, Underway, Planning)
- Land Condition (Original state either - Greenfield, Brownfield, Greyfield, Retrofit)
- Dwellings (number of...)
- Site Area (hectares)
- Dw/Ha (residential density as dwellings / hectare)

Bunning et al (2013) in the publication *Low-Carbon Sustainable Precincts: An Australian Perspective* identified six categories as the key sources of carbon emissions within precinct scale developments. These six categories have been included in the assessment table and marked with a 'Y' (Yes), 'N' (No) or '-' (where unknown). The more of these carbon sources addressed within the development the more comprehensive the low carbon approach.

Figure 5: Key emission sources within precinct developments.

Source: Bunning J, Beattie C, Rauland V and Newman P (2013)



## Short list of exemplary low carbon precincts

### Criteria for Selection

A 'shortlist' of 20 low carbon precincts were selected from the long list for further investigation / discussion based upon:

- the frequency of references to a project in the source material (see Appendix 2 for source list)
- how well the project addressed the six precinct carbon emission categories (as described by Bunning et al. 2013),
- development status ('constructed' or 'underway') a project was not considered if only 'planned'. It was noted in *The International Eco-Cities Initiative – A global survey 2* (2011) that a large number of planned sustainable projects had failed to eventuate or changed nature after the initial planning phase.
- International projects were selected over Australian projects because it was expected local projects are already well covered by Australian literature.

The resulting 'short list' of exemplary projects represent a diverse range of approaches to sustainable urbanism and an equally diverse range of strategies for delivery such as demonstration projects, integrated eco-services, and innovative funding and governance models for delivering low carbon precincts.

Table 1 provides a brief overview of the shortlisted case studies.

**Table 1 Case Study exemplars (the 'shortlist')**

Project Name	Country	Eco Claim	Status	Land condition	Site area (Ha)
BedZED	UK	carbon neutral district	constructed	brownfield/ greenfield	1.65
BO01, Malmo	Sweden	eco-district	constructed	brownfield	22
Castleward, Derby	UK	BREAM Good	underway	brownfield	12
Coopers Road Estate	UK	zero carbon	constructed	greyfield	1.69
Dockside Green	Canada	LEED Platinum	underway	brownfield	6
Eco Vikki	Finland	sustainable neighbourhood	constructed	greenfield	23
Graylingwell Park, Chichester	UK	Zero carbon	constructed	greyfield	34
Greenwich Millennium Village	UK	sustainable neighbourhood	underway	brownfield	20
Grow Community, Bainbridge Island Washington state	USA	One Planet Community	underway	greenfield	3.2
Hammarby Sjostad, Stockholm	Sweden	eco-district	constructed	brownfield	200
Hanham Hall	UK	Carbon Challenge, Zero carbon, CSH L6	constructed	greenfield / retrofit	5
Masdar, Abu Dhabi	UAE	Eco-city	underway	greenfield	600
Millennium water (Vancouver Olympic Village)	Canada	Model ' sustainable community, Net zero housing	constructed	brownfield	7
One Brighton	UK	One Planet Community	constructed	brownfield	2
Peterborough Carbon Challenge	UK	Carbon Challenge, Zero carbon. CSH L6	underway	brownfield	7
solarCity Linz-Pichling	Austria	solar city	constructed	greenfield	32
Sonoma Mountain Village	USA	One Planet Community	underway	brownfield	81
Stockholm Royal Seaport	Sweden	environmental city district	underway	brownfield	236
Vauban, Freiburg	Germany	sustainable urban district	constructed	brownfield	38
Vuores	Finland	eco-efficient living	constructed	greenfield	472

The short listed projects are described over the following pages in greater detail including:

- Project Name
- Eco Claim
- Project Description (Country, Land condition, size, land uses, Innovative delivery etc)

Details are also provided for the most relevant following low carbon categories:

- Embodied Carbon in Materials
- Construction processes
- Energy Production and management
- Transport
- Water management
- Waste management
- Other sustainable initiatives

## Case study exemplars

### BedZED, UK

*Eco Claim:* Carbon neutral district

*Project Description:* Beddington Zero Energy Development (BedZED) is a suburban, mixed-use development of 82 dwellings and 2500m<sup>2</sup> of commercial or live/work space on 1.65 hectares in South London. The project completed in 2002 is now a mature low carbon development providing many lessons, particularly around overcoming skill barriers but also market barriers.

In 1997 the UK charity BioRegional, seeking new office space to house their growing environmental social enterprise, decided that instead of renting a conventional commercial space they would 'express their commitment and ideas by building a green office' (Desai, 2010). This resulted in the BedZED development.

BedZED was developed using a strong sustainability vision referred to as the 'One Planet Living Principles' (developed collaboratively by BioRegional and the World Wildlife Fund). These principles have since been promoted and adopted as a benchmark for other 'One Planet' sustainable developments. The ten principles relate to carbon, waste, transport, materials, food, water, biodiversity, culture, economy and happiness, and effectively function as a reference point for decision making throughout the development process.

The BedZED 'urban eco-village' includes a low energy, medium density urban development (approximately 50 dw/ha) on a subdivision oriented to maximise passive solar design .

Although the project was not a success financially, BioRegional cite two primary factors that helped off-set the 'sustainability cost premium'. These factors were the use of a 'planning gain mechanism' and the property value premium the green designs attracted. The planning gain mechanism involved trading green innovation for additional development area, in this instance the production of a 'green transport plan' allowed the developer to seek permission for a reduction in car parking provision and road space which was transferred to additional development space that in turn translated to additional returns (estimated to be in the region of £3.7 million additional development value) (BioRegional, 2009). The market appeal of the innovative product "achieved premium values some 17-20% above the conventional new homes in the area. Buyers paid extra for the innovative design and the "green" credentials" (BioRegional, 2009, p.8).

Having a strong environmental vision at the outset of the project and a steward or 'sustainability integrator' (Desai, 2010) ensured the sustainability vision (One Planet Principles) were not compromised at any stage of the process from concept, through detailed design, construction and post occupancy management.

*Embodied Carbon in Materials:* Approximately 15% of total building material was derived from reclaimed or recycled sources.

*Construction processes:* Prefabrication was considered for the advantages it could bring to waste reduction and construction speed but it was deliberately not applied because of the project team's perception that it can lead to a 'deskilling' of the workforce (Bioregional 2002).

*Energy Production and management:* The subdivision was (quite rigidly) oriented to maximise passive solar design. The super insulated

buildings resulted in a 75% improvement upon UK building regulations (Desai, 2010, p.33), while renewable energy production in the form of PVs and biomass fueled trigeneration (supplemented by natural gas) resulted in an average 45% reduction in energy consumption (and 81% heating reduction) when compared to neighbouring, conventional developments.

*Transport:* Car club, walking distance to train stations and buses.

*Water management:* Water sensitive urban design innovations such as green roofs (accessible as private open space), rainwater harvesting. On-site 'enhanced reed bed system' for sewerage treatment (Desai, 2010).

*Waste management:* On-site reed bed sewerage treatment, waste separation and community composting.

*Other sustainable initiatives:* Long term plan to develop an urban farm and biomass cropping on adjacent agricultural land (not developed to date).

*Information sources and further information:*

Desai P (2010) *One Planet Communities. A real-life guide to sustainable living.* John Wiley & Sons

Bioregional (2002) *BedZED Beddington Zero Energy Development, Sutton.* Housing Energy Efficiency Best Practice Program.

Bioregional (2009) *BedZED: Toolkit Part II. A Practical guide to producing affordable carbon neutral developments.*

## **BO01, Malmo, Sweden**

*Eco Claim:* Eco-district

*Project Description:* BO01 is the first stage of a broader brownfield redevelopment of Malmo's Western Harbour (160ha) in Southern Sweden. From the outset there was a strong focus upon sustainability which permeated all stages of the development from planning, building, construction and management of the 'eco-district'. BO01 includes 22 ha of mixed use development with 1303 dwellings and a number of eco-businesses. The broader Western Harbour area includes Malmo University, around 80 companies, 6000 employees, a new park and a private and public school. 290 millions SEK have been granted for environmentally related investments through the Local Investment Programme (LIP).

*Embodied Carbon in Materials:* Recycled material streets and alleys (substrate),

*Construction processes:* Unknown.

*Energy Production and management:* 100% locally generated sustainable energy, district heating / cooling. Wind turbine in the harbour (3km away) powering local houses, integration of rooftop photovoltaics, water sourced heating and cooling (using seawater and aquifer for heat transfer/seasonal storage).

*Transport:* Pedestrian and cyclist priority, car free areas, only 0.7 parking spaces / household, all flats within 300m of a bus stop, frequent buses – every seven minutes during peak periods.

*Water management:* Green roofs, water sensitive urban design.

*Waste management:* Waste separation units (integral and external to homes), vacuum waste chutes, Waste to energy system. Waste water treatment and nutrient recovery.

*Other sustainable initiatives: Policy for sustainable development and food (City of Malmo) with the intent that 'all food purchased should be organic by 2020 and greenhouse gas (GHG) emissions from food procurement should be reduced by 40 % by 2020'.*

*Information sources and further information:*

<http://www.malmo.se/English/Sustainable-City-Development/Bo01---Western-Harbour.html>

Rauland, V (2013) *Decarbonising Cities: Certifying Carbon Reduction in Urban Development*. Curtin University Sustainable Policy Institute, PhD Thesis.

Williams, J (2012) *Zero Carbon Homes*. Earthscan, Oxon.

City of Malmo (n.d) *Vastra Hamnen The Bo01-area. A city for people and the environment*.

## Castleward, Derby, UK

*Eco Claim:* Sustainable BREEAM Community 'good'

*Project Description:* Castleward is a 12 hectare brownfield regeneration site in central Derby for 800 new homes (163 dwellings in phase 1 completed October, 2013) and 3,200sqm of commercial space. This joint venture between Derby City Council and Compendium Living is an early adopter the 2012 BREEAM Communities tool. According to BREEAM, the BREEAM Communities tool was seen by the developer as a 'cost-neutral' assessment that helped 'smooth out the planning process' (see: <http://www.breeam.org/>). BREEAM Communities was used as the framework to incorporate sustainability into the development (BREEAM 2013).

*Embodied Carbon in Materials:* Unknown

*Construction processes:* Unknown

*Energy Production and management:* Highly insulated buildings to increase energy efficiency (built to Code for Sustainable Homes Level 3). Commercial units developed to BREEAM standards

*Transport:* The site is a short walk from the railway station

*Water management:* Water sensitive urban design.

*Waste management:* Preparation of a site waste management plan guiding waste elimination and minimisation during construction phase.

*Other sustainable initiatives:* Biodiversity: Site tree survey to identify trees to be retained / removed, semi-mature trees will be planted to replace removed trees and more trees will be planted than removed from the site.

*Information sources and further information:*

<http://www.castleward.co.uk/>

BREEAM Communities Castleward, Derby case study at <http://www.breeam.org/> (accessed October, 2013)

Lovell (2013) Case study in sustainability: Affordable Housing, Castleward, available at: <http://www.morgansindall-sustainability.com/>

## Coopers Road Estate, UK

*Eco Claim:* Sustainable urban regeneration



*Project Description:* The Coopers Road Estate project involved the demolition and regeneration of a neglected 1960s housing estate in Southwark, London. The 1.69 hectare site includes six urban blocks containing 615 residential units. In 1999 following consultation with residents the site management Southwark Housing decided to demolish the tower blocks and rebuild with the assistance of the Peabody Trust in a new sustainable perimeter block typology (Turrent 2009).

The housing mix includes social housing for rent and market housing. The large social housing component helped the client (Peabody Trust) overcome the typical sustainability cost premium confronted by developers because the split incentive did not apply (ie developer also benefited from the investment in low carbon technology (in this instance the combined heat and power)). The cost savings associated with the combined heat and power will be recouped over the longer term through energy cost savings to the client (Peabody Trust).

*Embodied Carbon in Materials:* Material selection based upon low embodied energy and minimal environmental impact when disposed – preference for certified timber and masonry over plastic and steel. Contractors were encouraged to source materials from within a 50 mile (83km) radius where possible. Prefabricated windows and standardised elements used to minimise construction waste.

*Construction processes:* Unknown

*Energy Production and management:* Passive Design: Buildings around the courtyard perimeter are designed to maximise solar access to the courtyard (with 3 storey buildings to the south and four story blocks to the north). Roofs are designed to face south to maximise potential area for photovoltaic energy production. Daylight penetration into homes has been maximised to reduce heating and lighting demand.

Very high standards of insulation were too cost prohibitive for this social housing therefore a combination of a higher than Building Regulation standard was adopted (wall U-value 0.3 W/ m<sup>2</sup>K, roof 0.25 W/ m<sup>2</sup>K and windows 2.0 W m<sup>2</sup>K). Additional funding (London Electricity grant) was made available to encourage efficient appliances.

On-site power: on-site gas (with potential to switch to biomass) powered combined heat and power (11% heat demand, 12% electricity demand) was adopted despite higher construction costs because payback was calculated at less than 10 years.

*Transport:* Access roads designed as 'home zones' shared spaces with a focus on community life prioritising pedestrians and cyclists while allowing car access with a maximum speed of 20mph. Courtyards contain communal on-site bike storage.

*Water management:* Reduced water demand through low flush toilets and spray taps in kitchens. Rainwater harvesting for toilet flushing and garden irrigation.

*Waste management:* All dwellings have separated bins to encourage recycling. The courtyard gardens contain communal composting areas.

*Other sustainable initiatives:* Landscape treatment on the urban site included porous paving to allow on-site infiltration, biodiversity is encouraged through native street tree planting and wildlife hedgerow screens.

*Information sources and further information:*

Turrent D (2009) 'Coopers Road Estate: Regeneration' in Ritchie and Thomas (Eds) (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London.

<http://www.peabody.org.uk/homes-in-development/coopers-road>

[http://www.newlondonarchitecture.org/project.php?id=675&name=coopers\\_road\\_estate\\_regeneration](http://www.newlondonarchitecture.org/project.php?id=675&name=coopers_road_estate_regeneration)

## Dockside Green, Canada

*Eco Claim:* Sustainable waterfront living, LEED platinum

*Project Description:* Dockside Green is a six hectare harbourside mixed use (residential, commercial, light industrial) development on a former brownfield site in Victoria, British Columbia. The development has a target population of 2,500 residents for its planned completion in 2015 (Vancity see: <http://www.docksidegreen.com/>) (NB. This deadline is very unlikely to be met due to delays related to a financial downturn in Victoria (Kozakowski 2013)).

High building fabric and glazing insulation levels coupled with passive design led to significant energy demand reductions. A large biomass gasification district energy system for heating and hot water provide renewable heat sources to meet much of the building operational energy demand. Reduced water demand and 100% recycling of waste water for non-potable uses as well as water sensitive urban design (green roof and a significant 'naturalised creek' forming a major landscape water feature running through the development).

The owner and developer is Vancity Canada's largest credit union known as a Canadian 'leader in non-market housing' (Victoria Times 2006). Through a competitive tendering process City of Victoria sold the contaminated harbourside site to Vancity for \$1 in a bid deemed to have the highest return to the community (rather than a monetary return for the council). Part of the sale conditions included site remediation (estimated at \$12 million) and environmentally sustainable development with strict development build out targets (Victoria Times 2006). To monitor environmental progress Vancity conduct annual Dockside Green Sustainability Reports.

*Embodied Carbon in Materials:* Material selection aimed at durable and environmentally friendly products eg. Low embodied energy (fly ash) concrete, bamboo flooring and cabinets, salvaged wood, carpets selected from GHG neutral (Interface 'Cool Carpet' etc.). Local businesses and suppliers are targeted to reduce emissions related to transport. Sustainable wood products used when possible (a large number of wood products are sourced from Victoria-based Triton Logging a company that harvests standing forests flooded by hydro-reservoirs).

*Construction processes:* Unknown.

*Energy Production and management:* Biomass gasification heating and domestic hot water, solar water heating, photovoltaics, and small-building wind turbines. Low energy appliances and fixtures.

Meters are provided in each dwelling to monitor hot and cold water use, heating and electricity use.

*Transport:* Harbour ferry dock, car share scheme, dedicated bicycle storage and shower facilities. Car pool and mini-transit (shuttle bus) aim to reduce private vehicle kilometres travelled. Adjacent the regional 'Gallopig Goose' recreational (pedestrian and cyclist) trail.

*Water management:* High water efficiency shower heads, toilets, taps and white goods. On-site waste water treatment and reuse (membrane bioreactor technology). 100% of sewerage (grey and black water) treated on-site and reused for non-potable water demand eg. toilet flushing, irrigation. Excess treated water sold off-site. Water sensitive urban

Figure 6: Dockside Green



design (green roofs, 'naturalised creek') meaning Dockside Green does not use the municipal stormwater system.

*Waste management:* Target: Divert 75% of construction waste from landfill (status 2011 annual report: 95% of construction waste diverted from landfill). Recycling rooms in all buildings including an organics collector.

*Other sustainable initiatives:* Vancity collaborate with numerous tertiary and secondary educational institutions and local employers to share knowledge and support training opportunities. Acknowledgement of first nation Songhees people and inclusion of traditional ceremonies, history and art across the site.

*Information sources and further information:*

Dockside Green official website, see: <http://www.docksidegreen.com/>

*Dockside Green: Annual Sustainability Report 2011*, Vancity

General Electric (2007) *Water and Process Technologies Dockside Green Case Study*.

Kozakowski, M (2013) *Dockside Green to seek agreement re jig after missing targets*. Vibrant Victoria <http://vibrantvictoria.ca/local-news/dockside-green-seeks-agreement-re-jig-after-missing-targets/>

Victoria Times, 5 August, 2006. *Former CEO accuses Vancity of firing him over affordable housing*. See: <http://www.canada.com/story.html?id=bd558d69-7f5c-4125-b5fb-004d9de4ee02> (accessed October 2013)

## Eco Viikki, Finland

*Eco Claim:* A model environmental housing project (Eco community)

*Project Description:* Built as an ecological residential showcase Eco-Viikki was completed in 2004. Built on a greenfield site eight kilometres from Helsinki with 17,000 inhabitants in medium density row houses and apartment blocks; the area will also support 6,000 jobs and 6,000 students (Rinne 2009). Housing is clustered close to the motorway while large areas adjacent the site have been preserved as recreation or nature conservation sites for the benefit of residents. The project scope was defined in the 1990s as a City of Helsinki initiative to test and demonstrate an ecological community. The city held a competition and based planning outcomes upon the winning entry. The outcome led to an urban structure that maximised passive solar orientation, with the integration of nature through garden belts along the streets and wider green belts to serve as wildlife corridors.

Architectural competitions were held to develop designs for sustainable housing blocks with considerable interest from Finnish construction companies ([www.hel.fi/ksv/english/index.html](http://www.hel.fi/ksv/english/index.html)). All approved construction projects exceeded the minimum environmental standards set for Eco-Viikki which included 17 criteria related to five main issues emissions, the use of natural resources, health factors, biodiversity, and food production.

Although successful, post occupancy audits demonstrated that the ambitious targets set during planning have not been met, yet overall the project is much more environmentally friendly. Leading to the following conclusion 'The whole experience has shown that careful monitoring should play an important role alongside planning controls and evaluations in promoting ecologically sustainable construction.' ([www.hel.fi/ksv/english/index.html](http://www.hel.fi/ksv/english/index.html)). The project was to support a national program of ecologically sustainable buildings.

Figure 7: Eco Viikki



Figure 8: Eco Viikki



Additional costs associated with the basic requirements of the eco-criteria represented a 5% additional investment to be recuperated over the life of the project.

*Embodied Carbon in Materials:* Extensive use of (carbon neutral) timber.

*Construction processes:* Flexible timber construction techniques (including multi-storey timber framed apartment blocks) and extensive use of natural materials. An indoor air quality requirement meant certain buildings had no internal chemical coatings eg Viikki Church with an untreated timber interior finish.

Experimental construction projects supported by the National Technology Agency Tekes. Strict environmental controls carried out during the construction phase with the City of Helsinki as client and supervisor.

*Energy Production and management:* Low energy housing. Local solar heating schemes (solar thermal collectors over 10 properties). Co generation district heating network, Solar energy panels (1400msq), wood heated communal saunas. Majority of houses have south facing windows for passive solar. Glazed balconies on many buildings function to regulate temperature – capturing heat and buffering heat loss).

*Transport: Water management:* Water sensitive urban design management of storm water. Water minimisation techniques (target 40-50 litres /person /day).

*Waste management:* Target: 20% waste reduction (160kg / person / year), 10% reduction of building wastes.

*Other sustainable initiatives:* Urban agriculture. Resident's garden centre. Local biodiversity research projects. Reducing resource demand through multi-purpose use of space.

*Information sources and further information:*

City of Helsinki see: [www.hel.fi/ksv/english/index.html](http://www.hel.fi/ksv/english/index.html)

Energie Cites fact sheet (2008) [www.energie-cities.eu](http://www.energie-cities.eu)

Rinne H 2009 Eco Viikki fact sheet [www.hel.fi](http://www.hel.fi)

## Graylingwell Park, Chichester, UK

*Eco Claim:* Net zero carbon. Code for Sustainable Homes, Code Level 4 /Code Level 6 for energy.

*Project Description:* Graylingwell Park in Chichester is a 34 hectare former hospital site including 800 new and retrofit homes plus 8000 m<sup>2</sup> of commercial and community space managed by a Community Development Trust (UKGBC 2013).

Energy efficient buildings minimise energy requirements while photovoltaics and combined heat and power will meet the majority of energy demand. The project was recipient of the following UK awards Sustainable larger social housing project of the year, at Inside Housing magazine's 2010 Sustainable Housing Awards, Best low or zero carbon initiative, 2010 Housebuilder Awards, gold for 'Best Sustainable Development' and silver for 'Best Brownfield Development' at What House? Awards 2011.

Dr Nicholas Falk (2012) attributed much of project success on the involvement of a good housing association (Affinity Sutton).

The project developers Linden Homes emphasised 'engagement with the local community to ensure local stakeholders 'own' the sustainability ethos of the site' (UKGBC 2013).

The project demonstrates that it is possible to build green/low energy consuming buildings that are also affordable. The site is smart metered to monitor performance and to enable residents to measure household performance.

*Embodied Carbon in Materials:* Locally available (less than 80kms radius) materials were used where possible, materials found on-site (including reuse of buildings), recycled materials (around 30% of all materials) and low embodied energy materials were prioritised. 80% of timber was certified sustainable.

*Construction processes:* Unknown.

*Energy Production and management:* Energy efficient buildings, photovoltaic panels plus remainder of energy requirements (40%) met by off-site renewables. Dwelling emission rate <15kgCo<sub>2</sub>/m<sup>2</sup> for all new homes excluding renewable energy contributions. An average heat loss parameter across the whole site of 1.3W/m<sup>2</sup>.K. High levels of insulation in walls (0.17W/m<sup>2</sup>.K), roof (0.13W/m<sup>2</sup>.K), and floors (0.15W/m<sup>2</sup>.K). High performance double glazing with a u-value of 1.2W/m<sup>2</sup>.K. New buildings to achieve 3m<sup>3</sup>/h/m<sup>2</sup> airtightness. Active heat recovery ventilation. 100% low energy lighting throughout. All appliances recommended as A+ rated (UKGBC).

*Transport:* Green travel plan encouraging the use of public transport (bus), on-site car clubs and cycle routes to minimise private vehicle use. Car parking limits – one per dwelling (yet still attracted some criticism as too much space given over to car parking (Falk, 2012 p.9).

*Water management:* Target: water demand reduced by 33%. Achieved through low-flow aerated or spray taps in bathrooms and kitchens, dual-flushing cisterns rainwater harvesting for irrigation (flushing to be investigated), more than 50% of the roof area is used for rainwater harvesting or green roofs.

*Waste management:* Waste management strategy to minimise construction waste, minimise waste to landfill, segregation of waste streams from households and commercial premises.

*Other sustainable initiatives:* Allotments for residents to grow food. Ecologist commissioned to understand long term impact on biodiversity and to seek opportunities to enhance the site ecology. Most mature trees were retained and 1428 new trees (including fruit trees) have been planted on-site.

*Information sources and further information:*

UKGBC (2013) *Project Case Study Graylingwell Park*. Green Building Council (available at: [www.ukgbc.org](http://www.ukgbc.org) (accessed September 2013)

Falk N (2012) *Sustainable New Communities on the South Coast*. URBED

## Greenwich Millennium Village, UK

*Eco Claim:* Exemplary sustainable community (Millennium Communities Programme), BREEAM 'excellent'

*Project Description:* The 121 hectare, 1,400 dwelling sustainable mixed use brownfield development on the Greenwich Peninsula was delivered through English Partnerships Millennium Communities Programme.

The village was designed to minimise the impact of private motor vehicles (see below under transport) – reduced parking allowed greater site area for housing, cycleways, foot paths and open space.

Ambitious targets for the reduction of resources (energy, water, waste - see below) have been criticised by some commentators because of an impression that actual performance fell well short of the set targets (Secure, 2007). According to Katice Helsinki "...the winning architecture firm, Hunt Thompson and Associates, has resigned from the project "because the original ecological (or sustainable) standards were increasingly being run down by the developers, to such an extent that they could no longer sign-up to the project" (Secure 2010).

*Embodied Carbon in Materials:* Target: Reduce embodied energy in buildings by 50% by selecting materials from the BRE 'Green Guide' or reusing materials. Recycled and locally produced materials used wherever possible.

*Construction processes:* Unknown.

*Energy Production and management:* Target: reduce primary energy consumption by 80% through reduced demand (highly insulated buildings) and Combined Heat and Power.

Target: building emission target 260kgCO<sub>2</sub>/m<sup>2</sup> (excluding car park structures)

*Transport:* To reduce car dependence English Partnerships delivered the 'Millennium Busway' and produce annual monitoring including mode split and parking demand of residents as part of a strategy for reducing car use. North Greenwich tube station is connected to the site by bus, or is a 15 minute walk to the north. Car parking is restricted and located on the edge of the development with only 884 parking spaces for 1,400 dwellings. Residents do not get allocated a park but rather a 'right to park' which costs £17,500. As a result private car ownership is 18% compared to 44% Greenwich, 42% London. Four car share vehicles are parked on-site and available for use by club members. There is no off-street visitor parking. 2-3 secure bike parking spaces are provided per dwelling and designated cycle and pedestrian paths provide safe car-free connections across the village.

*Water management:* Target: 30% water consumption reduction through specification of water efficient taps, showers, toilets and white goods.

*Waste management:* Target: 50% reduction in construction waste. Construction waste was continuously measured and recorded and where possible recycled.

*Other sustainable initiatives:* Biodiversity – artificial lake ('Millennium wetlands') and ecology park.

*Information sources and further information:*

Secure (2007) *Benchmark study, Greenwich Millennium Village.*

European Sustainable Urban Development Projects (see:

<http://www.secureproject.org/>).

Foletta N (2011) *Europe's Vibrant New Low Car(bon) Communities, Greenwich Millennium Village.*

## Grow Community, Bainbridge Island Washington State, USA

*Eco-claim:* Pedestrian oriented, zero carbon goal by 2020, One Planet Community

*Project Description:* The Grow Community in Washington State is a 3.2ha development on Bainbridge Island. The masterplan aims to achieve social as well as environmental sustainability by planning for a multi-generational community with a mix of accommodation types to encourage variety in terms of family group size and economic level (Bioregional 2011).

Dwellings typically have a small footprint and there is an emphasis on outdoor space and urban agriculture to provide food and build community (hence Grow Community). Part of the sustainable food strategy will involve all dwellings having a garden (for the production of food / biodiversity).

*Embodied Carbon in Materials:* Sustainable materials with an emphasis on local sourcing. Multi use buildings (resource efficiency – school doubles as assembly space for community activities and includes a kitchen, play area, art and music rooms, and an outdoor terrace for events). 70% of lumber sourced from FSC-certified or local sustainably managed sources.

*Construction processes:* Unknown.

*Energy Production and management:* On and off site renewable energy sources particularly photovoltaics. Performance indicator: Total GHG emissions will be reduced from 4.5 tons per person to 0 tons/kWh by 2020.

*Transport:* A transport plan emphasises pedestrian and cycle movement. Car ownership kept at 0.6/dwelling. The project is within a five minute walk of a major transportation hub (35-minute ferry to downtown Seattle). Most social infrastructure (schools, grocer, library and restaurants) falls within a 5-10 minute walk of dwellings. Performance indicator: GHG emissions attributed to road travel reduced to 0.76 tons / person on-site (a 76% reduction). Car sharing (to be measured annually).

*Water management:* Water reuse systems incorporated into all residential buildings (detached homes and multifamily buildings) Performance indicator: Reduce total water consumption by 47% of Kitsap County average (81 gallons) by 2020 (to 43 gallons (163 litres) per capita per day). Improve the quality of water runoff to meet Washington State Department of Ecology standards.

*Waste management:* Only 2% of all waste from construction will go to landfill by ensuring 98% of construction waste is reused or recycled. Reduce waste generated by residents by 70%.

*Other sustainable initiatives:* Urban agriculture – organic pea pods and fruit trees dispersed throughout. Partnership with a nearby working farm a short walk from the community. Performance indicator for sustainable food: Organic food will make up 75% of the diet of Grow residents. 70% of the diet will be seasonal or local food and high carbon food consumption will be reduced to 1/3 of the US average.

Boost biodiversity on-site – Performance indicator: maintain 35% tree canopy averaged over the whole site.

*Information sources and further information:*

One Planet Communities Website:

<http://www.oneplanetcommunities.org/communities/endorsed-communities/grow/> (Accessed November 2013)

Bioregional (2011) *Grow Community Sustainability Action Plan*, available at: <http://growbainbridge.com/>



## Hammarby Sjostad, Stockholm, Sweden

*Eco Claim:* Eco-district

*Project Description:* Hammarby Sjostad is a 200 hectare medium to high density neighbourhood in central Stockholm that is the result of a public private partnership to redevelop a former naval yard into a showcase sustainable neighbourhood. The project, catalysed by the unsuccessful 2004 Stockholm Olympic bid, when complete in 2016 will include a mix of land uses including 10,000 dwellings, office, retail and community space. A special feature of the redevelopment is the high quality public realm which maximises the existing site assets (water, forest) and includes a long water frontage activated by harbourside walks fronted by restaurants and cafes (Energy Cities n.d.).

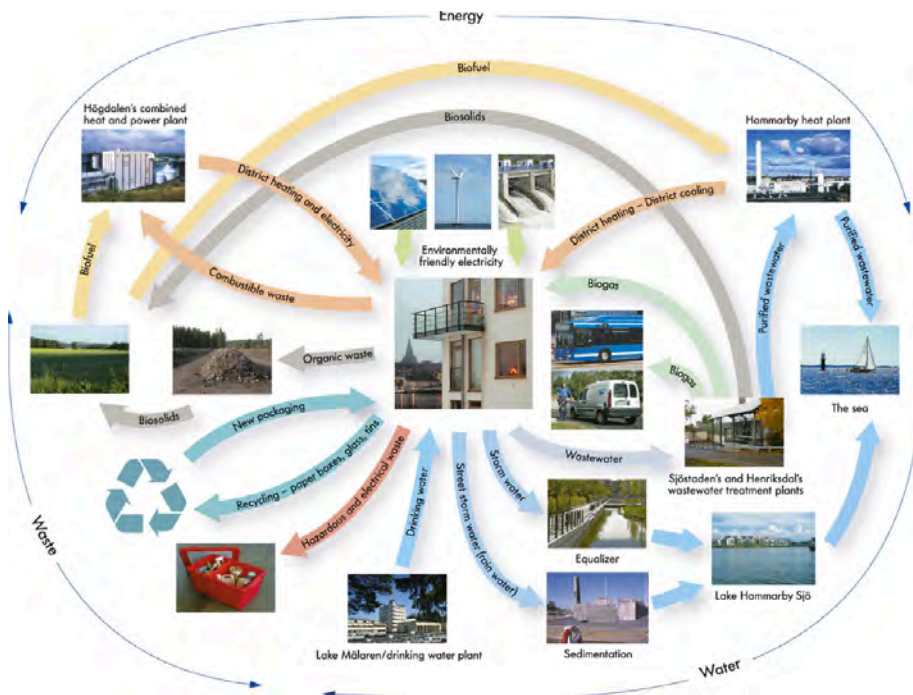
The development aims to achieve a 50% reduction in emissions and waste from a 1990s baseline established by surrounding communities through a series of 'integrated sustainable systems'. The series of integrated sustainable systems are summarised in the 'Hammarby (metabolic) model' (see figure below) (GlashusEtt, 2007). This is a holistic approach to urban services that increases efficiency by taking advantage of interdependencies between energy, waste and water management cycles.

The Hammarby model recognises that 'everybody who lives in Hammarby Sjostad is part of an eco-cycle' – the 'Hammarby Model' - that includes energy, waste, sewerage and water for both housing and offices (City of Stockholm, 2013). Development of the model required close collaboration between the various government agencies to seek mutually beneficial synergies that result in resource efficient industrial ecology. This model serves to reinterpret waste streams as resources to largely close the neighbourhood's urban 'metabolic loop' at the precinct scale. An example of the Hammarby Model eco-cycle is the incineration of combustible waste to produce both electricity and district heating in the precinct wide district heating network (GlashusEtt, 2007).

Figure 9: 'The Hammarby Model'

Source: GlashusEtt (2007)





Hammarby Sjöstad is exceptional in that it not only demonstrates innovation in project delivery but it also showcases innovation regarding integrated public services. Service agencies usually function within their own 'silo' largely a result of discrete funding streams that bring about a disregard, disinterest or disempowerment to engage with other agencies. The success of the model has seen a similar model introduced for use at Royal Seaport a follow up Stockholm eco-district.

*Embodied Carbon in Materials:* All construction materials aim to be sustainable, tried, tested and eco-friendly.

*Construction processes:* Unknown.

*Energy Production and management:* Target: 50% reduction in emissions from 1990 baseline. energy consumption of buildings of 50 kWh/m<sup>2</sup> out of which 15 kWh/m<sup>2</sup> for electricity; 100% RES; usage of 80% energy from waste; biogas production from sludge; all waste and waste water coming from the inhabitants will be recycled and returned to the area in the form of renewable energy

*Transport:* Targets: 80% of travel by public transport; 25% electric / biogas vehicles. Light rail, ferry, medium density walkable neighbourhoods.

*Water management:* Target: 60% reduction of water consumption / person. Rainwater harvesting, water sensitive urban design, stormwater treatment prior to discharge into the harbour, wastewater conversion to biogas. Greenroofs for reducing runoff peak flow.

*Waste management:* Target: 50% reduction in waste. 90% reduction of landfill waste and 40% reduction of all waste produced; reclaim 50% nitrogen and water, and about 95% of phosphorus to use as local agricultural fertilizer.

*Other sustainable initiatives:* Preserved and managed oak forest and 'ecoducts' – ecological corridors to provide biodiversity habitat and semi-natural recreational areas within the development.

An environmental education centre GlashusEtt provides information on the sustainable urban environment at Hammarby Sjostad for residents and visitors.

Envac (vacuum waste system) for waste collection / separation.

*Information sources and further information:*

Svane O (2007) *Hammarby Sjöstad, Stockholm City's Project Team and the Process of Environmental Management*. School of Architecture and the built Environment, Royal Institute of Technology, Stockholm.

Energy Cities (2008) *Guide to sustainable neighbourhoods in Europe*.

Available at: [http://www.energy-cities.eu/IMG/pdf/ademe\\_sustainable\\_districts\\_en.pdf](http://www.energy-cities.eu/IMG/pdf/ademe_sustainable_districts_en.pdf) (accessed November 2013)

Secure (2009) *Benchmark study: Hammarby Sjostad* European Sustainable Urban Development Projects.

## **Hanham Hall, Carbon Challenge, UK**

*Eco Claim:* Eco-village, Code for Sustainable Homes Level 6.

*Project Description:* Hanham Hall was the first of two UK Government Carbon Challenge projects (See also Peterborough Carbon Challenge). The 6.6ha former hospital site was redeveloped to include 195 dwellings and two parks. The project was developed by a multi-disciplinary consortium in response to a competitive tendering process (the Carbon Challenge). Development was subsidised by the UK Government regeneration authority – English Partnerships – to demonstrate and test the Code for Sustainable Homes Level 6 (zero carbon) (The Architecture Centre 2010)

*Embodied Carbon in Materials:* Low embodied energy materials.

*Construction processes:* Prefabricated house designs

*Energy Production and management:* Super insulated building fabric, on-site biomass combined heat and power will deliver energy to all homes, Solar water heating, passive solar design

*Transport:* Car club (2 electric vehicles), lockable storage for 172 bicycle parks

*Water management:* Rainwater harvesting for irrigation,

*Waste management:* Aggregate from demolished buildings will be recycled in new construction.

*Other sustainable initiatives:* A long term Development Trust based in Hanham Hall will be responsible for the on-going management of the project including environmental infrastructure. Allotment gardens and greenhouses for food production. Biodiversity – existing hedgerows, meadows and orchards retained and extended.

*Information sources and further information:*

The Architecture Centre (2010) Building Case Study Hanham Hall Eco-Village Bristol.

<http://www.hanhamhall.co.uk/site/web/home>

## **Masdar, Abu Dhabi, UAE**

*Eco Claim:* Zero Emissions, Zero Waste – One Planet Community.



*Project Description:* Masdar City, will be a highly planned, sustainable, research and technology intensive municipality built 17 kilometers from Abu Dhabi. The city will rely entirely on solar energy and other renewable energy sources, it is planned using the One Planet Principles to be a 'regenerative city' with a zero-carbon and zero-waste ecology. Despite being located in a hostile desert environment the climate responsive urban design aims to provide comfortable outdoor environments to encourage walking. A comprehensive and frequent network of public transport will be the dominant mode of transport, the city will not permit petroleum fuelled cars.

According to the architects (Foster and Partners) Masdar City is:

*Inspired by the architecture and urban planning of traditional Arab cities, (it) incorporates narrow streets; the shading of windows, exterior walls and walkways; thick-walled buildings; courtyards and wind towers; vegetation and a generally walkable city.*

Masdar City aims to be the world's first 'post-petroleum city' the Foster and Partners Masterplan applies the One Planet Principles and climate responsive urban design with the objective of creating a walkable, comfortable carbon neutral and zero-waste city in the desert.

The city is designed to be a clean tech hub – 'the silicon valley of green tech' (The Economist) and its first tenant Masdar Institute of Science and Technology (MIST) moved in September 2010.

The 1,500 businesses are proposed to be primarily commercial and manufacturing facilities specialising in environmentally friendly products and more than 60,000 workers are expected to commute to the city daily.

The development is currently under construction and is based upon appropriate urban design that was the outcome of research by ARUP engineers will include:

- A climatically responsive urban form including narrow streets to maximise street shading
- Central courtyards based upon traditional Arabic urban form
- High density and walkable city street with good public transport networks (as cars are banned)
- Initiated in 2006 the scheme is projected to cost US\$22 billion the majority of seed capital is provided by the government of Abu Dhabi.

*Embodied Carbon in Materials:* Low embodied energy construction with major buildings such as the Masdar Headquarters being subject to full lifecycle analysis to provide an evidence base for the selection of the lowest impact materials.

*Construction processes:* Widespread use of modular, prefabricated panels and interior modules to reduce waste and accelerate construction times.

*Energy Production and management:* Solar panels / solar will generate enough electricity to meet most of the city's energy needs. Expected carbon dioxide emitted during the construction phase will be offset through tree planting and surplus solar energy being put into the national electricity grid.

*Transport:* The masterplan with its narrow shaded streets is aimed at being a pedestrian oriented community. Light rail and metrolines will pass through the center of the city. Electric cars will be available but mostly confined the city's edge. A plan for automated, electric powered, single passenger 'personalised rapid transit' has been placed on hold due to costs (Hill D 2011).

*Water management:* The city will recycle 80% of its water and reduce water consumption to 50% of the Abu Dhabi baseline.

*Waste management:* Zero waste -all waste will be recycled, reused or converted to energy. No waste will go to landfill. All organic waste will be reused as fertilizer for landscape or converted to energy through digesters.

*Other sustainable initiatives:* Masdar will host the International Renewable Energy Agency (IRENA) currently the agency comprises 148 member states and the EU. IRENA is an intergovernmental organization for promoting the adoption of renewable energy worldwide. It aims to provide concrete policy advice and facilitate capacity building and technology transfer catalysing a shift toward regenerative cities (see: <http://www.irena.org/> ).

*Information sources and further information:*

<http://www.masdarcity.ae/en/>

<http://www.masdar.ae/>

<http://www.fosterandpartners.com/Projects/1515/Default.aspx>

<http://www.irena.org/>

Hill D (2011) 'Masdar City abandons transportation system of the future' in Singularity Hub, <http://singularityhub.com/> (accessed December 2013)

## **Millennium Water (Vancouver's Olympic Village), Canada**

*Eco Claim:* Model Sustainable Community, net zero, LEED Gold Community

*Project Description:* The 32ha harbourside brownfield redevelopment in Vancouver was constructed as the 2010 Winter Olympic Village and has since been converted and expanded into 'Millennium Water' mixed use community consisting of 1,100 dwellings, a commercial centre and community spaces. The project was a public private partnership with the City of Vancouver which led the site planning as well as negotiating and approving building designs. In February 2010 the project's high LEED rating led the US Green Building Council to name the Olympic Village as the 'Greenest Community in North America' (City of Vancouver, 2010) .

Moscovich (2009) makes the following observations regarding building performance, in order to minimise energy demand passive design systems were prioritised over mechanical systems, high performance building envelopes further reduce energy demand (walls have a U-value of 0.35W/m<sup>2</sup>K (R-15) and roofs a U-value 0.19 W/m<sup>2</sup>/K (R-30)). A commercial decision to maximise harbour views meant that many of the more recently built buildings have fully glazed facades compromising thermal performance, leading to occupant complaints. The consultant team had recommended a 70:30 glass to solidwall ratio to respect both a right to views and a commitment to energy efficiency (Moscovich 2009).

The developer was granted higher development density by the City of Vancouver in return for a commitment to LEED Gold certification. (Moscovich R, 2009). Millennium Water was treated as a test bed for trialling cost effective energy efficiency and renewable energy technology so that this knowledge could be transferred to future projects.

A strong emphasis was placed upon the need for an integrated design process with strong leadership working toward to common goals of environmental sustainability and liveability. This commitment has demonstrated that sustainable community objectives can be achieved without significant premiums (City of Vancouver 2010).

*Embodied Carbon in Materials:* Use of fly ash concrete.

*Construction processes:* From the outset Millennium Waters needed to satisfy two functions, firstly it needed to function temporarily as an Olympic Village and then transform into its legacy role as a residential community. The requirements of both functions did not match exactly and surfaces needed to be protected during the Games occupancy. The solution was to treat the dwellings with an 'overlay' fit out during the Games period that could later be removed. Carpet tiles and cabinet panelling was selected from material that could be reused and sold once removed.

*Energy Production and management:* Passive design and highly efficient building envelopes minimised heat demand and eliminated the need for mechanical cooling (natural ventilation and capillary cooling can be used to stabilise temperatures during hot weather).

Heat recovery by a 'Neighbourhood Energy Utility' (NEU) will distribute heat from the main downtown sewer system for distribution to buildings through out the site (meeting approximately 65% of the projects energy demand). Heat is distributed through a 'radiant capillary heating (and cooling) system' mounted above the ceiling. The NEU will meet the majority of building heat demand with gas supplement only on the coldest days.

Heat is also captured from roof mounted solar thermal technology and the 'senior's affordable housing project' (multi-residential building) will capture waste heat from an adjoining supermarket.

Planning requirement for low energy appliances and lighting.

*Transport:* The site is well served by public transit (streetcar, two rapid transit lines and bus). The seawall includes an extensive pedestrian and bicycle route.

*Water management:* Target: Potable water use reduced by 40% through reduced irrigation and low flow plumbing. Water sensitive urban design (green roof, swales and retention ponds) will minimise stormwater runoff by 25%. Harvested rainwater is treated and stored in underground tanks for irrigation and toilet flushing. Vegetation is climatically appropriate for Vancouver's typically drier summer months minimising need for irrigation (no potable water used for irrigation).

*Waste management:* Unknown.

*Other sustainable initiatives:* The previously treeless site has had considerable habitat restoration including the creation of football oval sized 'Habitat Compensation Island' in the harbour to encourage wildlife and waterfowl, extensive street tree planting and all buildings have a minimum 50% green roof coverage. Incorporation of urban agriculture allows opportunities for on-site food production.

*Information sources and further information:*

City of Vancouver website and factsheets see:  
<https://vancouver.ca/home-property-development/olympic-village.aspx>

City of Vancouver (2010) *CIP 2010 Awards for Planning Excellence Submission: Olympic Village.*

Moscovich R (2009) 'Millennium Water: Vancouver's Olympic Village in: Ritchie and Thomas (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London

## One Brighton, UK

*Eco Claim:* Mainstream (unsubsidised) sustainable development. One Planet Community

*Project Description:* One Brighton is a 172 unit mixed-use, brownfield infill, commercially viable, follow-up to BedZED in Brighton on England's South Coast. The scheme applies the One Planet Principles to a high density inner city development adjacent the Brighton Train Station. One Brighton occupies a 2 hectare site (Blocks E and F) within the larger 8ha New England Quarter - a masterplan for regeneration of lands adjacent Brighton railway. The development includes a major commitment to social housing (30%) operated by an external housing association. The market driven development by BioRegional Quintain was a joint venture with builder partners Crest Nicholson (Desai, 2010).

The vacant (surface car park) site was initially bought by a supermarket chain to be developed as a typical 'big-box' supermarket with surface car parking, however community opposition to the proposal led to the local government calling for a comprehensive Master Plan that sought to incorporate the supermarket as one component of a mixed-use development incorporating residential, retail and community space.

The winning tenderer, developer Bioregional Quintain, wanted to demonstrate that sustainable urbanism could overcome typical market barriers, be commercially viable and compete with conventional, unsustainable development. Bioregional Quintain was a value-led developer created through the merging of developer group Quintain, with environmental charity Bioregional (Desai 2010).

The sustainability narrative did not dominate the sales pitch instead a 21<sup>st</sup> century lifestyle was pitched along with the idea of 'five minute living' – having shops, work, school, theatres and public transport all within five minutes of home. These collective messages allowed this development to outperform the major UK house builders sales rates in a difficult post Global Financial Crisis economy (50% improvement on industry benchmarks) (Desai, 2010).

The development sought very few concessions with the exception that negotiations were made with the council to reduce private vehicle parking requirements to zero on-site car parking with the exception of disabled and car club parking. This permitted increased site yield ('a planning gain mechanism'). The sustainability cost premium was partly absorbed by the higher yield on the small site resulting in an increase the number of apartments from a permissible 80 to 172 units (internal rate of return was approximately 15%) (Sustainability Victoria, 2011).

Bioregional Quintain also introduced the role of 'sustainability integrator' to ensure the sustainability principles were 'integrated seamlessly from design through construction to estate management' (Desai 2010). A 'long term estates management strategy' was developed to manage the integrated environmental systems post-sales at which point the sustainability integrator handed over to a site caretaker to continue to ensure the smooth running of the long term estates management strategy. Given the use of unconventional sustainability technologies in most low carbon precincts, ongoing maintenance is critical for long term success.

To help monitor suitable products BioRegional also developed a not for profit service called 'One Planet Products' that assesses products and

suppliers against the One Planet Principles to catalogue a 'green' supply chain permitting efficient selection of the most appropriate products and suppliers (see <http://www.oneplanetproducts.com/>).

The development was almost entirely funded through private finance (with minor renewable energy grant subsidies). By aligning project objectives with the consent authority's high level sustainability objectives the proponent was able to submit a non-complying scheme and argue for merit based planning gain to make the sustainable scheme financially viable. The scheme went to market in 2009 shortly after the global financial crisis with the project achieving a 15% internal rate of return (on par with conventional developments) and with a clearance rate 50% better than industry benchmarks – although this is in part attributed to a range of location specific opportunities including 'strong local demand for investment property, quality transport links, proximity to London, demography and business growth (Sustainability Victoria 2009).

Innovative governance mechanisms allowed the developer to ensure ongoing management of the development without the added risk of post-construction involvement. Such measures included establishment of an Energy Services Company, Community Management Company and Community Interest Company to ensure the ongoing management responsibility of the project.

*Embodied Carbon in Materials:* green concrete (50% cement replacement with 100% waste aggregate and locally sourced sand) and natural clay blocks. 49% renewable materials (by weight) used in construction

*Construction processes:* during the construction phase waste timber went to a local timber recycling project.

*Energy Production and management:* Target: 100% renewable energy. Reduced energy demand from highly efficient buildings (LEED platinum equivalent / EcoHomes 'excellent' rating). Triple glazed windows and highest efficiency lights and appliances.

On-site (9.52kW<sub>peak</sub>) photovoltaic array and biomass/gas boiler for renewable heat and hot water. The (500kw) biomass/gas boiler and PV provide around 50% of the energy demand with the shortfall met by off-site wind energy purchased in bulk by the EScO.

*Transport:* Green transport plan, reduced on-site car parking (only disabled and car-share club parking), a two year membership in the car club is included in every apartment purchase, less than 5 minute walk to Brighton train station. Adjacent bike and pedestrian paths with secure on-site underground bike parking for 130 bicycles.

*Water management:* Installation of dual flush toilets and aerated taps and showers in all apartments, water efficient appliances, rainwater harvesting for irrigation.

*Waste management:* Target: 98% waste diversion from landfill by 2020. Target construction waste less than 15 msq per 100msq of floorspace.

*Other sustainable initiatives:* On-site green caretaker (sustainability integrator) to support residents in sustainable living.

*Information sources and further information:* One Brighton fact sheet Sustainability Victoria - [sustainability.vic.gov.au](http://sustainability.vic.gov.au) (accessed April 2013)

Bioregional Quintain (2010) *One Planet Action Plan Annual Review 2010*. Available at: <http://www.oneplanetcommunities.org/wp-content/uploads/2011/01/One-Brighton-Annual-Review-2010-final.pdf>

Desai P (2010) *One Planet Communities. A real-life guide to sustainable living*. John Wiley & Sons p.28.

## Peterborough Carbon Challenge, UK

*Eco Claim:* Zero Carbon, Code for Sustainable Homes Level 6

*Project Description:* This case study was part of the 'Carbon Challenge' a UK government initiative that saw the public sector working with private developers to 'accelerate innovation' (English Partnerships, 2007) by raising environmental standards while reducing construction costs. Peterborough was the larger of the two Carbon Challenge projects (see also Hanham Hall).

The Peterborough Carbon Challenge project consists of 295 dwellings (including a 40% affordable housing) a centrally located office and community space within a seven hectare brownfield site in the historic city of Peterborough. This public private partnership was led by English Partnerships in conjunction with development authority 'Opportunity Peterborough' and other government stakeholders (Opportunity Peterborough, 2011). A competitive tender process resulted in the winning team being awarded subsidised land sale to absorb the additional risk and costs associated with innovative sustainability measures.

Currently under construction, Peterborough Carbon Challenge, will be the UK's largest zero-carbon, mixed-use development when completed (Peterborough City Council, 2011).

The winning scheme included highly insulated buildings (reaching PassivHaus standard), combined heat and power plant, water sensitive urban design and integration of urban ecology on a constrained site, on-site food production including small orchard plantings and allotments and a community café that will sell locally produced goods (RUDI, 2008; Department of Homes and Communities, 2011).

The Carbon Challenge Brief directs developers to the BRE Green Guide which provides life cycle assessment of building material to help in the selection of low impact, low carbon supply chains (English Partnerships 2007).

*Embodied Carbon in Materials:* Developers required to submit a specification and supply chain strategy which will only include materials that meet minimum material classifications (specified in the Code for Sustainable Homes). These specifications go beyond just embodied energy to include lifecycle and durability, categories include: maintenance and durability, life time expectation and costs, transport implications, reusability at end of life cycle and embodied energy.

*Construction processes:* Unknown.

*Energy Production and management:* Highly insulated buildings (reaching PassivHaus standard), combined heat and power plant.

*Transport:* Local bus stop, one kilometre from Peterborough railway station, links to regional cycle and walking trails, car club.

*Water management:* Target: Household water consumption not to exceed 80 litres/person/dwelling/day. Rainwater harvesting Sustainable urban drainage system.

*Waste management:* Unknown.

*Other sustainable initiatives:* On-site food production including small orchard plantings and allotments and a community café that will sell locally produced goods



Information sources and further information:

English Partnerships (2007) *Carbon Challenge Standard Brief*.

Peterborough City Council (2011) 'Peterborough leads 'zero carbon' homes agenda as plans are approved 8 February 2011 (accessed July, 2013).

RUDI (2008) 'Peterborough zero carbon community developer selected' <http://www.rudi.net/node/20114> (accessed July, 2013).

UK Department of Homes and Communities (2011) [http://www.homesandcommunities.co.uk/carbon\\_challenge](http://www.homesandcommunities.co.uk/carbon_challenge)

## solarCity Linz-Pichling, Austria

*Eco Claim:* Solar City, sustainable urban development

*Project Description:* The 36ha development in Pichling-Linz includes 1,298 apartments and supporting retail, schools and community facilities. The City of Linz owned the large greenfield parcel and formed contracts with 12 developers to deliver a new community comprising of low energy social housing to address the local housing shortage. The City established a series of sustainable planning objectives including low energy construction and 'solar architecture' (according to the European Solar Charter of architecture and town planning (1996)) utilising active and passive solar energy, 'building biology', family-oriented infrastructure and sustainable transport with the intention of becoming a European model of sustainable urban development (Treberspurg et al 2008).

The City entered into quality agreements with developers and also conducted community consultation. To ensure ongoing success the City included binding agreements related to preservation of the basic ideas of the solarCity in the sales contracts (Breuste and Riepel, 2005).

Marketing measures promoted quality of life over the technical aspects of the development. Landscape planning focussed on lifestyle aspects such as a recreational lake, play areas and a hiking trail through an adjacent nature reserve.

*Embodied Carbon in Materials:* The majority of construction materials selected were renewable and recyclable, durable and low maintenance (ie low embodied carbon over the material lifecycle). Construction materials included low embodied materials such as wood and lightweight concrete, and prioritised locally sourced supplies to reduce transport miles.

*Construction processes:* Unknown

*Energy Production and management:* Passive design of buildings (south orientation) and avoidance of overshadowing (Building heights were limited to 2-4 storeys to ensure solar access to all dwellings). 'Bio-climatic' design to reduce the need for mechanical cooling. Highly insulated housing (including three to PassivHaus standard) Solar panel mainly for hot water (to keep costs down photovoltaics were only included on civic buildings), all buildings connected to district heating from the natural gas and biomass fuelled combined heat and power system. Energy saving street lights. Thermal heat values of buildings 28kWh/m<sup>2</sup>/year (Breuste and Riepel, 2005).

*Transport:* Central tram (maximum 300m walk to apartments) and bus. Priority given to pedestrians and cyclists with paths throughout the site, residential areas are almost car free and on-site parking is limited.

Figure 10: SolarCity Linz-Pichling aerial 2008  
(source: Treberspurg et al 2008)



Figure 11: SolarCity Linz – Pichling site plan.  
(source: Treberspurg et al 2008)



*Water management:* Water saving fixtures in homes, rainwater harvesting, Constructed wetlands for waste water treatment. Permeable materials used for footpaths and bike lanes and car parks to maximise infiltration and reduce runoff.

*Waste management:* Waste separation and recycling during construction and occupancy.

*Other sustainable initiatives:* Protection of the riverside forest and incorporation of a creek as a central landscape feature. Paths with interpretive signage link the development to adjacent natural areas and the incorporation of recreational lake (including swimming) offer lifestyle choices and a connection to nature.

*Information sources and further information:*

Breuste J, Riepel J (2005) *Solar Linz/Austria – A European Example for Urban Ecological Settlements and its Ecological Evaluation*. University of Salzburg.

Treberspurg M, Smutny R, Ertl U (2008) *Sustainability Evaluation of 'the solarCity Linz-Pichling' in Austria*. World SBO8 Melbourne

## Sonoma Mountain Village, USA

*Eco Claim:* 100% renewable energy, One Planet Community

*Project Description:* Sonoma Mountain Village is an 81 hectare brownfield redevelopment in northern California, USA. The mixed use community consists of 1,892 homes, and plans for 3,300 jobs in 55,000 m<sup>2</sup> of office, retail and commercial space. The development aims to meet 100% of its energy needs through renewable energy and has built the largest private solar energy array in the USA consisting of a 2.14 megawatt array to power the community's 1,694 homes (<http://www.sonomamountainvillage.com/community/index.php>).

The development is designed as a walkable community with all residents within a 5-minute walk of shops and services.

Existing buildings were subject to retrofits to increase efficiency and greatly reduce their energy and water demands.

*Embodied Carbon in Materials:* Low energy Cold-Formed Steel Frame system, manufactured within retrofit buildings within a solar powered factory using 40% less steel than conventional light-gauge steel frame approach. Very high levels of material reuse from demolished on-site buildings (including ceiling tiles, furniture, structural steel, insulation, piping, hardware, railings, fencing, fixtures and so on). FSC-certified wood is widely used.

*Construction processes:* High degree of adaptive reuse and material reuse (see above).

*Energy Production and management:* Existing buildings were retrofit and adapted to achieve high levels of energy efficiency.

*Transport:* 82% reduction in transport emissions. A new trainline (the Sonoma-Marin Area Rail Transit (SMART) train station is planned to be built within a 10 minute walk of the development by 2016 and will link Sonoma to San Francisco (70 kilometres south). Developed as a walkable community.

*Water management:* 65% reduction in use of municipal water - all irrigation and toilet flushing demand met by non-potable water.

*Waste management:* 97% reduction of construction waste. 70% of operational waste reclaimed / recycled. Zero-waste is the goal, recycling

rates are significantly up but the goal has not yet been met and is unlikely to be met while the Sonoma County Waste Management agency are not partners working with the community to meet this target (for more see SOMO One Planet Community, One Planet Action Plan Annual Review 2011).

*Other sustainable initiatives:* 65% local food consumption goal. A year round farmers market encourages consumption of local seasonal food. Non-profit business incubators promote sustainability-oriented and socially relevant technology start-up companies.

*Information sources and further information:*

<http://www.oneplanetcommunities.org/>

<http://www.sonomamountainvillage.com/community/sustainability.php>

Bioregional (2011) *SOMO One Planet Community, One Planet Action Plan Annual Review 2011*

## Stockholm Royal Seaport, Sweden

*Eco Claim:* Sustainable urban district, world class environmental city district.

*Project Description:* This 236ha brownfield harbourside infill area in Stockholm builds upon the success of Hammarby Sjostad. Both projects are based upon the City of Stockholm's strategic planning concept of 'building towards the centre' that is to prioritise high density urban infill to avoid fringe sprawl – the site is within walking distance of the city centre. By 2030 the goal is to have delivered 10,000 dwellings, 30,000 new workspaces, 600,000 m<sup>2</sup>

of commercial space.

*Embodied Carbon in Materials:* Unknown.

*Construction processes:* Prefabricated insulated building panels

*Energy Production and management:* Target: 55kWh/ m<sup>2</sup>/year (PassivHaus toward energy plus housing). Target: 30% locally produced renewable energy. Biogas will be produced as part of an integrated eco-cycle similar to Hammarby Sjostad. Biofuelled combined heat and power will be supported by smart grids for electricity and heat. Passive cooling of buildings will minimise the need for mechanical cooling. An energy quality hierarchy will encourage high energy quality use only where demanded.

*Transport:* Eco-efficient transport with a traffic hierarchy promoting modes in the following order walking and cycling, public transport (metro, bus, tram, ferry), car pools (biogas and electric), private cars (biogas and electric).

*Water management:* Water sensitive urban design to manage stormwater flows and reduce peak runoff. Waste water will feed into an integrated eco-cycle based upon the model from Hammarby Sjostad.

*Waste management:* Sustainable recycling system and planned eco-cycle similar to Hammarby Sjostad using the Envac waste vacuum collection and sorting system. Each user will be issued a waste access card to monitor waste contribution. Kitchen food waste collection will tap into the Envac system and waste will be converted to biogas and nutrient (phosphorous, nitrogen, potassium) recovery will be diverted from the Baltic Sea where it is causing eutrophication.

Figure 12: Royal Seaport (photo montage)  
source: City of Stockholm



*Other sustainable initiatives:* Smart grid and information technology built into the development to measure / monitor household energy use / demand, distributed energy systems, electric vehicles and substations. The 'World class agreement' a commitment from key stakeholders to uphold the vision and active participation in achieving the agreed goals. There is a commitment by the city for continuous evaluation through all phases (planning, construction and operation) and to dispersing knowledge on sustainable urban systems developed as part of the project.

*Information sources and further information:*

City of Stockholm (2011) *Stockholm Royal Seaport* see:  
<http://www.stockholmroyalseaport.com/en/>

## Vauban, Freiburg, Germany

*Eco Claim:* sustainable urban district

*Project Description:* The 38 hectare Vauban neighbourhood completed in 2006 is the greenest quarter of Germany's 'ecological capital' – Freiburg. The City of Freiburg helped facilitate and empower residents through an interesting model of community participation involving a not for profit, community engagement platform, Forum Vauban (closed in 2004 due to bankruptcy). Forum Vauban, working in collaboration with the City of Freiburg, developed a community vision that sought to balance environmental, social and economic goals to guide future development of the brownfield site (Forum Vauban, 2004). The city council set requirements, boundaries and incentives such as reduced tax on land acquisition, to help implement the vision.

A key element enabling the cost effective implementation of this vision was the establishment of 'construction communities' (owner-developer collectives of 3-21 households in size) based on the co-housing concept where a group of individuals with a common vision for living formed a co-operative to develop apartment buildings on their terms (NB in Germany, unlike Australia, 55% of homes are self procured (Wyatt 2008). Because construction communities are owner occupied a number of these developments exceeded the high building standards required by the council, with a 100 dwellings built to the PassivHaus standard and 59 dwellings that exceed this to add energy back to the grid as 'plus energy houses' (Forum Vauban, 2004).

By cutting out conventional developers driven by a profit motive, collectives of several households with a common vision work together to build apartments or a city block to their own specifications. Similarly, community funded decentralised energy allowed residents to simultaneously invest in their local community and receive income as dividends from energy sales.

Community and owner-occupier investment has the advantage of removing much of the financial burden from government while allowing the local government approval processes to ensure developments to meet minimum criteria relating to sustainability performance and social responsibility based upon the values that emerged from the community engagement (Forum Vauban, 2004). Funds that might ordinarily have been absorbed by the developer's profit margin can be invested in sustainable technology overcoming some of the sustainability cost premium.

The City funded infrastructure delivery including pipes for district heating, water, power and sewage, while keeping roads narrow (4m on residential streets) reduced costs. Funding for infrastructure was generated through the sale of lots. The City acquired the former military

barracks for around 20% of the site value because of the contaminated state of the land. Masterplanning allowed infrastructure costs to be calculated and the city was able to borrow money at a favourable rate available to local authorities. The land was divided into four phases and disposed of rapidly to recoup expenses. Small plots were sold and a limit was placed on number of plots available to favour small builders and cooperative groups (Wyatt 2008).

*Embodied Carbon in Materials:* A wide variety of approaches due to the many small scale developers and individual owner builders / coops.

*Construction processes:* A wide variety of approaches due to the many small scale developers and individual owner builders / coops.

*Energy Production and management:* Super insulated buildings - 100 dwellings built to the PassivHaus standard and 59 dwellings that exceed this to add energy back to the grid as 'plus energy houses'. District heating and low carbon energy is provided by a combined heat and power fuelled by (imported) gas or biomass (wood pellets). Dwellings are required to consume less than 65Kw/ m<sup>2</sup>/year (less than a third of German regulations in 2008) there is a move toward reducing this to 55Kw/ m<sup>2</sup>/year. In 2008 photovoltaics met 10% of the energy demand but there is a push to increase this to 40%.

*Transport:* Integration of land use and transport planning with high density and mixed use services concentrated along the tram route and bus corridors, a comprehensive cycle and pedestrian network (in addition to low trafficked streets) and high performance building requirements. 50% of all households are car free, car speed limit of 30km/hour on main roads and 5km/hour in residential areas.

*Water management:* Water sensitive urban design reduces run-off and increases on-site infiltration. Rainwater harvesting for internal non-potable uses and irrigation.

*Waste management:* House hold waste must be sorted and placed in recycling collection areas. Waste has been reduced to 114kg / resident/ year. Residual waste is incinerated in a CHP plant.

*Other sustainable initiatives:* The project has a strong emphasis on community participation in decision making and development, this would appear to be both cultural and cultivated through Forum Vauban until its closure in 2004.

*Information sources and further information:*

Forum Vauban (2004) <http://www.forum-vauban.de/overview.shtml> (accessed July, 2013).

Wyatt (2008) *Learning from Freiburg, University of Cambridge Study Tour*. URBED

Scheurer J and Newman P (2009) *Vauban: A European Model Bridging the Green And Brown Agendas*. Case study prepared for Revisiting Urban Planning: Global Report on Human Settlements 2009.

Secure (2007) *Benchmark study, Vauban*. European Sustainable Urban Development Projects (see: <http://www.secureproject.org/> ).

## Vuores, Finland

*Eco Claim:* Eco Efficient living – exceeding ECOCITY standards

*Project Description:* The 473 hectare greenfield development of Vuores in the southern part of the Finnish town of Tampere is the result of a strong environmental vision based upon the EU ECOCITY project but the targets for Vuores went further to outline the 'Vuores Ideas'. Success

is monitored against a range of indicators against specific criteria (Urban Planning, Transport, Energy, Information technology, Conservation of the natural environment, social issues). The vision and development concepts were communicated 'as cards. Each card contains an illustration of the concept, the measures to be taken according to it, objectives to be fulfilled by it and criteria and indicators with which it should comply.' (Concepts for ECOCITY model settlements p. 60)

The urban structure is based upon maintaining a close relationship with nature, and all dwellings are a short distance from green areas. Planning also considered the water system (especially drainage), recreational uses of the forest and microclimates.

With the broad parameters of the urban structure decided, a competition was held in 2004 for the development of the mixed use centre. Part of the competition guidelines included adhering to the ECOCITY principles, and these principles followed through to the town planning and implementation phases.

*Embodied Carbon in Materials:* The majority of construction material is carbon neutral renewable timber.

*Construction processes:* Unknown.

*Energy Production and management:* General principles: 'optimising energy conservation and energy system performance; minimising heat loss; increasing awareness of energy use; reducing electricity use'.

Super insulated buildings fitted with ventilation heat recovery reduces heating energy consumption by 50-60%.

District heating from a combined heat and power plant is planned for the higher density areas. Renewable energy including ground source heating and active solar systems also help reduce conventional energy consumption to meet heating demand. Tampere City is a shareholder in a local windfarm reducing the carbon intensity of the city's electricity supply.

*Transport:* General principles: 'optimising the street network; minimising car traffic; optimising public transport; providing space for walking and cycling; providing flexible parking systems; optimising mobility management'.

Low density resulting from an emphasis upon preserving nature led to a risk of car dependence, to counter this services are concentrated around the main centre and four sub-centres.

Bicycle and pedestrian journeys are prioritised and light rail is planned for the future but currently a bus runs along the light rail corridor.

*Water management:* Unknown.

*Waste management:* Waste sorting at household level and drop-off collection points with an eco-sorting centre. Biogas from compostable waste will be used as an energy source.

*Other sustainable initiatives:* 'optimising the urban structure, its buildings, public spaces and traffic system; taking into account the microclimatic conditions in the area; preventing traffic noise and other harmful emissions'.

*Information sources and further information:*

*Concepts for ECOCITY model settlements:* Vuores, available at: [www.upv.es/contenidos/CAMUNISO/info/U0511279.pdf](http://www.upv.es/contenidos/CAMUNISO/info/U0511279.pdf) (accessed September 2013)



## Case study discussion and conclusions

The following conclusions are drawn from the review of low carbon precinct case studies cited in this scoping study. Lessons learnt from the case study review are provided at the end of each subsection as a list of considerations that Australian low carbon precincts should seek to achieve. These could form the basis of a check list for possible future policy on low carbon precincts.

Some areas discussed in the conclusions are well documented but others require further research and these are extracted as recommendations for further research in the following section. Conclusions are structured around two major themes:

- emissions sources (including embodied and operational emissions) and,
- delivery processes (that enabled successful translation from concept to implementation).

### Low Carbon Precinct emissions sources

#### Emissions related to embodied carbon

Surprisingly a large number of case studies appeared not to address embodied carbon – focussing more upon operational emissions ('energy management and emissions') (refer to Appendix 1). Where embodied carbon was addressed (particularly in Europe eg. solarCity Linz-Pichling, Hanham Hall, MINERGIE residential building Brunnenhof) stringent criteria were adhered to to minimise impact of specified material.

Material selection included:

- carbon 'neutral' contemporary biogenic materials (ie regenerative organic materials – wood (Voures, EcoViikki), wool, strawbale (Christies Walk), shell etc)

and low carbon alternatives to conventional construction materials such as:

- low carbon concrete (with fly ash (Millennium Water, Dockside Green), or aerated (Christies Walk) etc),
- low carbon steel (eg. Sonoma Mountain Village utilises low embodied energy Coddling Steel Frame system, created within a solar powered factory using 40% less steel than conventional light-gauge steel frame approach (Bioregional 2011)).

Low carbon concrete is the subject a CRC project RP1004 but as noted there are many other low carbon materials – timber (as with other biogenic materials) if sustainably sourced can sequester carbon (by storing it in the built structure) recent experimentation with the use of structural cross laminated timber in Australia and overseas is showing much promise of this as a technologically and financially viable option, particularly because it lends itself to prefabrication.

In Stockholm Royal Seaport, Hanham Hall and Coopers Road Estate manufactured assembly, prefabrication and other off-site modular building construction methods were used to speed up construction, lower embodied energy and improve building lifecycle performance. A major advantage of prefabrication is reduced construction / market costs do to less waste and shorter construction / holding times. By lowering construction costs it is possible for developers to spend more



on sustainability measures while remaining competitive in the conventional market.

According to London Olympic Village Contractor, Andrew Kinsey (Head of Sustainability – Construction (Mace)) when talking to the UK Green Building Council about lessons learnt from constructing the Olympic Village in London “Next time design would be more modular – less energy input and more efficient logistics”.

<http://www.ukgbc.org/events/delivering-sustainable-athletes-village>

Minimising material use through prefabrication or construction waste policies can greatly reduce emissions associated with materials. In the USA Farr (2007 p.29) observes that “a New Urbanist custom home builder throws away the material equivalent of one house for every five built”. Some case studies (eg Sonoma Mountain Village, Grow Community, Graylingwell Park, Greenwich Millennium Village) sought to reduce emissions through construction waste policies. Sonoma Mountain Village and the Grow Community as well as requiring low embodied energy material and waste minimisation also claimed over 95% diversion of waste from landfill.

To reduce emissions associated with the transport of materials some projects material selection criteria state a preference for locally sourced or supplied materials (eg. Dockside Green, Graylingwell Park, Greenwich Millennium Village).

Australian low carbon precincts should seek to:

- Use low embodied carbon materials and ideally maximise the use of ‘carbon neutral’ (eg. reused products) or ‘carbon negative’ materials (such as sustainably sourced regenerative organic products)
- Develop construction waste minimisation strategies
- Source materials and suppliers locally where possible to reduce transport miles
- Use waste reducing technologies such as prefabrication.

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EXISTING CRC projects on embodied carbon

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RP1004 – Performance based Criteria for Concretes: Creating Pathways for Low Carbon Concrete Manufacture with Existing Standards

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EXISTING CRC projects on construction processes

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RP1011 – Sustainable and affordable living through modular, net zero energy, transportable, and self-reliant homes and communities

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RP1010 – Monitoring and modelling the CSR Low Energy House

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## Emissions related to operational energy

### Building performance:

As mentioned earlier ASBEC (2011) suggests the Australian built environment sector follow a three step energy hierarchy 1. Improved energy efficiency 2. On-site renewable energy 3. Off-site renewable or low carbon energy. From the case studies cited in the scoping study the following conclusions can be drawn:

#### 1. Improved energy efficiency

Reducing energy demand through improved energy efficiency of buildings is both cost and carbon effective – it is a core component of a low carbon precinct. An intention for emission reductions through

improved energy efficiency was universal amongst the case studies. The best examples included super insulated building envelopes eg. Passivhaus (Vauban, Salvatierra Apartments, Hallein), MINERGIE (MINERGIE residential building).

Policies such as the UK Code for Sustainable Homes (CSH) (2007) and recommendations such as those outlined by ASBEC (2011) recognise the importance of demand reduction. In 2009 when the CSH was being debated widely in the UK, Pooran Desai of BioRegional (behind BedZED and One Brighton) argued that high thermal efficiency of buildings rather than on-site renewable energy should be the policy priority. Energy should be a concern for larger scale (ie national or regional policies) in the online journal Building Desai (2009) states:

*The real solution to zero carbon lies in a recognition that electricity is best considered as a pooled resource and that creating a low-carbon electricity supply should be led by national energy policy rather than trying too hard to turn buildings, directly or indirectly, into power generators. We need a green grid which we must accelerate through increasing incentives through renewables obligation certificates (ROCs) – money paid for generating energy using renewables and feed-in tariffs (plus heat ROCs) (see: <http://www.building.co.uk/eco-regulation-cutting-through-the-green-tape/3141159.article> ).*

According to the CSIRO (2010) 'Energy use in buildings is responsible for 26 per cent of Australia's greenhouse gas emissions and is the primary cause of peak energy demand on the electricity network... On Australia's hottest days, air conditioners consume up to 22 per cent of all the electricity generated in the nation. Heating and cooling buildings typically also accounts for over half of a building's energy needs.' (See: <http://www.csiro.au/opticool> )

Reducing building energy demand will go a long way to lowering the carbon footprint of Australian cities (and financial expenditure on electricity). Regardless of whether energy is supplied from on-site renewables or a (decarbonised) national grid lowering demand has significant environmental and economic benefits.

Metrics for energy consumption by floor area are useful but considering that Australian house sizes are on average are the largest in the world and average household size is shrinking (meaning floor area per capita is increasing) (ABS 2005) then total energy demand per dwelling may prove a more useful target for effective emissions reductions. The Green Building Council's (multi-unit) benchmarking methodology (GBCA 2009) considers the implication of larger floor area dwellings but it may also be useful for an international benchmarking comparison highlighting the difference in average residential floor space per capita. Wilson (2013) has done this and the results can be seen in the interesting infographic below.

Figure 13: Average residential floor space per capita in m<sup>2</sup>

Source: Wilson 2013 (shrink that footprint.com)



The implication is that benchmarking needs to consider not only a square meter emissions component, but also total building performance. There is a climatic component (ie climate zones impact heating and cooling demand – GBCA 2009) and a cost factor. Equity in terms of affordability is also critically important the cost requirements

for a super insulated (eg PassivHaus or higher) dwelling may be more cost prohibitive than good insulation plus renewables and it may be possible to achieve better carbon savings with the later combination at lower cost.

Australian low carbon precincts should seek to:

- Optimise building envelope efficiency as this is currently the most cost effective way to reduce energy demand and associated emissions in the built environment (ClimateWorks 2013).
- Identify untapped energy efficiency potential
- Emphasise passive cooling and heating measures to reduce energy demand spikes associated with mechanical temperature regulation associated with climatic extremes

Benchmarking of building energy efficiency should be related to a building's absolute performance and not just energy m<sup>2</sup>/year. The metric should include carbon emissions related to all energy used (ie. MJ/m<sup>2</sup>/yr for details see Newton and Tucker 2011).

## *2. On-site renewable and low carbon energy*

The integration of renewables and low carbon energy is a core component of a low carbon precinct. Renewable energy in combination with demand reduction can lead to carbon neutral or 'energy plus' development.

Renewables are a feature in nearly all the case studies with some case studies emphasising the role of renewable energy strategies through a strong expression of integrated renewables within the building typologies (eg. Solar Valley, Millennium Water, Masdar, Sonoma Mountain Village). Several of the case studies such as Vauban, Vuores, Malmo include a number of 'energy plus' buildings – these superinsulated buildings have such a low energy demand that their integral (usually PV) renewable provide an annual net contribution of energy to the grid.

Given heating and cooling create such a significant energy demand finding efficiencies to maximise benefits integral or adjacent decentralised power (eg captured waste heat from combustion fuelled (usually biomass or gas) decentralised power plants production for use in district heating and cooling networks (trigeneration)) (eg BedZED, BO01, Hammarby Sjostad, Royal Seaport). Ground source (eg. Voures) and water source (eg. BO01) heat pumps tap into the thermal mass of underlying soil and waterbodies respectively and to provide central heating (or cooling) to reduce overall energy demand by helping stabilise internal temperatures. Similarly the Neighbourhood Energy Utility at Millennium Water captures waste heat from an adjacent sewerage mains to heat residential buildings.

Australia is only just starting to implement district energy and CRC project RP3007 will provide useful information to accelerate uptake. One implication for developments is that because of the additional infrastructure required to distribute district heating and cooling (ie pipes) this technology becomes less viable as densities reduce. This consideration may require research into cost effective densities to support district heating and cooling. A general observation from the case studies that include district heating and cooling is that this technology in Europe seems to require densities in excess of 50 dw/ha (eg BedZED – 50 dw/ha, BO01 – 59dw/ha, Hammarby Sjostad – 50dw/ha).

Australian low carbon precincts should seek to:

- Incorporate cost effective forms of renewable energy

Seek opportunities for capturing waste heat (or coolth), by design (eg trigeneration) or by proximity (eg. ground / water source, adjacent buildings or other locally available energy sources to reduce primary energy demand).

### 3. Off-site renewable energy

This category falls outside the scope of low carbon precincts but defining what is acceptable to satisfy various rating systems may be an area worth further investigation (cf *The Code for Sustainable Homes* (UK)).

Australian low carbon precincts should seek to:

- Provide very clear guidelines for any future Australian urban policy on what constitutes acceptable off-site renewable (or low carbon) energy for any low, or carbon neutral, precincts.

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#### EXISTING CRC projects on Energy production and processes

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RP1003: Status report and directions on Integrating PV with building products

RP1006 – Viable integrated systems for zero carbon housing systems

RP1007 – Intelligent automated monitoring of commercial photovoltaic (PV)

RP1008 - Industry support mechanisms for renewable heating and cooling

RP1009 – Closing the Loop on Evidence-based Low Carbon Design of nonresidential buildings

RP2002 - Integrated Energy, Transport, Waste and Water (ETWW) Demand Forecasting and Scenario Planning for Precincts

RP2004 - Innovative applications of interoperability and interrogation of energy and water data in the Sydney metro region

RP3007 - Opportunities and challenges for the development and implementation of community-scale renewable energy projects

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#### Transport:

Low carbon transport will be the subject of a separate scoping study RP2009. Reducing emissions related to transport should be a core component of a low carbon precinct.

It is worth noting that a common themes within low carbon precinct case studies that consider transport are integrated land use and transport (higher densities with mixed use centres within a short walk of public transport hubs and other services eg. SolarCity Linz, Bo01, Hammarby Sjostad, Vauban) and Green Transport Plans to prioritise zero carbon transport such as walking and cycling and discourage private car use (eg Masdar, Royal Seaport, One Brighton).

Australian low carbon precincts should seek to:

- Integrate land-use and transport (ie. Use strategic planning to locate areas best served by public transport as having the potential for upzoning to higher density low carbon precincts (cf Transit oriented development)
- Develop green transport plans to reduce reliance upon private cars and in turn reduce on-site parking requirements. Reduced on-site parking demand allows the potential transfer of site area previously required for auto-infrastructure to be reallocated to eco-infrastructure and/or increased site yield to pay for sustainability measures.

RP2009 - Scoping study - Planning a research agenda for low carbon transport

RP2002 - Integrated Energy, Transport, Waste and Water (ETWW) Demand Forecasting and Scenario Planning for Precincts

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**Waste Management:**

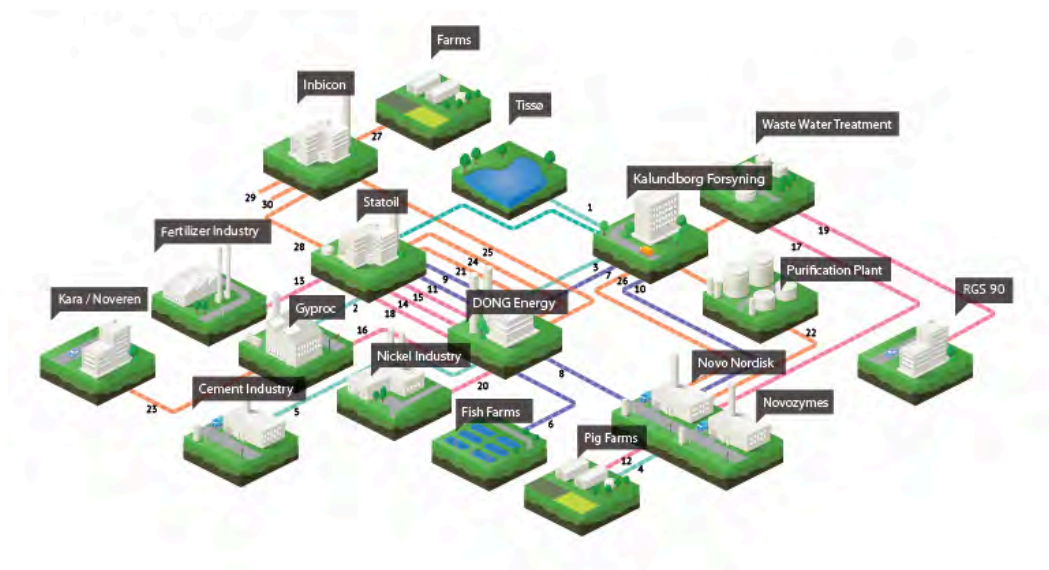
Vast quantities of carbon emissions can be tied to wastes resulting from an inefficient linear metabolism, cities that instead aim to close their metabolic cycle by finding uses for their waste can greatly improve their efficiency by effectively turning wastes into resources (Girardet 1992, Newman and Kenworthy 1999). Several of the case studies observed, particularly in northern Europe, have in place (or planned) systems capable of achieving this (eg. Malmö (Sweden), BedZED (UK), Peterborough Carbon Challenge). Particularly effective at this 'industrial ecology' were the residential eco-districts of Hammarby Sjöstad and Royal Seaport (Sweden) and the eco-industrial park at Kalundborg (Denmark). The 'Hammarby model', which integrates urban eco-cycles finding symbiotic relationships between water, waste and energy services to reduce overall resource consumption. This process is well documented and details can be found under the Hammarby Sjöstad case study earlier in this report.

The process at Hammarby Sjöstad also incorporates an Envac system – an underground vacuum waste disposal and sorting system. While at Stockholm Royal Seaport the Envac system will also incorporate an innovative access card to monitor individual waste contributions to track consumer behaviour.

Kalundborg focuses on industry purposes and while not residential in nature is worth noting because since the 1960s has been refining the industrial ecology / eco-cycle process and finding new synergies to optimise business and resource efficiency.

Figure 14: Kalundborg Industrial ecology 2012

Source : <http://www.symbiosis.dk/en>



Australian low carbon precincts should seek to:

- work with utilities provides to find synergies to reuse waste products in a local / district / regional industrial ecology to minimise resource consumption, reduce costs and lower emissions.
- Consider new technologies and waste sorting approaches such as vacuum waste collection.

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EXISTING CRC projects on waste management

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RP2002 - Integrated Energy, Transport, Waste and Water (ETWW) Demand Forecasting and Scenario Planning for Precincts

RP2008 - Beneficial Reuse of Solids from Wastewater Treatment Operations

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**Water Management:**

Water management is an indirect source of emissions but has the potential to reduce the overall emissions, particularly as increased water demand (due to population growth and climate change) over future decades makes the case for energy intensive desalination plants stronger. Demand reduction and efficient water management are the alternatives to increased potable water, this can occur at the dwelling scale through efficient appliances but the application of water sensitive urban design techniques is particularly relevant to the precinct scale.

Energy use associated with water in Australian Cities is the focus of a comprehensive report prepared by the CSIRO (2008) for the Water Services Association – *Energy use in the provision and consumption of urban water in Australia and New Zealand* (Kenway S et al 2008). This report identifies that energy use associated with residential water use is relatively low:

*Energy use for residential water heating in Sydney, Melbourne, Perth, Brisbane, Gold Coast and Adelaide (46 PJ) represented 1.3% of energy use in the total urban system* (Kenway S et al 2008 p.v).

But this figure will increase considerably as recently constructed or planned desalination plants come online in Australia (eg. Melbourne

(Wonthaggi), Sydney (Kurnell), Perth/Bunbury (Perth Seawater, Southern Seawater), Adelaide (Port Stanvac) and the Gold Coast). Only one of these (Perth Seawater) was operational at the time of the 2008 CSIRO/Water Service Association report. Given the rapid population growth planned for Australian cities it would seem likely that water demand reduction to reduce desalination energy (and pumping energy) is desirable.

The Australian Government Department of the Environment <http://www.environment.gov.au/node/22261> indicates per capita consumption for 2011-12 averaging 115kL or 315 litres/person/day. Based upon current population growth projections to remain in sustainable yield by 2030 Canberra needs to reduce its consumption by 30%, while Adelaide and Perth have very little capacity to increase water demand. Compare this to the UK *Code for Sustainable Homes* (Level 6) (including Hanham Hall and Peterborough Carbon Challenge) where the code sets a target for water consumption to be less than 80 litres/person/day (Department for Communities and Local Government 2013). The CSIRO/Water Service Association identified that at the time of publishing (2008) that much greater energy demand was associated with hot water:

*Residential hot water uses on average 6.5 times the energy that is used to deliver urban water services* (Kenway, 2008 p.v).

Opportunities for renewable sources of water heating are available to reduce hot water primary energy demand. For example in Rhinzoa 'city of sunshine' and Solar Valley both in China, nearly all houses are equipped with solar water heating systems (Joss et al 2011), while at the Vancouver Olympic Village low grade heat in sewerage and waste water is being recovered by heat exchange sewer pipework then upgraded using a heat-pump (Richie and Thomas, 2009).

Australian low carbon precincts should seek to:

- Reduce mains water demand through the integration of water efficient appliances, climatically appropriate landscapes, and water sensitive urban design (including water storage and recycling).
- Maximise renewable water heating opportunities eg. solar hot water systems or heat exchange technology.

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#### EXISTING CRC projects on water management

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RP2002 - Integrated Energy, Transport, Waste and Water (ETWW) Demand Forecasting and Scenario Planning for Precincts

RP2004 - Innovative applications of interoperability and interrogation of energy and water data in the Sydney metro region

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#### Urban Agriculture

Urban Agriculture is a recurring theme and in some case studies (eg. Grow Community, Eco-Viikki, Vauban, Lochiel Park) food production was integral to the development.

Embodied energy in food (food miles, fertilizers etc) can contribute considerably to the carbon intensity of a city. According to the City of Malmö approximately 25% of Sweden's greenhouse gas emissions are the result of food production and consumption. In response the City of Malmö produced a 'Policy for sustainable development and food' with a policy goal 'that all food purchased should be organic by 2020 and greenhouse gas (GHG) emissions from food procurement should be reduced by 40 % by 2020, compared to the 2002 level, which was 13,360 ton CO<sub>2</sub>-equivalents' (see <http://www.malmo.se/English/Sustainable->

[City-Development/Sustainable-food-in-Malmo.html](#) ). Similarly Sonoma Mountain Village has a 65% local food consumption goal and has designed in a farmers market to sell locally grown produce and urban agriculture opportunities so residents can grow their own.

Herbert Girardet in 2012 calculated that 36% of South Australia's Ecological Footprint was due to food consumption.

(<http://www.thesolutionsjournal.com/node/1153>)

Precinct scale development has the potential to address the embodied energy in food through strategies of on-site food production, markets and local food policies.

Australian low carbon precincts should seek to:

- Incorporate opportunities for local food production to reduce associated carbon emissions, but where communal urban agriculture exists (eg. community gardens) these can also improve liveability through added lifestyle opportunities and social interaction between residents.
- Investigate opportunities for local food policies, education programs and the incorporation of local farmers markets where appropriate.

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EXISTING CRC projects on urban agriculture

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None known

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### **Biodiversity**

Integration of natural and ecology was seen as important in many exemplars (Vauban, Eco Viikki, Voures, BedZED, Grow Community, Hanham Hall, Sonoma Mountain Village), including some of the more urban developments (eg. Millennium Village wetlands, and the bioarchitecture proposed for Milano Santa Monica).

The urban structure at Voures (Finland) was driven by a strong landscape footprint aimed at preservation of the natural environment to ensure every house was within a short distance of the green areas. Similarly SolarCity Linz and Hammarby Sjostad both constructed walking and cycle trails to ensure residents had good and easy access to adjacent forest reserves. In Millennium Waters the barren brownfield site underwent habitat regeneration including street tree planting and the creation of a 'habitat island' to provide wildlife habitat, recreation areas and various physical mitigating benefits of green infrastructure.

Advantages of biodiverse green infrastructure includes mitigation against urban heat island effect, increased infiltration of rainwater, reduced runoffs and an increased affinity of residents to nature (Beatley 2010).

Attractive landscapes resulting from the incorporation of good landscaping can pay dividends through increased property values (CABE Space, 2005).

Australian low carbon precincts should seek to:

- Incorporate green infrastructure to benefit from the various 'eco-system services' eg. mitigation against urban heat island effect, increased infiltration of rainwater, reduced runoffs and an increased affinity of residents to nature.

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EXISTING CRC projects on biodiversity

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RP2005 - Urban Micro Climates: Comparative study of major contributors to

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the Urban Heat Island effect in three Australian cities (Sydney, Melbourne, Adelaide)

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### **'Smart' Cities**

A growing trend is the emergence of the so called smart city (not to be confused with the New Urbanist concept of 'smart growth' also worthwhile but related to site planning not digital monitoring). Smart cities utilise technology to monitor and manage urban systems, particularly electric energy but the case studies also have examples of monitoring water (Lochiel Park) and waste (Royal Seaport). For example PlanIT (Portugal), Nanjing Eco high-tech Island (China) and Fujisawa Sustainable Smart Town (Japan). Of these Fujisawa with its corporate backing by Panasonic working with the City of Fujisawa and a group of developers would appear to be the most likely candidate for development within the near future. Housed on a former Panasonic factory site the development plans for every building to be connected to a 'smart grid' including sensor controlled lighting and appliances, providing real-time information on electricity use so that supply can be exactly matched to demand. The aim is to reduce CO<sub>2</sub> emissions by 70% compared with typical levels for the city in 1990 (Joss et al 2011). Existing examples include Lochiel Park (smart meters), Royal Seaport (smart grid) and Masdar (smart grid).

Australian low carbon precincts should seek to:

- Integrate smart city monitoring to track emission reduction performance and to educate occupants on use patterns and to assist authorities to manage opportunities for further reductions, Delivery processes

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EXISTING CRC projects on smart cities

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None known

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## **Low Carbon Precinct Processes**

The following section is based upon observations drawn from the case studies relating to processes for the delivery and management of low carbon precincts. This section is an overview based upon the limited information available within the source material. It is expected that this section will be considerably expanded in Phase 2 of the scoping study following site visits and interviews with stakeholders involved in project delivery.

### **Vision and Metrics**

All of the precincts reviewed benefited from a strong vision and commitment to sustainable urbanism, this required a systemic rethink of prevailing unsustainable systems that dominate current city planning and the construction industry. The visions outline a desirable aspiration and the more successful examples tend to be supported by specific principles, rating tools or other metrics to measure performance (for example the One Planet Principles used for BedZed, One Brighton and Masdar City).

'What gets measured gets managed' - this common mantra among business leaders is equally true for sustainable built environment leadership. Most of the case studies observed had clear goals to meet carbon reduction with the most legitimate developments having specific and regularly monitored goals rather than just aspirational

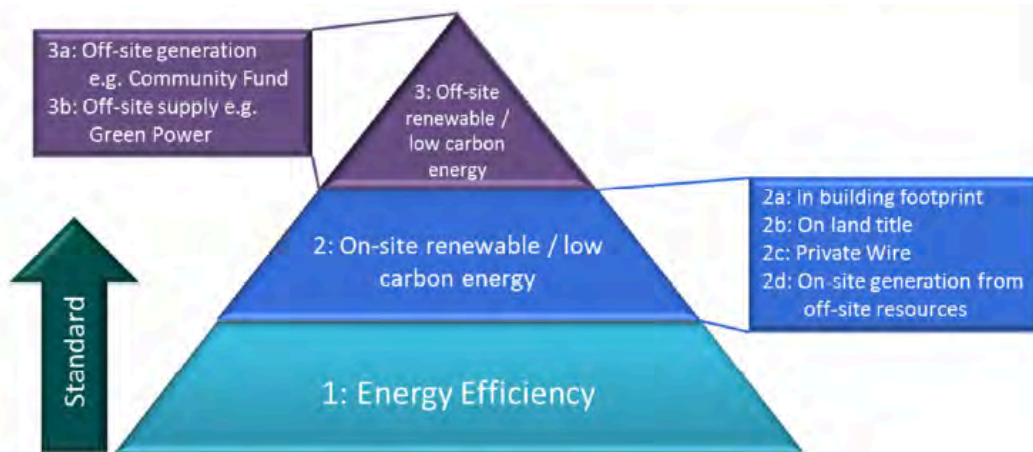
targets set out at the planning stage. Certain projects monitored and reported progress back to demonstrate the effectiveness of the various sustainability measures eg Eco Viikki, BedZED, Hammarby Sjostad, Lochiel Park).

The case studies highlighted that there are many methods for planning and monitoring the environmental performance of precincts (eg. BREEAM, LEED ND, GreenStar, Code for Sustainable Homes, One Planet Community etc) and buildings (eg PassivHaus, MINERGIE, NABERS). The diversity of approaches is also reflected by the eco-claims of the various developments 'ecoDistricts' (Portland, Hammarby), 'carbon neutral' (BedZED), 'zero carbon' (Peterborough, Hanham Hall) and so on. The diverse approaches make direct comparison difficult. A standardised metric would assist in comparisons between projects. Such a metric would ideally be an absolute measure related to carbon neutrality. But again clear definitions around terms will be essential to ensure metrics are workable and consistent. The Carbon Challenge initiatives in the UK (Peterborough, Hanham Hall) helped highlight this by demonstrating the ambiguity of 'zero carbon' early on in the process requiring policy amendment (particularly relating to renewable energy 'on-site').

Based upon the UK's experience with the Code for Sustainable Homes, ASBEC (Riedy C, Lederwash A and Ison N, 2011) recommends the following 3 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 3. Off-site renewable or low carbon energy.

Figure 15: Recommendations for Australian standard zero carbon building emissions

(source: ASBEC 2011)



But the ASBEC model has limitations when considering the key precinct carbon emission sources identified by Bunnings et al (2013):

1. Embodied Carbon in Materials
2. Construction processes
3. Energy Production and management
4. Transport
5. Water management
6. Waste management

The ASBEC model account only for emission sources generated under the third category – Energy Production and Management. However

across each of these six categories the same principle of minimising demand through consumption efficiency should be a priority.

In terms of monitoring the other five categories different tools (such as 'ecological footprinting' (Wackernagel & Rees, 1996)) offer a broader sustainability lens. However care must be taken not to design urban areas as efficient machines, liveability is critical for a successful sustainable development (Newton 2012, and Newman and Kenworthy 1999). The 'extended metabolism model' (Newman and Kenworthy 1999) describes a systematic approach for a 'balance sheet' of environmental flows allowing measurement of a wide range of urban inputs and outputs as well as providing measures for liveability.

To successfully monitor precinct sustainability an appropriate precinct scale approach with an absolute baseline (for ease of comparability) and targets (possibly as policy goals) would be ideal. Such a model would require ongoing monitoring to ensure targets are met and maintained.

Organisations seeking to deliver low carbon precincts in Australia should seek to:

- Define clear project visions at the outset for agreement and adherence by all project stakeholders – this may form part of the tendering or contractual process
- Measure performance against absolute benchmarks for ease of comparison (eg 'carbon neutral' – as yet undefined)
- To ensure a holistic approach monitoring should be benchmarked against a range of measures not just building operational performance. Measures should include at least the following embodied carbon in materials, construction processes, energy production and management, transport, water and waste management, other considerations might included food production and biodiversity
- Regularly monitor performance against the agreed benchmarks to ensure they are being met and to find opportunities for further improvement.

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EXISTING CRC projects on indicators and targets

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RP2001 - Scoping study for Precinct Design and Assessment Tools

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### **Innovative financing models**

Essential to the uptake of low carbon precincts is that they are financially viable, without this mainstreaming of sustainable urbanism will not occur.

Several case studies describe the use of innovative financing models. These may be the result of favourable government intervention such as reduced land tax (eg Vauban) to partially offset the sustainability cost premium. But in the absence of such incentives a number of case studies effectively negotiated planning concessions to increase site yield and with the additional revenue were able to subsidise sustainability improvements eg. One Brighton, Graylingwell Park, Greenwich Millennium Village. Each of these examples sought on-site car parking reductions to reduce costs for car parking infrastructure while increasing the amount of floor area for sale. To satisfy the parking reduction all schemes had good access to public transport and One Brighton used a Green Transport Plan to also negotiate a considerable increase in site yield from a permitted 80 to 172 dwellings which

allowed a healthy financial return and exemplary environmental outcome.

Another innovative model currently only used for retrofits but with the potential to be expanded to precinct scale is the Property Assessed Clean Energy (PACE) loans scheme (City of Berkley, 2008). This model allows property owners to receive full funding to retrofit homes with sustainable measures thus overcoming the 'split incentive barrier' through PACE loans that are repaid via a local government or state property tax tied to the property over a specified period (e.g. 20 years) (cf. Environmental Upgrade Agreements (EUA) Sustainable Melbourne Fund). Reduced utility costs can save the occupant money over time while reducing household carbon emissions. The Berkley model has been widely replicated across the US and is now in use in 31 US states (PACE Now, 2013).

PACE works well for single owner occupied buildings but another split incentive barrier exists for rental and multi-family buildings where the owners may be reluctant to pay for sustainability improvements they can not recoup from tenants. A 2013 pilot project overcomes this through On-Bill Repayment (OBR) which allows owners to repay loans through monthly utilities bills (Kim et al. 2012).

Both the PACE and OBR models are aimed for individual buildings it would be a small step widen this to the precinct scale to encourage decentralised energy systems particularly for regeneration or new build projects. A Greening, Revitalisation and Improvement District (GRID) concept has been proposed by Rauland (2013) as a model for funding precinct scale eco-infrastructure and the PACE and OBR models may provide the financial template for this to occur.

Organisations seeking to deliver low carbon precincts in Australia should seek to:

- Identify opportunities for government led incentives such as tax concessions, feed in tariffs, or zoning bonuses
- Identify opportunities for innovative sustainable loan schemes such as PACE and OBR at household and precinct scale

Perhaps the largest incentive of all would be if a carbon accreditation scheme could be developed by the Federal Government as part of their Direct Action Plan. This would be a global first if a fully certified process of achieving low carbon urban development could be developed with carbon credits that were given a dollar value through the government's proposed auctioning system.

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EXISTING CRC projects on innovative financing models

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RP2010 - Informing and Trialing the Inclusion of Low Carbon Requirements in State Government Built Environment Sector Tenders

RP2006 - Action research to examine and demonstrate how to mainstream low-cost and low carbon housing in Western Australia

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## Governance and organisational structures

### **Government Owned Development Corporations**

According to Spiller and Khong (2013) *GODCs can be instituted to address one or more of the following public policy issues in urban development:*

- *Underdeveloped market competition in greenfield land and housing development, leading to housing supply shortfalls and exploitative consumer prices*
- *A lack of innovation within the private land and housing development sector on such matters as dwelling mix, water sensitive design and energy sustainability*
- *The inability of the land and housing market to overcome barriers to major redevelopment projects due to blighting, land fragmentation, contamination from former industrial uses and concentrated land ownership amongst government organisations.*

Several of the case studies are the result of GODCs enabling government policy as demonstration projects (eg. The UK Carbon Challenge Projects – Hanham Hall and Peterborough Carbon Challenge, Eco-Viikki, Hammarby Sjostad, Royal Seaport).

As a case study of how GODCs can demonstrate desirable urban models and influence policy the UK Government's 2007 initiative 'the Carbon Challenge' is a good example. The Carbon Challenge initiative as led by England's national regeneration agency English Partnerships (now part of the Department for Homes and Communities). The two projects Carbon Challenge projects (Peterborough, Hanham Hall) were heavily supported by government subsidies to showcase innovation and to demonstrate exemplary solutions for the UK's ambitious sustainable housing policy – *the Code for Sustainable Homes*. English Partnerships stated the objective of the Carbon Challenge was:

*...in order to develop the skills and technologies in the house building industry that are necessary to deliver new zero carbon homes at Level 6 of the Code for Sustainable Homes. The Carbon Challenge will make house builders and their suppliers better prepared to meet the Government's goal that all new homes will be zero carbon by 2016. English Partnerships, Carbon Challenge Standard Brief (August 2007).*

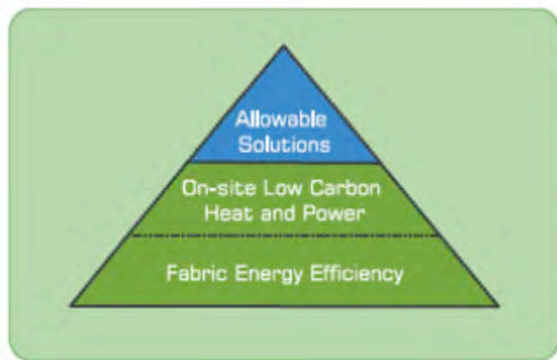
The Carbon Challenge benefits industry and government by testing the policy and highlighting opportunities and weaknesses that need to be addressed. It also enables the community to understand what a 'zero-carbon' community can look like (Department of Homes and Communities, 2011).

The driver for government involvement in the project was the *Code for Sustainable Homes* (CSH) released in response to the 'Stern Review' recommendation for the government to take early and strong action on climate change to minimise future social and economic disruption. When the Code was released in 2006, no existing housing development satisfied the aspirational future code requirements therefore the Carbon Challenge was developed as a pilot program to demonstrate that zero-carbon housing was possible, to showcase excellence in sustainable urban development and initiatives, and to test and monitor new ideas.

Lessons from the Carbon Challenge process led to a modification of the initial prohibitively expensive requirement for all energy to be produced on-site, to a more cost-effective approach that ensures new development delivers high building fabric energy efficiency with more lenient 'on-site' energy requirements (see Figure 2) with any further carbon emission reduction requirements able to be compensated by 'allowable solutions' (off-site).

Figure 16: The three parts of the UK Government's stepped policy approach to zero carbon homes.

Source: *Zero Carbon Strategies*, Zero Carbon Hub (2013)



### The three parts of the Government's stepped policy approach to zero carbon homes.

Zero carbon is achieved through:

- good fabric energy efficiency,
- inclusion of on-site low carbon heat and power technologies, and
- use of Allowable Solutions to compensate for carbon emissions reductions that are difficult to achieve on site

The 'Carbon Challenge' was a useful process for the UK government, providing demonstration projects to showcase new technology and 'accelerating innovation' within the private sector to help meet national emission reduction objectives. More importantly, however, it allowed rapid prototyping and testing of policy outcomes, ultimately leading to the revision of an onerous and costly burden upon the developer to meet all their renewable energy needs 'on-site'. The amended policy shifted the emphasis toward the creation of highly efficient building envelopes to reduce energy demand from housing stock. The generation of on-site renewables while encouraged may also be met by 'allowable solutions' off-site (Zero Carbon Hub, 2011).

The problem with this approach is that the main carbon market is at the front end of the economy and thus is not available to help incentivise the end user built environment sector. The opportunity provided by the shift in focus of the new Federal Government's Direct Action Plan is that a low carbon incentive could be created if a proper framework was developed at a precinct scale.

To facilitate this the Government could:

- Use a GODC structure to enable such urban developments to be managed in a way that enables local governments, developers and communities to be fully cognisant of the process and requirements of achieving low carbon urban development credits.
- Use large scale government led housing projects as test beds to trial sustainable urbanism innovation (cf. Carbon Challenge (UK)) to build capacity within the development, construction and engineering sectors.

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EXISTING CRC projects on the role of government owned development corporations

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None known

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### **The role of 'not-for-profits' and social enterprises**

Stewardship by organisations with strong environmental values have been responsible for promoting, project managing, financing, and on-going management of several case studies (eg Forum Vauban (Vauban), Bioregional (One Brighton, BedZED). Some organisations such as BioRegional, Green Building Council, EcoDistricts have developed tools for assisting sustainable urban development (eg GreenStar Communities (GBCA), One Planet Living Principles (Bioregional), EcoDistricts Framework (EcoDistricts). Bioregional's One Planet Communities typically provide occasional or annual sustainability

reports to track progress against some or all agreed sustainability objectives outlined in their Sustainability Action Plans (eg. Sonoma Mountain Village, BedZED, One Brighton, Masdar)

While in the UK several of the case studies benefited from the project management or financial support from charitable housing associations (eg BedZED - Peabody Trust, Coopers Road – Southwark Housing and Peabody Trust).

Not for profits (NFPs) can assist with the ongoing management of developments (eg. Graylingwell Park - Community Development Trust to manage open spaces, One Brighton - Energy Services Company, Community Management Company and Community Interest Company to ensure the ongoing management responsibility of the project).

Organisations seeking to deliver low carbon precincts in Australia should seek to:

Investigate the role of NFPs, or social enterprises (where profitable), to fill sustainability service niches that are currently not served by conventional developers or government.

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EXISTING CRC projects on the role of not for profits and social enterprises

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None known

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### **CoDesign and community co-operatives**

Community led design can result in more active participation in local sustainability initiatives (Rauland 2013) and also reduce costs for housing by cutting out the developer profit margin (eg. Vauban). Community led design can fill a niche not met by conventional developers. In Germany 55% of homes are self procured and in Vauban self procurement by owner developers through construction communities this was an important factor behind the high performance of housing (ie there was no split incentive because the owners would benefit from investment in eco-infrastructure). In Australia there are a number of intentional communities where co-operative housing has resulted in sustainable outcomes but these are usually outside of urban areas and are relatively uncommon. Two exceptions are Christies Walk in Adelaide and WestWyck in Melbourne.

Organisations seeking to deliver low carbon precincts in Australia should seek to:

- Work with local and future communities to deliver desirable products and to increase community engagement with sustainable products to drive demand for innovation.

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EXISTING CRC projects on codesign and community co-operatives

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None known

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### **Communication and marketing**

According to Olympic Village Contractor, Andrew Kinsey - Head of Sustainability - Construction, Mace *“Communication is key to getting all operatives on board with sustainability. Incentives are useful. Make sustainability visible and engaging and articulate the value wherever possible so it drills down to every decision making process”.*



Knowledge sharing, particularly the proliferation of online resources can help quickly spread information about low carbon development. Resources such as centralised national government knowledge repositories eg. The UK's Zero Carbon Hub (to support the government agenda to decarbonise the built environment) (<http://www.zerocarbonhub.org/>), institutional resources such as BREEAM (<http://www.breeam.org/>), the Green Building Council and LEED (<http://www.usgbc.org/leed>) and Passivhaus (<http://www.passivhaus.org.uk/> and <http://passiv.de/en/>) increasingly social enterprises and not for profits are sharing information about pathways to low carbon living eg One Planet Communities based out of the UK (<http://www.oneplanetcommunities.org/>) or Living City Block from the USA (<http://livingcityblock.org/>) and EcoDistricts (<http://ecodistricts.org/>).

Ritchie and Thomas (2009, p.93) emphasise *'the importance of an ongoing dialogue between the designer, constructor and the 'ultimate' client – the occupier – who is often not the design client.'*

The 'Zero Carbon Hub', may be of particular interest to the CRC, as a public private partnership 'established to take day-to-day operational responsibility for coordinating delivery of low and zero carbon new homes' with the strategic objectives to: create confidence during change, reduce risk and clear obstacles, disseminate practical guidance (Zero Carbon Hub, 2008). This knowledge sharing portal helps disseminate lessons to government, industry and community accelerating uptake of knowledge relating to the building sector and helping to overcome the skill and knowledge barriers.

Organisations seeking to deliver low carbon precincts in Australia should seek to:

- Spread information about the cost / benefits of sustainable options for development to drive consumer demand for sustainable urban environments that can improve liveability and reduce running costs.

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#### EXISTING CRC projects on communication tools

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RP3009 - High Performance Housing: Monitoring, Evaluating and Communicating the Journey: "Josh's House" "Lochiel Park" and "CSIRO ZEH" Living Laboratories

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## Overall Conclusion

The case studies indicate that sustainable urbanism practice is being taken very seriously in the major economies. In particular Europe is emerging as a global leader but the last few years have seen major low carbon urban initiatives delivered in North America, Asia and the Middle East. Low carbon sustainable urbanism is a rapidly growing market sector and the precinct-based approach appears to be a cost effective format for its delivery. Given the expected growth in this area, if Australia can emerge as a global leader it could be expected to benefit from the early mover advantage. Advantages are many, including rapidly decarbonising its cities, kudos for leadership and developing the economy around construction, manufacturing and service provision with the potential for export of both knowledge and products.

An overall conclusion from the processes would be that no such comprehensive approach exists that is fully accredited and certified by government. Many innovations are happening but eventually they need to be part of a mainstreamed government process. The new Direct



Action Plan of the Australian Government offers an opportunity as it is seeking certified carbon credits for end use actions which include built environment innovations. If a precinct-based process can be developed it may be possible to create innovative low carbon urban developments that can earn carbon credits.

## Low Carbon Precinct Recommendations

As a result of this study an overall recommendation for precinct scale urban development has been developed to conduct integrated low carbon built environment research (R1). This is followed by several key areas that have been identified for further research that have the capacity to help mainstream low carbon sustainable urbanism in Australia. They are briefly listed below as topics for consideration by the CRC partners.

### Overall Recommendation.

R1: The precinct scale of urban development is an obvious and useful scale on which to conduct built environment research. Precincts enable most aspects of built environment innovation to be trialled as an integrated system, thus if the total carbon involved is significantly lowered the demonstration project can be replicated quickly in other parts of the city and indeed across the world. Precinct scale low carbon urban development should be examined closely as innovations in this area are becoming globally competitive and the CRC for Low Carbon Living can help Australia to achieve multiple benefits in the built environment sector.

In particular the creation of a process that can enable claims of carbon accreditation for Low Carbon precinct development should be developed in close consultation with the Direct Action plan of the Australian Government. Following endorsement by the CRC leadership this approach will be expanded in Phase 2 of this work.

NB. It is envisioned that a holistic approach informed by the conclusions of this scoping study and findings from further research related to the detailed recommendations below would form the basis of such a framework.

### Detailed Recommendations

R2. A research project should be instigated with government and industry partners to establish an accreditation process for low carbon precinct development. All six of the key precinct carbon emission areas (as outlined by Bunnings et al 2013) covered in this report should be considered in the framework developed.

#### *Emissions related to embodied carbon*

R3: Explore opportunities for low embodied energy materials (to complement CRC project RP1004 - low carbon concrete) that are appropriate within Australia. If considering the transport dimension, the most appropriate low embodied materials may differ between major centres therefore local studies may be required.

R4: Investigate construction waste reduction strategies and technologies, in particular the potential for building prefabrication (with an emphasis on carbon neutral or carbon negative materials) to reduce the embodied energy and construction cost of development.

#### *Emissions related to operational energy*

R5: To support existing building envelope performance benchmarking recommendations (GBCA, ASBEC and others) complementary cost-benefit analysis conduct investigations into environmentally and financially effective combinations of 'building envelope performance' and 'building envelope + renewables' will assist development of appropriate and implementable planning policy targets for aspirational energy efficient developments. Such modelling should provide recommendations on total building emissions, and variations across several Australian climatic regions (cf. seven climate zones designated by the Australian Building Codes Board).

R6: An investigation is needed into, and workshops with, urban service / infrastructure providers to find synergies to reduce the urban metabolic loop and to reduce resource consumption (cf. Hammarby Sjostad). Such an investigation would necessarily need to include mechanisms for governance and funding and possibly new eco-infrastructure (eg. district heating and cooling pipes and /or vacuum waste collection and sorting).

R7: Study potential carbon emission savings related to water demand reduction and on-site water capture and reuse (eg on-plot rainwater tanks, sitewide water retention and detention basins, aquifer storage and recovery) to reduce energy emissions related to water pumping and potable water desalination.

R8: Study methods to reduce water heating demand including the potential of waste water heat exchange, at both the individual house level or at the precinct scale (cf. Millennium Waters sewer heat recovery).

R9: Investigate potential carbon emission reductions related to precinct scale local food production. Such a study may measure the success (or otherwise) of programs such as Malmö's sustainable food policy. Similarly does the integration of urban agriculture actually lead to behaviour change in food consumption patterns that significantly reduce greenhouse gas emissions? Are there other benefits such as improved sales (property values or clearance rates) related to the integration of urban food production as a lifestyle option?

R10: Investigate precinct scale benefits of green infrastructure for precinct scale carbon reductions through the mitigation urban heat island effect, reducing run-off peaks, cooling through shading and evapo-transpiration and even sales premiums (to offset the sustainability cost premium).

R11: Measure the success of smart meters and smart grids as tools for monitoring and improving consumer behaviour and reducing emissions. Longitudinal studies of smart metered projects can compare modelled versus actual performance (both where there is monitoring and where there is no on-going monitoring).

#### Delivery processes

R12: Phase 2 of this scoping study should seek to develop or adopt a clear vision for low carbon precincts and define some simple baseline metrics and targets influenced by best practice performance observed in shortlisted exemplar projects.

R13: Investigate innovative funding models to help offset the additional cost of eco-infrastructure (eg. value capture from zoning uplift of higher densities to finance district heating and cooling networks and other community scale energy systems).

R14: Investigate potential funding mechanisms (eg. financing, tax incentives, rezoning, development bonuses) to overcome the 'sustainability cost premium' and 'split incentive' associated with eco-infrastructure. Investigations should also explore how potential planning controls could lead to additional site yield ('planning gain mechanism') (for example a reduction of parking requirements where a site is well served by public transport could lead to increased site yield / development bonuses by the consent authority where achievement of minimum sustainability standards is demonstrated (cf. One Brighton)).

R15: Investigate the level of carbon credits that would be needed to enable low carbon urban development to become mainstreamed.

R16: Investigate options / appetite for Government Owned Development Corporations (GODCs) to work with the CRC to develop low carbon and sustainable tendering processes (including competitions) for demonstration projects (particularly major government housing projects, possibly as 'living labs'). GODCs demonstration projects will assist in the dissemination of information while also expanding sustainability skills and technologies within the built environment and engineering sectors to deliver carbon neutral precincts. Developing consistent quality benchmarks, score cards or other mechanisms to improve sustainability could help GODCs to compare products, share knowledge and compete for sustainability and built environment excellence. Investigation should also consider the role GODCs can play in trialling Direct Action certification and accreditation

R17. Investigate the role GODCs could play in identifying and assembling / amalgamating sites to unlock key locations with the greatest potential for higher density sustainable development. The most strategic locations would likely be infill sites (greyfield or brownfield) well served by public transport, with good access to open space, retail and services. Potential for low carbon energy sources (eg. Water source cooling, adjacent land uses with waste heat or combustible wastes might also be mapped).

R18: Investigate how not-for-profits or social enterprises might work to drive value-led development to deliver low carbon developments in Australia. Similarly what role might not-for-profits or social enterprises play in the on-going management and monitoring of low carbon precincts (cf. One Brighton)? This may involve collaboration with existing organisations or the potential establishment of new organisations.

R18: Investigate whether self procurement of homes and housing co-operatives might be a useful approach for delivering improved low carbon urban sustainability in Australia (cf. Vauban). A review of Australian experiences may identify any structural barriers or supportive policy changes to facilitate greater uptake of CoDesign or community co-operatives to permit an uptake of sustainable housing and increase consumer choice (cf. Christies Walk, Westwyck).

R19: The CRC might consider developing a dedicated website (cf. Zero Carbon Hub) to function as a trusted central knowledge repository for the dissemination of technical information on low carbon urban development in an accessible manner. Such a website would function as a one-stop knowledge shop for policy makers, the public and industry. The CRC may act as a knowledge aggregator to support its partner organisations and while also disseminating its own recent research. To be effective it may be necessary to provide

accessible recommendation summaries to widen the audience of the technical papers.



## Next Steps

This study has identified a number of successfully delivered low carbon precincts. Phase 2 of this scoping study will expand in two main directions:

### 1. Planned future research

Planned future research will try to develop a better understanding of how some of the exemplary case studies (selected from the 'shortlist') were delivered. Following further inquiry into the logistics of visiting and meeting stakeholders for interview a series of 'must visit' locations will be compiled for possible site visits and interviews.

### 2. Suggested further direction seeking endorsement of CRC leadership

As per recommendations, future direction will seek to closely align research to enable the Direct Action policy to have a focus on how low carbon precinct-scale urban development could be certified and accredited to receive carbon credits. This will involve discussions with Australian stakeholders to understand how low carbon precinct developments could meet the wider needs of industry, local government, state government, NGO's and professional urban development bodies.

Once resolved partnership-based research may be trialled through the CRC 'living labs' to provide a much needed evidence-based framework for decarbonising Australian cities to give Australia a clear competitive edge.

# References

## References

- ACIL Allen Consulting, Delivering Abatement through Direct Action: Emissions Reduction Fund – Concept Design and Practice, Sydney, 2013.
- Australian Bureau of Statistics (2008) 3222.0 - *Population Projections*, Australia, 2006 to 2101
- Australian Government (2013a) *State of Australian Cities*. Department of Infrastructure and Transport.
- Australian Government (2013b) *Overcoming split incentives – factsheet*. Department of Industry September 2013.
- Beatley, Timothy (2010) *Biophilic Cities: Integrating Nature Into Urban Design and Planning*, Washington DC: Island Press.
- BioRegional (2009) *BedZED seven years on: The impact of the UK's best known eco-village and its residents*. BioRegional, London.
- Bunning J, Beattie C, Rauland V and Newman P (2013) "Low-Carbon Sustainable Precincts: An Australian Perspective" in *Sustainability* 2013, 5, 2305-2326
- CABE Space (2005) *Does Money Grow on Trees?* Commission for Architecture and the Built Environment.
- Carter, A.J., Pisaniello, J.D. and Burritt, R.L. (2010), 'Government sustainability policy in Australia: moving from rhetoric to effective implementation', *Centre for Accounting, Governance and Sustainability Occasional Working Papers, No. 3*, October, University of South Australia, Adelaide.
- City of Stockholm (2013) <http://www.hammarbysjostad.se/> (accessed July 2013).
- City of Berkley (2008) <http://www.ci.berkeley.ca.us/berkeleyfirst/> (accessed July 2013).
- COAG (2009) *Green Skills Agreement*. Department of Industry.
- COAG Reform Council (2011) *Review of capital city strategic planning systems*
- Cole, D (2012) 'Economic Growth or The Environment. Both: Sustainable Capitalism' *Metis*, Volume 3, 2012.
- Creagh S, Denis A, Canadell P, Reidy C (2013) 'Greenhouse emissions stable over decade as GDP grew 31%' *The Conversation*, July 30 2013.
- Denis, A. et al. (2013) *Tracking Progress Towards a low carbon economy. National Progress Report*. ClimateWorks Australia, July 2013.

Desai (2009) 'Eco regulation: cutting through the green tape' Building.co.uk <http://www.building.co.uk/eco-regulation-cutting-through-the-green-tape/3141159.article> (accessed Oct 2013)

Desai P (2010) *One Planet Communities. A real-life guide to sustainable living*. John Wiley & Sons p.28.

Economist (2013) *Urban dreamscapes, starting from scratch*. September 2013

Energy Cities (n.d.) 'Hammarby Sjostad' [http://www.energy-cities.eu/IMG/pdf/Sustainable\\_Districts\\_ADEME1\\_Hammarby.pdf](http://www.energy-cities.eu/IMG/pdf/Sustainable_Districts_ADEME1_Hammarby.pdf) (accessed July, 2013)

English Partnerships (2007) *Carbon Challenge standard brief*.

International Labour Organization (2011) *Study of occupational and skill needs in green building: final report / International labour office*, Ilo Skills and Employability Department. Geneva: Ilo, 2011.

Farr D (2007) *Sustainable Urbanism: Urban Design with Nature*. Wiley

Falk N (2012) *Sustainable New Communities on the South Coast*. URBED

Forum Vauban (2004) <http://www.forum-vauban.de/overview.shtml> (accessed July, 2013).

Gehl J (2010) *Cities for People*. Island Press London.

Generation Investment Management LLP. *Sustainable Capitalism*. White Paper, London, UK: Generation Investment Management LLP, 2012.

Girardet H (1992) *The GAIA Atlas of Cities: New directions for sustainable urban living*. GAIA books. London.

Girardet H (2012) 'Regenerative Adelaide' in *Solutions for a sustainable and desirable future*. Volume 5, Issue 3, p 46-54, September 2012

GlashusEtt (2007) *Hammarby Sjöstad – a unique environmental project in Stockholm*. City of Stockholm

Green Building Council of Australia (2009) *Green star multi-unit residential energy calculator benchmarking methodology*. Green Building Council of Australia

Green Building Council of Australia (2011) *Putting a price on pollution: What it means for Australia's property and construction industry*. Green Building Council of Australia

Kelly J (2010) 'Home insulation program flawed and risky, Hawke report finds'. *The Australian*. April 22, 2010.

Kim, C et al. (2012) *Innovation and Opportunities in Energy Efficiency Finance, White Paper*, Wilson Sonsini Coodrich & Rosati, NY. May 2012, second edition.



Mumford L (2010) *Technics and Civilization*. University of Chicago Press (Original work published 1923)

Newman P and Kenworthy J (1999) *Sustainability and Cities: Overcoming Automobile Dependence* (Island Press, Washington DC).

Newman P, Bachels M and Scheurer J (2010) *The Knowledge Arc Light Rail: Sections F and G, Delivering TODS*, Curtin University Sustainable Policy Institute and Parsons Brinkerhoff.

Newton P (2012) "Liveable and Sustainable? Socio-Technical Challenges for Twenty-First- Century Cities". *Journal of Urban Technology*, Routledge.

Newton P, Murray S, Wakefield R, Murphy C, Khor L and Morgan T (2011) *Towards a New Development Model for Housing Regeneration in Greyfield Residential Precincts*, Final Report no. 171, Australian Housing and Urban Research Institute, Melbourne, [http://www.ahuri.edu.au/publications/download/50593\\_fr](http://www.ahuri.edu.au/publications/download/50593_fr)

Newton and Tucker (2011) 'Pathways to decarbonizing the housing sector: a scenario analysis' in: *Building Research and Information*. 39 (1), p. 34-50

Opportunity Peterborough (2011) 'Future Plans' <http://www.opportunitypeterborough.co.uk/invest/future-plans/> (accessed August, 2013)

Pace Now (2013) Financing energy efficiency. <http://pacenow.org/pace-programs/> (accessed October, 2013).

Peterborough City Council (2011) 'Peterborough leads 'zero carbon' homes agenda as plans are approved 8 February 2011 (accessed July, 2013).

Rauland, V (2013) *Decarbonising Cities: Certifying Carbon Reduction in Urban Development*. Curtin University Sustainable Policy Institute, PhD Thesis.

Riedy C, Lederwasch A and Ison N (2011) *Defining zero emission buildings – Review and recommendations: Final Report*. (Prepared for Sustainability Victoria by the Institute for Sustainable Futures, University of Technology, Sydney).

Ritchie and Thomas (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London

Rogema R (2012) *Swarming Landscapes: The Art of Designing For Climate Adaptation*. Springer Science+Business Media Dordrecht.

Roper T. Direct Action Policy Emissions Reduction Fund Letter to the Minister for the Environment. 18 November 2013 ASBEC, Sydney. Available at: <http://www.environment.gov.au/submissions/emissions-reduction/tor/182-asbec.pdf>

RUDI (2008) 'Peterborough zero carbon community developer selected' <http://www.rudi.net/node/20114> (accessed July, 2013).

Sheffield Univerity (n.d.) Knowledge Transfer Centre - BREEAM case Study  
<http://www.shef.ac.uk/efm/currentprojects/amrc/ktc>

Sanders R, Milford L and Rittner T (2013) *Reduce Risk, Increase Clean Energy. How States and Cities are Using Old Finance Tools to Scale Up a New Industry*. Clean Energy and Bond Finance Initiative.

Spiller and Khong (2013) *Government sponsored urban development projects: What can Australasia take from the US experience?* SGS Economics and Planning (unpublished occasional research paper)

Sustainability Victoria (2011) *Business models for enabling sustainable precincts*. The Government of Victoria p.6.

Wackernagel, Mathis & Rees, William (1996)"Our Ecological Footprint" (New Society Press)

Wilfred C, Ramos M (2009) *Zero Carbon Compendium: Who's doing what worldwide*. NHBC Foundation.

Williams, J (2012) *Zero Carbon Homes*. Earthscan, Oxon.

Wilson, L (2013) 'How big is a house? Average house size by country' in *Shrink that footprint*. available at: <http://shrinkthatfootprint.com/how-big-is-a-house>

UK Department of Homes and Communities (2011)  
[http://www.homesandcommunities.co.uk/carbon\\_challenge](http://www.homesandcommunities.co.uk/carbon_challenge)

Zero Carbon Hub (2008) <http://www.zerocarbonhub.org/> (accessed July, 2013).

Zero Carbon Hub (2010) *Zero carbon compendium: who's doing what in housing worldwide*.

Zero Carbon Hub (2011) *Fabric Energy efficiency for zero carbon homes. A flexible performance standard for 2016*.

Zero Carbon Hub (2013) *Zero Carbon Strategies*.

# Appendix 1

# Appendix 1: The long list

Table 2: the 'long list'

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list
Abbey walk, Storrington	UK	Low carbon, CSH L4	constructed	brownfield	12	0.28	43	Y	Y	Y	N	Y	N
Almere (and Nobelhorst)	The Netherlands	eco-homes	underway	greenfield	2000	201	10	Y	Y	Y	Y	-	Y?
Barangaroo	Australia	One Planet Community	planning	brownfield	5000	22	227	-	-	Y	Y	Y	N
BedZED	UK	carbon neutral district	constructed	brownfield/greenfield	82	1.65	50	Y	Y	Y	Y	Y	Y
Beijing Olympic Village	China	LEED Gold	Constructed	-	1800	65	27	-	-	Y	Y	Y	N
BO01, Malmo	Sweden	eco-district	constructed	brownfield	1303	22	59	Y	Y	Y	Y	Y	Y
Castleward, Derby	UK	BREAM Good	underway	brownfield	800	12	67	-	Y	Y	Y	Y	Y?
Changxing Ecological City	China	Eco-city	planned	-	35000	500	70	Y	Y	Y	Y	Y	N
Christies Walk, Adelaide	Australia	Ecopolis	constructed	brownfield	27	0.2	135	Y	Y	Y	Y	Y	Y
Coin Street Housing	UK	affordable sustainable housing	constructed	greyfield	59	1.2	49	-	-	Y	N	N	N
Coopers Road Estate	UK	zero carbon	constructed	greyfield	250	1.69	148	Y	Y	Y	Y	Y	Y?
Copenhagen	Denmark	Carbon neutral city by 2025	underway	Retrofit	-	-	-	-	-	Y	Y	Y	N
Dockside Green	Canada	LEED Platinum	underway	brownfield	1000	6	167	Y	Y	Y	Y	Y	Y?

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list	
Dongtan	China	100% renewable E	Planned (stalled)	greenfield	27000	624	43	N	Y	Y	Y	N	Y	N
Eco Vikki	Finland	sustainable neighbourhood	constructed	greenfield	1700	23	74	Y	Y	Y	Y	Y	Y	Y?
EcoDistricts, Portland	USA	EcoDistrict	underway	retrofit	-	-	-	-	Y	Y	Y	Y	Y	N
Ecovillage at Ithica, NY	USA	eco-village	constructed	greenfield	140	70	2	Y	Y	Y	Y	Y	Y	N
EVA Lanxmeer	Netherlands	eco-district	constructed	greenfield	250	20	13	-	Y	Y	N	N	N	N
Ferrara	Italy	2003 EU Sustainable City Award	constructed	retrofit	-	-	-	-	-	Y	-	-	Y	N
Fujisawa Sustainable Smart Town	Japan	energy independent	planned	brownfield	1000	19	53	-	-	Y	Y	Y	-	N
Graylingwell Park, Chichester	UK	Zero carbon	constructed	greyfield	780 (105)	34	23	Y	Y	Y	N	Y	-	Y?
Greenwich Millenium Village	UK	sustainable neighbourhood	underway	brownfield	2800	20	140	-	-	Y	Y	Y	Y	Y?
Grow Community, Bainbridge Island Washington state	USA	One Planet Community	underway	greenfield	131	3.2	41	Y	Y	Y	Y	Y	Y	Y?
Hamburg-Harburg	Germany	eco-city	retrofit	brownfield/greyfield	-	-	-	-	-	Y	Y	Y	Y	N
Hammarby Sjostad	Sweden	eco-district	constructed	brownfield	10000	200	50	N	N	Y	Y	Y	Y	Y

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list	
Hanham Hall	UK	Carbon Challenge, Zero carbon, CSH L6	constructed	greenfield / retrofit	195	5	39	Y	Y	Y	Y	Y	Y	
Hollerich	Luxemburg	One Planet Community	planned	brownfield	-	3.6	-	Y	Y	Y	Y	Y	N	
Ivory Park	South Africa	eco city (village)	constructed	brownfield	30	2	15	Y	Y	Y	N	Y	-	N
K2	Australia	Sustainable affordable housing	constructed	greyfield	96	0.48	200	Y	Y	Y	-	Y	Y	N
Kalundborg	Denmark	eco-industrial park	constructed	industrial	-	-	-	-	-	Y	-	Y	Y	N
Knockroon, Cumnock, Ayreshire	UK	sustainable neighbourhood	underway	greenfield	600	28	21	Y	Y	Y	N	Y	Y	N
Kronsberg, Hannover	Germany	Eco-estate	constructed	greenfield	2800	60	46	-	-	Y	Y	Y	Y	N
Lo to No, Helsinki	Finland	Low carbon urban development model	planned	brownfield	9500	100	95	Y	Y	Y	Y	Y	Y	N
Lochiel Park	Australia	green village	constructed	greenfield	106	4.25	25	-	-	Y	N	Y	Y	N
Lovejoy Lane, Windsor	UK	Zero carbon	constructed	greyfield	9	0.15	60	Y	Y	Y	N	Y	-	N
Made in Stockwell, London	UK	"Advanced" performance	constructed	redevelopment	290	1.2	242	Y	Y	Y	Y	Y	Y	N

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list
Masdar, Abu Dhabi	UAE	Eco-city	underway	greenfield	40000	600	67	Y	Y	Y	Y	Y	Y?
Masthusen, Malmo	Sweden	BREAM Excellent	planned	brownfield	700	6.3	111		Y	Y	Y	Y	N
Mata de Sesimbra (Resort)	Portugal	One Planet Community	planned	greenfield	5000	500	10	Y	Y	Y	Y	Y	N
MediaCityUK, Manchester	UK	BREAM	planned	brownfield	14.5	-	-	-	Y	Y	Y	-	N
Menlyn Maine, Pretoria	South Africa	green mixed use city precinct	underway	greyfield	320	16.5	19	-	-	Y	Y	-	N
Milano Santa Monica	Italy	bioarchitecture	planning	-	2000	-	-	-	-	Y	-	-	N
Millennium water (Vancouver's Olympic Village)	Canada	Model sustainable community, Net zero housing	constructed	brownfield	1110	7	159	Y	Y	Y	Y	Y	Y
MINERGIE residential building, Brunnenhof	Switzerland	MINERGIE	constructed	-	72	-	-	Y	Y	Y	N	N	N
Nanjing Eco high-tech Island	China	Eco High-tech	planning	greenfield	700	-	-	-	-	Y	-	Y	N
Newington, Sydney	Australia	Sustainable neighbourhood	Constructed	brownfield	1900	90	21	-	-	Y	Y	Y	N
Nieuw Terbregge	Netherlands	Eco-district	constructed	regeneration	860	21	41	-	-	Y	-	Y	N



Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list	
North West Bicester	UK	One Planet Community, ecotown	underway	greenfield	393	21	19	Y	Y	Y	Y	Y	N/Y?	
One Brighton	UK	One Planet Community	constructed	brownfield	172	2	86	Y	Y	Y	Y	Y	Y	
One Gallions, Thames Gateway	UK	One Planet living	planning (stalled)	brownfield	200	1.2	167	Y	Y	Y	Y	Y	N	
Panama Pacifico	Panama	green city	underway	brown/grey/greenfield	20000	1400	14	-	-	Y	-	Y	-	N
Parkmount	N. Ireland	EcoHomes (very good) passive design	constructed	greyfield	58	0.57	102	-	-	Y	N	N	N	N
Pedra Branca	Brasil	sustainable city	underway (stalled)	greenfield	10000	242	41	-	-	Y	Y	Y	Y	N
Peterborough Carbon Challenge	UK	Carbon Challenge, Zero carbon. CSH L6	underway	brownfield	295	7	42	Y	Y	Y	Y	Y	Y	Y
Prince Charles House	UK	BREEAM outstanding	constructed	regeneration	31	-	-	Y	Y	Y	N	Y	N	N
Rizhoa City, Shandong Province, China	China	Solar City	underway	new build / retrofit	-	-	-	-	-	Y	-	-	-	N
Royal Albert Dock	UK	Green Enterprise District	planning	brownfield	-	20	-	-	-	Y	Y	-	-	N
Hallein, Salsburg	Austria	super insulated	constructed	-	31	-	-	-	Y	Y	-	-	-	N

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list
Salvatierra Apartments, Rennes, Beauregard	France	Low E passivhaus	constructed	-	40	-	-	Y	Y	Y	N	N	N
Shirecliffe, Norfolk Park and Falstaff, Sheffield	UK	BREAM Very good	planned	-	8.5	305	36	-	Y	Y	-	-	N
Skotteparken, Egebjerggård, Ballerup	Denmark	50% E reduction	constructed	greenfield	100	3	33	-	-	Y	N	N	-
Solar Valley, Dezhou, Shandong Province, China	China	Solar Valley	underway	New build	-	330	-	-	-	Y	-	-	-
solarCity Linz-Pichling	Austria	solar city	constructed	greenfield	1300	32	41	Y	Y	Y	Y	Y	Y
Sonoma Mountain Village	USA	One Planet Community	underway	brownfield	1892	81	23	Y	Y	Y	Y	Y	Y
Standings Court, Horsham	UK	Zero carbon	constructed	greyfield	38	0.48	79	Y	Y	Y	N	Y	-
Stirling City Centre	Australia	eco-friendly	strategy	retrofit	-	-	-	-	-	Y	Y	Y	Y
Stockholm Royal Seaport	Sweden	Sustainable urban district	underway	brownfield	10000	236	42	Y	Y	Y	Y	Y	Y
Stratford Olympic Village	UK	Sustainable neighbourhood	constructed	brownfield	2800	27	104	-	-	Y	Y	Y	Y

Project Name	Country	Eco Claim	Status	Land condition	Dwellings	Site area (Ha)	Dw/ha	Construct Processes Embodied CO2	Energy	Transport	Water	Waste	Short list	
The Wharves Deptford, London	UK	CSH level 4	planned	greyfield	905	4.5	201	Y	Y	Y	Y	Y	N	
Treasure Island, San Francisco	USA	sustainable urban community	Planned	brownfield	8000	164	49	-	-	Y	Y	Y	N	
Tregunnel Hill, Cornwall	UK	sustainable neighbourhood	underway	greenfield	174	4.4	40	Y	Y	Y	N	Y	N	
Upton Northampton	UK	sustainable urban extension	constructed	greenfield	1220	43	28	Y	Y	Y	Y	Y	N	
Vauban, Freiburg	Germany	sustainable urban district	constructed	brownfield	2000	38	53	Y	Y	Y	Y	Y	Y	
Vista Montaña Zero Energy Community, Watsonville, California	USA	Zero Energy Homes	constructed	greenfield	389	29	13	N	N	Y	N	Y	N	
Vuores	Finland	eco-community	constructed	greenfield	7000	472	15	-	-	Y	Y	N	Y	Y?
Westwyck, Victoria	Australia	One Planet Community	constructed	greyfield	30	0.5	60	Y	Y	Y	Y	Y	Y	Y?
Zero Energy Housing, Etten Leur	The Netherlands	zero energy houses	constructed	greenfield	43	-	-	-	-	Y	-	-	-	N
zHome, Issaquah	USA	zero net energy	constructed	greenfield	10	-	-	Y	Y	Y	Y	Y	Y	N

# Appendix 2

## Appendix2: Low Carbon Precinct source list

### Books and Articles

Bunning J, Beattie C, Rauland V and Newman P (2013) "Low-Carbon Sustainable Precincts: An Australian Perspective" in *Sustainability* 2013, 5, 2305-2326

Bioregional (2002) *BedZED Beddington Zero Energy Development, Sutton*. Housing Energy Efficiency Best Practice Program.

Bioregional (2009) *BedZED: Toolkit Part II. A Practical guide to producing affordable carbon neutral developments*.

Bioregional (2011) *Grow Community Sustainability Action Plan*, available at: <http://growbainbridge.com/>  
BREEAM Communities Castleward, Derby case study at <http://www.breeam.org/> (accessed October, 2013)

Bioregional (2011) *SOMO One Planet Community, One Planet Action Plan Annual Review 2011*

Bioregional Quintain (2010) *One Planet Action Plan Annual Review 2010*. Available at:  
<http://www.oneplanetcommunities.org/wp-content/uploads/2011/01/One-Brighton-Annual-Review-2010-final.pdf>

Breuste J, Riepel J (2005) *Solar Linz/Austria – A European Example for Urban Ecological Settlements and its Ecological Evaluation*. University of Salzburg.

City of Malmo (n.d) *Vastra Hamnen The Bo01-area. A city for people and the environment*.

City of Vancouver (2010) *CIP 2010 Awards for Planning Excellence Submission: Olympic Village*.

Desai P (2010) *One Planet Communities. A real-life guide to sustainable living*. John Wiley & Sons p.28.

*Dockside Green: Annual Sustainability Report 2011*, Vancity

English Partnerships (2007) *Carbon Challenge Standard Brief*.

Energie Cites fact sheet (2008) [www.energie-cities.eu](http://www.energie-cities.eu)

Energy Cities (2008) *Guide to sustainable neighbourhoods in Europe*. Available at: [http://www.energy-cities.eu/IMG/pdf/ademe\\_sustainable\\_districts\\_en.pdf](http://www.energy-cities.eu/IMG/pdf/ademe_sustainable_districts_en.pdf) (accessed November 2013)

Farr D (2007) *Sustainable Urbanism: Urban Design with Nature*. Wiley

Falk N (2012) *Sustainable New Communities on the South Coast*. URBED

Foletta N (2011) *Europe's Vibrant New Low Car(bon) Communities, Greenwich Millennium Village*.

General Electric (2007) *Water and Process Technologies Dockside Green Case Study*.

Hill D (2011) 'Masdar City abandons transportation system of the future' in Singularity Hub, <http://singularityhub.com/> (accessed December 2013)

Joss S, Tomozeiu D, Cowley R (2011) *The International Eco-Cities Initiative – A global survey 2*. Global Eco-Cities Initiative, University of Westminster

Lovell (2013) Case study in sustainability: Affordable Housing, Castleward, available at: <http://www.morgansindall-sustainability.com/>

Kozakowski, M (2013) *Dockside Green to seek agreement re jig after missing targets*. Vibrant Victoria <http://vibrantvictoria.ca/local-news/dockside-green-seeks-agreement-re-jig-after-missing-targets/>

Moscovich R (2009) 'Millennium Water: Vancouver's Olympic Village in: Ritchie and Thomas (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London

One Brighton fact sheet Sustainability Victoria - [sustainability.vic.gov.au](http://sustainability.vic.gov.au) (accessed April 2013)

Peterborough City Council (2011) 'Peterborough leads 'zero carbon' homes agenda as plans are approved 8 February 2011 (accessed July, 2013).

Rauland, V (2013) *Decarbonising Cities: Certifying Carbon Reduction in Urban Development*. Curtin University Sustainable Policy Institute, PhD Thesis.

Rinne H 2009 Eco Viikki fact sheet [www.hel.fi](http://www.hel.fi)

Ritchie and Thomas (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London

RUDI (2008) 'Peterborough zero carbon community developer selected' <http://www.rudi.net/node/20114> (accessed July, 2013).

Scheurer J and Newman P (2009) *Vauban: A European Model Bridging the Green And Brown Agendas*. Case study prepared for Revisiting Urban Planning: Global Report on Human Settlements 2009.

Secure (2007) *Benchmark study, Greenwich Millennium Village*. European Sustainable Urban Development Projects (see: <http://www.secureproject.org/>).

Secure (2009) *Benchmark study: Hammarby Sjostad* European Sustainable Urban Development Projects.

Secure (2007) *Benchmark study, Vauban*. European Sustainable Urban Development Projects (see: <http://www.secureproject.org/>).

Svane O (2007) *Hammarby Sjöstad, Stockholm City's Project Team and the Process of Environmental Management*. School of Architecture and the built Environment, Royal Institute of Technology, Stockholm.

The Architecture Centre (2010) *Building Case Study Hanham Hall Eco-Village Bristol*.

Treberspurg M, Smutny R, Ertl U (2008) *Sustainability Evaluation of 'the solarCity Linz-Pichling' in Austria*. World SBO8 Melbourne.

Turrent D (2009) 'Coopers Road Estate: Regeneration' in Ritchie and Thomas (Eds) (2009) *Sustainable Urban Design: An Environmental Approach* (2<sup>nd</sup> Ed) Taylor and Francis, London.

UKGBC (2013) *Project Case Study Graylingwell Park*. Green Building Council (available at: [www.ukgbc.org](http://www.ukgbc.org) (accessed September 2013))

Victoria Times, 5 August, 2006. *Former CEO accuses Vancity of firing him over affordable housing*. See: <http://www.canada.com/story.html?id=bd558d69-7f5c-4125-b5fb-004d9de4ee02> (accessed October 2013)

Williams, J (2012) *Zero Carbon Homes*. Earthscan, Oxon.

Wyatt (2008) *Learning from Freiburg, University of Cambridge Study Tour*. URBED

Zero Carbon Hub (2010) *Zero carbon compendium: who's doing what in housing worldwide*.

## Websites

City of Helsinki see: [www.hel.fi/ksv/english/index.html](http://www.hel.fi/ksv/english/index.html)

City of Stockholm (2011) *Stockholm Royal Seaport* see: <http://www.stockholmroyalseaport.com/en/> (Accessed November 2013)

City of Vancouver website and factsheets see: <https://vancouver.ca/home-property-development/olympic-village.aspx> (Accessed November 2013)

*Concepts for ECOCITY model settlements: Vuores*, available at: [www.upv.es/contenidos/CAMUNISO/info/U0511279.pdf](http://www.upv.es/contenidos/CAMUNISO/info/U0511279.pdf) (accessed September 2013)

Dockside Green official website, see: <http://www.docksidegreen.com/>

Forum Vauban (2004) <http://www.forum-vauban.de/overview.shtml> (accessed July, 2013).

<http://www.peabody.org.uk/homes-in-development/coopers-road>

[http://www.newlondonarchitecture.org/project.php?id=675&name=coopers\\_road\\_estate\\_regeneration](http://www.newlondonarchitecture.org/project.php?id=675&name=coopers_road_estate_regeneration)

<http://www.malmo.se/English/Sustainable-City-Development/Bo01---Western-Harbour.html>

<http://www.masdarcity.ae/en/>

<http://www.masdar.ae/>

<http://www.fosterandpartners.com/Projects/1515/Default.aspx>

<http://www.irena.org/>

<http://www.hanhamhall.co.uk/site/web/home>

<http://www.oneplanetcommunities.org/>

<http://www.sonomamountainvillage.com/community/sustainability.php>

One Planet Communities Website: <http://www.oneplanetcommunities.org/communities/endorsed-communities/grow/> (Accessed November 2013)

UK Department of Homes and Communities (2011)

[http://www.homesandcommunities.co.uk/carbon\\_challenge](http://www.homesandcommunities.co.uk/carbon_challenge) (Accessed November 2013)