Faculty of Humanities
Curtin University Sustainability Policy Institute

Decarbonising Cities: Certifying Carbon Reduction in Urban Development

Vanessa Rauland

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material, which has been accepted for the award of any other degree or diploma in any university.

Signature:

Date: 12.07.2013

Abstract

There are many outstanding examples of carbon neutral, zero carbon and other forms of low carbon cities, districts and urban development around the world, which have demonstrated the vast potential for carbon abatement within the built environment. However, these concepts and approaches have not yet become mainstream. Furthermore, how each city or development defines its carbon claim, including how emissions are calculated and goals are achieved (for example, if offsets are used) varies considerably. This makes comparisons difficult, claims less meaningful and replication challenging. It also leads to concern around false carbon claims and 'greenwashing'.

Although carbon certification is now widely adopted as a voluntary carbon market instrument for a variety of sectors, it has not yet been applied to urban development. This research therefore examines the implications of certifying carbon reductions within this sector. A framework is proposed, which includes a standardised approach to quantifying emissions at the precinct-scale and five core elements that would need to be considered when certifying urban development.

It is argued that certification can help to acknowledge and reward progressive developers, increase the credibility of carbon claims within the built environment and help to provide benchmarks and baselines for the sector. Certification could also become a mechanism by which a variety of incentives can be offered to developers to encourage greater uptake of low carbon design. It is expected that a combination of factors – a standard approach to quantifying emissions, carbon certification and the provision of incentives – can help to mainstream this type of development, which will be essential in addressing many global challenges such as climate change and resource depletion.

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ACCC	Australian Competition and Consumer Commission
CDP	Carbon Disclosure Project
CFI	Carbon Farming Initiative
CNP	Carbon Neutral Program
ESCo	Energy Service Company
GHG	Greenhouse Gas
ICLEI	Local Governments for Sustainability (Formerly 'International Council for Local Environmental Initiatives')
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation of Standardisation
NCOS	National Carbon Offset Standard
NGERS	National Greenhouse and Energy Reporting Scheme

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Publications

The following authored and co-authored publications have come out of this thesis and are duly regarded for their benefits to the thesis. The work presented here, whilst using some of the ideas and outcomes generated by the group of people involved at CUSP, is a wholly independent exercise.

1. Varnas, A., Nykvist, B., Persson, A., and Rauland, V. (2010) *Personal Carbon Trading as a Potential Policy Instrument to Reduce Swedish Greenhouse Gas Emissions*. Stockholm Environment Institute, Working Paper – 2010. Retrieved from http://www.sei-international.org/mediamanager/documents/Publications/SEI-WorkingPaper-Varnas-PersonalCarbonTrading-2010.pdf
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4. Rauland, V., & Newman, P. (2011). *Decarbonising Australian cities: A new model for creating low carbon, resilient cities*. Paper presented at the MODSIM2011: 19th International Congress on Modelling and Simulation Perth, WA. Dec 12-16 2011
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8. Bunning, J., Beattie, C., Rauland, V., and Newman, P. (2013) Low Carbon Sustainable Precincts: An Australian Perspective. *Sustainability Journal.* Special Issue: 'Sustainable Cities.
9. Bunning, J., Beattie, C., Rauland, V., and Newman, P. (2013) Decarbonising City Precincts: An Australian Perspective. In '*Cities for Smart Environmental and Energy Futures*'. Editors Pardalos, P, M. and Rassia, S, T. Springer.

Chapter 1 – Introduction and Methodology

1 Introduction and Methodology

1.1 Background

Climate change and the depletion of natural resources, together with a rapidly rising population, are three of the great global challenges facing humanity in the 21st century. They are each innately interconnected, and together, remain the most politically complex, capricious and tenuous issues to address, particularly at the international level. The solution, however, is increasingly identified as being best addressed at the local level, specifically within cities and local communities, where action and innovation can occur at a much more rapid rate (Brugmann, 2010; Bulkeley et al., 2011; Glaeser, 2011; ICLEI, 2010 Roseland, 2005; UN Habitat, 2011).

Cities are both a major cause of climate change and resource depletion, but also fundamental in their solution. As cities are likely to be particularly vulnerable to the impacts of both issues, significant motivation exists for them to take action (World Bank, 2010). Cities, faced with the dual challenge of climate change mitigation and adaptation, have therefore long been calling for, and taking action on, climate change thereby leading the way in preparing for a carbon- and resource-constrained future (Brugmann, 1996; Bulkeley et al., 2011; Roseland, 2005).

Through the process of urbanisation, cities have also been having a significant impact on the rate of population growth (UNEP, 1996). Research has shown that family size tends to reduce when people move to cities as a result of better access to a range of services including family planning and medical services and greater educational opportunities as well as the increased living costs making larger families more costly (Newman, 2011; UNEP, 1996).

As more of the world's population move into cities in the coming decades, the importance of cities in addressing climate change, declining resources and a rising population, will only intensify. The way we design, build and adapt our cities, and how we learn to live within them, will play an instrumental role in addressing the key challenges facing us, as cities will ultimately determine our survival as a species on this planet. It is hoped that this research will play a small part in assisting cities in taking up this important role. The following outlines the nature of the three global challenges.

1.1.1 Climate Change

In 2007, the Intergovernmental Panel on Climate Change[1] released a report that delivered three critical and unequivocal messages, which were that:

1. The global climate is warming, bringing a range of impacts affecting both the natural and industrial worlds;
2. Humans are very likely a significant cause of this change in climate; and
3. The rate at which the climate is changing, and the subsequent impacts, are occurring much faster than anticipated or projected by the models (IPCC, 2007).

It is well understood and accepted that climate change is caused by an increase of carbon dioxide and other greenhouse gases[2] in the earth's atmosphere. While the earth's climate has changed over millions of years due to natural variations in carbon dioxide levels (e.g., through volcanoes and melting permafrost), there is strong evidence correlating the current rise in carbon dioxide with human activities, primarily from the combustion of fossil fuel for energy production and use (IPCC, 2007).

Some of the known and predicted impacts of climate change include an increase in floods, droughts and severe storms, sea level rise, species extinction and a spread of diseases (IPCC, 2007). However, it is the unknown consequences of climate change, which occur once tipping points are passed leading to a series of cascading and potentially irreversible events, that worry the world's most accomplished scientists and climate experts.

The forecast impacts of climate change are likely to cause significant upheaval in our cities and to our urban infrastructure, disturb our agricultural processes and wreak havoc on natural ecosystems and biodiversity, all at great financial cost to the economy and particularly for future generations (Garnaut, 2008; IPCC, 2007; Stern, 2006; VijayaVenkataRaman, 2012). Traditionally, addressing climate change has focused on mitigation, as this was identified as being more cost effective than paying the largely

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[1] This is an international scientific community consisting of thousands of reputable climate scientists and experts from all corners of the globe, co-ordinated through the United Nations.
[2] Within this thesis I will be using the terms carbon, CO2 and greenhouse gas emissions interchangeably to represent the six GHG's covered under the Kyoto protocol, unless otherwise stated. The six Kyoto gases include: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). These gases are represented as tonnes of carbon dioxide equivalent (t CO2-e).

unknown costs associated with the impacts of climate change (e.g., disaster relief, adaption measures, relocating climate refugees). However, as a certain degree of warming has now been locked into the climate system, greater attention is being given to adaption, particularly in the most vulnerable cities, settlements and areas.[3]

1.1.2 Resource Depletion and Environmental Degradation

There have been significant concerns for many years regarding the ability of the earth to sustain an ever-increasing population in terms of resources, particularly based on current and predicted extraction rates and consumption trends.

Thomas Malthus was one of the first to warn of the consequences of overconsumption, contending in 1798 that humans will consume resources at an unsustainable rate until an event (i.e. war, famine or disease) will lead to their collapse (Malthus, 1999). In 1968, two important publications set the scene for a Malthusian revival. Paul Ehrlich revived the population debate with his book 'The Population Bomb' which sold over 2 million copies and Garret Hardin presented the problem of excessive resource consumption as a social dilemma caused by the overuse of common resources in his essay 'The tragedy of the commons' (Hardin, 1997). However, the resource problem was really bought to the world's attention in the early 1970's by The Club of Rome through its popular book 'The Limits to Growth' (Meadows et al., 1972). The authors explored the relationship between unlimited economic and population growth and a limited supply of resources. They produced several computer-modelled scenarios based on five interconnected variables: world population, food production, industrialisation, resource depletion and pollution. A number of the scenarios tested, including the 'standard run', ended in collapse of the earth's systems (Meadows et al., 1972).

Countless others have also predicted and warned of a variety of global environmental and human catastrophes and collapses resulting from the overconsumption of resources and the inability of the earth's system to regenerate (Carson, 1962; Diamond, 2005; Ehrlich, Ehrlich & Holdren, 1970; Simon, 1981). Although the prophesied 'extreme' collapse scenarios have not eventuated, the

[3] Low-lying cities and settlements are at extreme risk, as are cities prone to flooding and drought. Ironically, many of the most vulnerable cities are located in developing countries, which are neither responsible for the problem nor able to financially manage the impacts.

predictions have not been entirely incorrect. There have been many confirmed peaks and significant declines in a variety of natural resources, as well as drops in numbers and extinctions of various species (Meadows et al., 2004; Millenium Ecosystem Assessment (MEA), 2005; Rockström, 2009).

Wackernagle and Rees (1996), using their ecological footprint model[4], have demonstrated that humans are living in a perpetual state of overshoot, meaning more resources are being consumed and more waste being produced than the earth can currently replace or absorb. This poses significant problems into the future.

The arguments, analyses and viewpoints put forward have been helpful in raising awareness and spurring the debate[5] around issues associated with overconsumption and the finite capacity of the earth, particularly in relation to a continuously increasing human population. Few of them, however, suggest much about what cities can do to ease the problems.

1.1.3 Population Growth

Since world population reached its first billion in the early 1800s, it has been growing at an exponential rate. While it took all of human history till then to reach the first billion, world population has doubled several times since, each in a substantially shorter period of time causing many people to question how long this rapid growth can continue unchecked.

In 2011, our population reached seven billion, re-awakening concern over the impacts of population growth and reigniting the debate on what a sustainable population might be. It is worth noting that population in isolation is not the primary problem. It is the impact a population has on its environment, due to a variety of factors such as consumption of resources and production of waste that creates the issue. In an attempt to demonstrate this relational impact, Paul Ehrlich (1970) proposed a formula, which he expressed as IPAT, which means:

Impact = Population x Affluence (or consumption) x Technology.

[4] An Ecological Footprint is defined as "the land and water area that is required to support indefinitely the material standard of living of a given population, using prevailing technology" (Chambers, Simmons and Wackernagle 2000:17).
[5] Julian Simon contradicted the gloomy perspective held by Ehrlich and others, suggesting that technological advances and human ingenuity would prevail. Simon and Erlich had numerous public debates and wagers on this topic.

The formula shows that a person's impact will vary depending on where they are in the world, how much they can afford and how efficient the infrastructure and technologies servicing them are. While it acknowledges that some people will have a far lower impact on the planet than others, whether from the use of better technology or from having lower affluence, the formula ultimately leads to the assertion that an increase in population unequivocally results in a net negative impact.

Others have contested this conclusion, suggesting that humans are also capable of solving many of the world's resource problems, and of improving the overall condition of the planet (Newman, 2011; Simon, 1981) particularly through better-designed cities (Birkeland, 2008; Brugmann, 2010; Dodman, 2009; Droege, 2006; Glaeser, 2011; Newman, 2011; Newman et al., 2009; Newman & Jennings, 2008; Simon, 1981). Highlighting human ingenuity as the most important natural resource, Simon (1981) in his book 'The Ultimate Resource', contends that humans have a boundless capacity to create and adapt in order to provide and survive, and thus argues that population growth can actually create more resources. It has also been argued that human ingenuity and creative thinking are amplified when people live in close proximity to one another, as ideas and solutions spread and evolve far quicker (Brugmann, 2010; Glaeser, 2011; Simon, 1981). From this premise, one could derive that a growing population living in denser cities could indeed help to provide greater solutions to the global issues faced.

Nevertheless, there are people and international agencies, who advocate for a decreasing population in order to cope with the environmental pressures such as climate change, peak oil and resource scarcities (Ehrlich, 1970; O'Connor, 2010; The United Nations Population Fund [UNFPA] 2012). The major challenge however, is how to achieve such a reduction. Forceful methods to control population growth such as mandatory sterilisation or contraception, and policies that disincentivise multiple children such as China's one child policy, often have atrocious consequences (Ren, 1995), and thus remain highly controversial and unlikely to receive universal support. Extremist ways of controlling population throughout history have led to mass genocide and ethnic cleansing by infamous figures such as Hitler and Pol Pot (Newman, 2011).

However, there are also less aggressive measures to reduce population that are proving successful and are generally accepted by all sides of the debate. For example, global movements aimed at improving education for women and providing better access to family planning services and contraception, primarily in developing countries where current access to both are limited, have had a valuable and significant impact in reducing population (UNEP, 1996).

In terms of developed countries and cities, Newman (2011) argues that limiting population is not only unlikely to do much in addressing the resource and environmental concerns facing cities and the planet, but could in fact produce entirely the opposite effect, which is to ensure that the inefficiencies of the current system are locked in or stabilised in stagnant or declining cities. On the other hand, increasing population on purely economic grounds and using existing and often out-dated and inefficient systems, will also result in higher carbon emissions, declining resources and increasing environmental concerns. Newman (2011), therefore, proposes a new approach for addressing the debate, which uses population growth in cities (generally accompanied by economic growth) to enable the implementation of new low carbon technologies and more intelligent infrastructure to transform cities and the urban environment into healthier, more liveable and productive low-carbon cities. Labelled 'The Urban Sustainability Model', Newman (2011) contends that the three factors highlighted by Erhlich (1972) - population, affluence and technology – are useful to consider with regard to our impact on the planet, but don't inevitably result in a worsening impact.

While it is not the intention of this thesis to provide a comprehensive or definitive argument or opinion on the population issue, it is based on the premise that humans can, through well-designed cities that include density as a key feature, create a more sustainable world and future.

1.2 Context

1.2.1 The Role of Cities: How Cities Contribute to the Challenges

Despite occupying only around 2.5 per cent per cent of the planet's landmass[6], cities consume extraordinary amounts of natural resources and discharge considerable volumes of waste into the atmosphere, waterways, oceans and soil (Barles, 2010; Potere, 2007; UNEP, 1996). Numerous studies have shown that the amount of resources required to sustain cities, including the consumption of raw materials and the land

[6] This percentage is increasing rapidly as more people move into cities as a result of urbanization, and is expected to grow considerably if cities grow through urban sprawl instead of density.

required to absorb wastes, often extend far beyond a city's geographic or legislative boundary (Churkina, 2008; Hoornweg, 2011; Kennedy, 2011; Satterthwaite, 2008). As a result, cities, through their local activities and global consumption habits, are having an increasingly wider impact on the global environment (Borghesi, 2003), most notably in the form of anthropocentric climate change. Some research has suggested up to 80 per cent of global GHG emissions are attributable to cities (Satterthwaite, 2008), though there is still debate on the exact contribution (Dodman, 2009; Hoornweg, 2011). On a per capita basis, cities are often seen to have a smaller carbon footprint than their rural counterparts (Dodman, 2009).

Cities are also likely to be the most severely affected and vulnerable to the effects of the very problems they are causing, such as climate change[7] and resource depletion. On the other hand, cities have also been identified as having the greatest ability to address environmental problems, through improved infrastructure provisions, local action planning and capacity to generate and accelerate innovation (Brugmann, 2010; ICLEI, 2010; The World Bank, 2010). They are also where education and health services can be made available to all. Recognising that overconsumption and inefficiency are largely designed into our cities through our infrastructure and service provision (Bartholomew & Ewing, 2009; Ewing et al., 2008; Newman & Kenworthy, 1999; Newton, 2012), greater attention is now being given to enabling low carbon transitions in urban planning that foster greater flexibility in systems and urban design (Newton, 2008).

Thus, cities, through their ability to re-design themselves, their capacity to innovate, provide employment, health and education services and their unique decision making capabilities, can dramatically affect not only population growth, but also the amount of energy and resources consumed and emissions produced, making them a powerful force in global GHG mitigation (Dhakal, 2010; Dhakal & Shrestha, 2010; Dodman, 2009; Ewing et al., 2008; Hoornweg, 2011; Satterthwaite, 2008).

1.3 The Need for This Research

Scientists have called for a reduction of carbon in the global economy by 80 per cent by 2050 in order to keep global warming below two degrees of pre-industrial levels

[7]For example, many cities were built on low-lying land at the mouth or rivers, which leave them very susceptible to sea level rise.

(IPCC, 2007). As outlined above, cities are making a major contribution to global emissions. A question that thus arises is: could the creation of zero carbon or carbon neutral cities be a major means or mechanism for achieving the carbon reduction required?

1.3.1 The Global Shift to a Low Carbon Economy

Over 90 developed and developing countries, representing around 80 per cent of global GHG emissions, have now made pledges to reduce their domestic emissions (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education [DIICCSRTE], 2013c; UNFCCC, 2012). Many of these countries have communicated their existing or proposed emissions reduction actions and measures that will assist them in achieving their targets. Carbon taxes and emissions trading schemes appear to be the most popular amongst developed countries with legally binding commitments (DIICCSRTE, 2013b), while developing countries without binding commitments have identified a range of other 'nationally appropriate mitigation actions' (NAMA's), such as energy efficiency, improved forest management and increasing the amount of renewable energy generation (UNFCCC, 2011).

While there are countless ways to tackle carbon emissions, action is commonly split between two broad areas of the economy - the 'Front End' and the 'End User' (Newman & Ingvarson, 2012). The Front End generally refers to emissions that are produced from activities that use fossil fuels directly, such as power generation, refining and large industrial practices. Emissions are thus targeted as they enter the economy. Policies focused on the End User target carbon as it is used in the home and businesses, as well as emissions from the built environment.

Table 1 below identifies the primary policies and mechanisms for targeting emissions at both ends of the economy, which can be voluntary or mandatory. Examples of these are provided within an Australian context, though are relevant to most cities, particularly in the developed world [8].

[8] This thesis contains primarily Australian examples, in order to provide a consistent political and legal framework, particularly in relation to the development of a certification scheme.

POLICIES & MECHANISMS	FRONT END EXAMPLES	END USER EXAMPLES
REGULATION	Mandatory emissions reporting – i.e. NGERS Renewable Energy Target (RET) Clean coal requirements	Building codes Mandatory energy disclosure for buildings Mandatory energy performance standards
MARKET BASED INSTRUMENTS	Emission Trading Schemes Carbon tax Other tax incentives Clean Development Mechanism Joint Implementation	Voluntary carbon trading Carbon Offsets Standards and Carbon Neutral Programs Subsidies & Rebates (e.g., solar panels, home insulation)
MORAL PRESSURE	International Treaties Corporate social responsibility (large businesses and utilities)	Carbon neutral businesses, Local Government Areas (LGAs) Corporate social responsibility (CSR) Green Building Council ratings Other environmental ratings schemes GreenPower™, NaturalPower™
INFRASTRUCTURE & SERVICES	Smart Grids Renewables linked to grids Public transport Solar Flagship Program	Smart meters Electric Vehicle plug-in facilities Infrastructure for walking/cycling/ transit Green infrastructure for local developments Power utility energy efficiency programs
EDUCATION	Energy efficiency programs, Solar Cities Program	Household Sustainability Audits, Travel Smart programs Living Smart programs
R&D & DEMONSTRATION	Investment in Carbon Capture and Storage (CCS)/Clean coal Solar Flagships Renewable Natural Gas	Carbon neutral communities Design models for low carbon planning and building of precincts
VISIONING/ STRATEGIC PLANNING/ GOVERNANCE	Garnaut Report and Energy White Paper The Australian Federal Government's Energy Efficiency Plan	Strategic Planning Clinton Climate Initiative ICLEI cities Coalition of Australian Governments (COAG) Urban Planning focus on reducing carbon

Table 1. Front End and End User Carbon Mechanisms with Australian Examples. Adapted from Newman & Ingvarson (2012).

Although the uptake of carbon policies around the world has been a relatively slow process, those that have been implemented have primarily targeted the Front End of the economy. The reason for this focus is the greater ability to account for, and regulate all the carbon entering an economy. This is the approach advocated by most governments, scientists and international NGO's working in the climate space. However, as demand for carbon comes from the End User, it has become increasingly evident that a policy gap is emerging around the emissions associated with the consumer, which have been growing steadily in line with rising private energy and material consumption. The majority of end-user consumers are located in cities.

Frustration at the inertia and inaction occurring within higher levels of government and at the international level has seen an increasing number of individuals, businesses and local governments taking voluntary action to reduce their greenhouse gas emissions at the end-user level, particularly as this also generally leads to improved performance and a reduction in operational costs.

1.3.2 Voluntary Action and Carbon Claims: Increasing the Credibility

The concept of carbon neutrality, which involves using offsets to neutralise emissions, emerged out of the willingness of people and businesses to take voluntary action to address climate change. It materialised at a time of exceptionally high public awareness of climate change due to numerous government reports (e.g., Australia's Garnaut Review, 2008, IPCC Fourth Assessment Report, 2007; UK Stern Review, 2006), and prominent public figures such as Al Gore (An Inconvenient Truth, 2006).

Carbon neutrality is now applied to a range of emissions stemming from a variety of different activities. An individual's personal activities along with business products, projects, services and entire organisations can become carbon neutral. The concept has also become popular amongst local governments, cities and land developers keen to promote their green credentials. The general process involves reducing emissions to the extent possible before purchasing enough offsets to reduce the remaining emissions to zero.

Nevertheless, despite the increased usage of the term and perhaps because of the wide variety of applications, there remains no universal definition, nor any widely accepted framework for calculating emissions or certifying achievements. Murray and Dey (2008) note that the term currently appears to be 'defined by popular usage' (p. 238). Adding to the problem has been the emergence of a whole set of new terminology, such as Carbon Zero (or Zero Carbon), Zero Emission, Carbon-Free, Low Carbon, Carbon Negative, Carbon Positive, Climate Positive and Climate Neutral. This has probably been the result of the need to differentiate oneself in an increasingly ambitious world. The myriad of names and their varying definitions, or lack thereof, have led not only to confusion, but also to scepticism and mistrust commonly represented by the term 'greenwash', or perhaps more appropriately, 'carbonwash'. The lack of consistency in definition and in the methodology for calculating emissions or how the carbon reduction is ultimately achieved (for example, whether offsets are used) remains an issue.

Nevertheless, in an attempt to deal with the 'wild west' nature of the emerging voluntary carbon market, new guidelines and protocols have gradually been developed to bring standardisation to carbon claims, as well as new carbon certification schemes and regulations around the development of offsets. However, these processes are not always applicable to all sectors wishing to pursue carbon neutrality. The built environment and urban development is one such area in which it is not well defined. This sector lacks meaningful frameworks and systems for determining emissions, as well as emissions reductions, or ways of recognising achievements. Indeed, no successful model or program exists or is being developed that provides a standardised way to account for the carbon emissions, or a method for achieving carbon neutrality, specifically within the built environment.

While the lack of focus on End User carbon, particularly within the built environment, is a global phenomenon, Australia is used as a case study within this thesis, as Australia has in recent years begun to place greater focus on the End User, which can be useful for other nations.

In 2010, the Australian Federal Government introduced a new national voluntary scheme for certifying Carbon Neutrality in order to bring greater credibility to carbon neutral claims (Department of Climate Change and Energy Efficiency [DCCEE], 2011b).[9] They defined carbon neutrality as:

> a situation where the net emissions associated with a product or an organisation's activities are equal to zero through the reduction of emissions and the acquisition and cancellation of carbon offsets that meet stringent criteria, to offset the remaining emissions. (DCCEE, 2011b, p. 1)

However, the guidelines remain broad and are more directed at organisations and services, and thus fail to achieve any further clarification regarding emissions associated with many built environment activities such as land development. Nor do

[9] In 2013, the Department of Climate Change and Energy Efficiency merged with another department. Climate Change now sits within the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE).

they take into account various other issues specific to this sector such as ongoing maintenance of carbon neutrality (who is ultimately responsible?) and what offsets should be considered eligible. In relation to offsets, significant changes in Australia's political landscape over the past five years, such as its ratification of the Kyoto Protocol, the cessation of the Greenhouse Friendly Initiative and the introduction of the National Carbon Offset Standard (NCOS), Australia's new carbon pricing legislation and the introduction of the Carbon Farming Initiative (CFI)[10], have had important implications in relation to the use, and eligibility of offsets used for carbon neutrality. As a result, land developers pursuing low-carbon or carbon-neutral urban development are largely prohibited from using their onsite emissions reductions (i.e. renewable energy production) as offsets[11] for other aspects of their development. Thus, despite there being a political and popular desire to decarbonise urban development, there is no coherent and useful certification process for achieving it.

1.3.3 Voluntary Carbon Abatement at the Precinct Level: The Need for a Sector Specific Framework

The precinct level is identified in this thesis as an opportune sector to target emissions due to the various and abundant carbon abatement opportunities available if alternative practices are adopted in areas such as the construction process, materials selection, onsite energy, water and waste management practices and transport options (Bunning et al., 2013; Newton & Tucker 2010, 2011; Rauland & Newman, 2011).

The importance of going beyond the individual building and considering precinct-scale urban land development is that it begins to consider the urban and regional structure and form in terms of infrastructure provision, taking into account both traditional centralised and distributed forms of resource management, as well as opportunities for greater public transport infrastructure.

Many well-known eco-cities, districts and low carbon communities around the world have demonstrated various elements of the precinct-scale carbon reduction opportunities mentioned above (Ewing et al., 2008; Joss, 2011; Newman et al., 2009; Roseland, 2012; Williams 2012). Some of the most recognised and promoted developments include BedZED in the UK, Vauban in Germany, Hammerby Sjostad in

[10] Offset projects eligible under the Carbon Farming Initiative must be in sectors not covered by the Carbon Price Mechanism.
[11] That is, offsets that are recognised under official certification schemes.

Sweden, Western Harbour in Malmo, Sweden, and Masdar City, in the United Arab Emirates.[12] However, since there is currently no defined way of calculating the emissions associated with precinct-scale urban development, it is difficult to compare the developments as each has calculated various sources of emissions and asserted their achievements in diverse ways.

1.3.4 Research Significance

Against a background where there has been very limited academic research into carbon neutral concepts and initiatives at the urban scale, the significance of the research in this thesis relates to the following:

1. There is currently no framework or guidelines, which sets out what emissions should be included in an analysis of low carbon or carbon neutral urban development. Countless rating tools and schemes exist that attempt to measure various aspects of sustainable development at the precinct level (Australian Institute of Landscape Architects [AILA], 2010), but most are limited to check lists and none focus solely on GHG emissions or offer a comprehensive or specific enough carbon accounting framework to recognise carbon neutrality;
2. Although several carbon neutral certification schemes exist around the world, there has never been anything like the complexity of an urban subdivision, new precinct development or community-scale redevelopment submitted for certification. As a result, no carbon accounting framework or consistent process for certifying land development currently exists, meaning standards may vary between developments; and
3. There is no evaluation of such initiatives that can inform the planning process or enable the developer to gain from the experience. Thus, valuable information that could provide specialised guidance for future low carbon and carbon neutral development may be lost.

This research, therefore, seeks to better define what low carbon and carbon neutral can mean in the context of the built environment, and develop new ways of recognising it. Creating a standardised framework and approach to quantifying the carbon emissions arising from precinct-scale development is critical. It will not only help

[12] These are examples of a social movement that is advocating low carbon, green cities (Roseland, 1997). This is discussed in greater depth in Chapter 3.

to make assertions more meaningful and comparable, but will also make benchmarks possible. This is critical to determine the overall contribution urban development can have in addressing climate change and where reductions can be best achieved.

It is expected that the creation of a new mechanism to certify and acknowledge the carbon reductions achieved within urban development, incentives to reward progressive developers, and processes to capture and distribute knowledge gained will help to encourage greater uptake of low carbon and carbon neutral development.

At the global scale, this research is the first attempt to fully conceptualise carbon neutral and various forms of carbon reduction within urban development in all of its characteristics. It focuses on Australia, which helps to provide a well-defined legal and political context for the carbon reduction activities. The Australian Federal Government has also shown leadership in recent years having developed carbon mechanisms at both ends of the economy (e.g., a mandatory Carbon Price Mechanism[13] targeting the front end of the economy, and a Government endorsed voluntary Carbon Neutral certification scheme that recognises carbon abatement from End Users). Australia thus has the opportunity to be seen as a leader in climate change mitigation and to compete in the global innovation stakes on decarbonising development, which is rapidly becoming a defining point for post-industrial, post-carbon economies. This is particularly significant for Australia, considering the country's current urban form, which is based largely around low-density, carbon intensive urban sprawl and inefficient infrastructure. Combining these two perspectives, i.e. urban development and decarbonisation, therefore offers great potential.

Tackling these problems is an important aspect of this country's place within a global economy, though every country will need to begin this journey. Encouraging low carbon innovation within the urban planning and development context will greatly assist cities in reducing emissions, improving carbon management, and will provide the opportunity to challenge and change existing patterns of land development.

1.4 Research Questions and Objectives

The objective of this research is to bring greater understanding of the total carbon emissions associated with urban development in order to enable more accurate comparisons to be made, and subsequently, to create a process by which low carbon or

[13] This is essentially in the form of a carbon tax.

carbon neutral developments can be recognised, certified and potentially rewarded for their carbon reduction.

The core research question being explored in this thesis is:

How can urban development be certified and/or recognised for its carbon reduction, and what mechanisms can assist in mainstreaming the concept?

Further sub-questions include:

- What is the carbon reduction potential of urban development?
- What does carbon certification involve and can it be applied to urban development?
- What are the core elements of carbon certification for precinct-scale urban development?
- What are the barriers to low carbon urban development and what opportunities exist to overcome them and promote wider adoption of the concept?

1.5 Research Design And Methods

1.5.1 Research Methodology

The overarching methodology used in this thesis is based around interpreting existing knowledge and data. A significant proportion of research to date on how to decarbonise cities has focused on developing new, empirical knowledge through experimentation, investigation and examination of raw data from urban developments. The rapid rate at which this is occurring, however, is providing new research opportunities to examine this growing body of existing knowledge and data in order to draw new conclusions and new understandings (Cooper et al., 2009). The relevance and importance of this research approach is highlighted in the OECD's Frascati Manual (2002), which defines research and development as "work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (p. 30). The latter part of this definition, that is, using existing knowledge to devise new applications and new knowledge, forms the basis of the research undertaken in this thesis.

The research examines, analyses and interprets publically available information to increase the understanding of the emissions associated with and attributable to urban development, including the processes for calculating these emissions. Some case studies are examined in detail that were part of the broad research program[14] into which this thesis fits. This knowledge is then used to develop new frameworks and approaches to calculating the GHG emissions at the precinct level, as well as for identifying new opportunities to incentivise low carbon urban development.

The broad methodologies adopted within this research are 'qualitative meta-analysis' and 'research synthesis'. Cooper et al (2009) define a meta-analysis as a "set of procedures for summarising the quantitative results from multiple studies" (p. 347). As indicated by the definition, meta-analysis has traditionally been quantitative in nature, and is most well known for its use within the medical sciences (Saratakos, 1998) though it has also been used in urban research (e.g., Bartholomew & Ewing, 2009; Ewing & Cervero, 2010). This research, however, mostly applies the methodology qualitatively rather than quantitatively, in order to derive new information within a qualitative policy setting. Light and Pillemer (1984) have also used this methodology within the policy domain to aid decision-making.

'Research synthesis' is identified as its own methodological approach and is defined by Feldman (1971) as "systematically reviewing and integrating…the literature of a field…using a characteristic set of techniques and methods" (p. 86). Although similar to meta-analysis, research synthesis focuses more on integration of existing knowledge and research to form new ideas, knowledge and interpretations, rather than identifying correlations and other quantitative interactions as is common in meta-analysis.

Various other terms have also been used to describe the process of examining and integrating knowledge and evidence from existing bodies of research. Such terms include systematic review and integrative review (Swartz 2010). Paterson et al (2001) use the term 'meta-synthesis' – a combination of meta-analysis and research synthesis – to describe this methodology when used specifically in qualitative research.

[14] This was an Australian Research Council [ARC] Industry Linkage Project titled 'Decarbonising Cities and Regions'.

1.5.2 Research Framework and Design

An applied research framework is adopted within this thesis, as the aim of the research is to help inform policy and decision-making, in particular around issues of rising carbon emissions and the impact of climate change. Sarantakos (1998) notes that applied research is "directly related to social and policy issues and aims at solving specific problems and establishing policy programs" (p. 6). Applied research typically involves tackling real-world problems, and therefore, is increasingly "contributing to major public policy debates and decisions" (Bickman & Rog 2009, p. ix).

As mentioned in the previous section, this research is primarily examining existing knowledge and data that is qualitative in nature. The research adopts a mix of descriptive, comparative and evaluative research designs in order to analyse the current problem (i.e. rising carbon emissions) and the present policy context (i.e. the mechanisms that exist to encourage carbon emissions reduction within the built environment), and to inform the design of the GHG framework and certification guidelines proposed towards the end of the thesis.

Descriptive research is used in the early chapters where it aids in setting the scene on why a policy intervention (e.g., certification) is needed (Bickman & Rog, 2009). Comparative research design, which is also often identified as descriptive-comparative research in the literature (Sarantakos, 1998), is predominantly used within Chapter 3, where the carbon claims of various urban developments are analysed and compared, and Chapter 5, where existing carbon accounting frameworks are examined. Finally, evaluative research is used to inform Chapters 5, 6 and 7, where it provides valuable insight into the development of the framework and certification guidelines. The section below outlines the various methods and data sources used in this research.

1.5.3 Data Sources

The data sources used within this research consist exclusively of secondary data/material, of which the majority is from publicly available sources. Secondary data refers to data that is not originally developed or prepared for the purpose for which it is being analysed or reviewed (i.e. this thesis) (Sarantakos, 1998). The main sources of data included journal articles, industry reports, academic reports, PhD theses and research papers, conference papers, books, websites, online media content including blogs, press releases, government documents and statistical yearbooks, and personal communications. The majority of the data sources used in Chapters 5, 6 and 7 are industry-based reports, some of which have been done as part of the larger Decarbonising Cities and Regions research project.

1.5.4 Research Methods

A variety of methods have been used to conduct the integrative review and analysis processes within this research. These include a literature review, an evaluation and comparative analysis, and case study analysis. It is important to note that many of these review methods are often used simultaneously throughout this research. These methods are elaborated on below.

Literature Review

The literature review is primarily used in Chapter 2 to analyse the various reasons behind the high carbon emissions associated with cities and urban development, as well as the abundant opportunities for reducing emissions when adopting different urban design and resource management approaches. A literature review is also carried out in Chapter 8, which analyses several current barriers facing the adoption of low carbon development. However, the nature of this research, i.e. as a meta-synthesis, means that most chapters contain some form of a literature review.

Case Study Analysis

A case study method is loosely adopted in Chapter 3 (Low Carbon and Carbon Neutral Claims: Comparison of Case Studies Within the Built Environment)[15] in order to review, analyse and compare the carbon claims. The aim of the case study analysis is to determine whether carbon claims are consistent across the case studies in terms of the emission sources included. As the review is dependent on secondary sources of data, results are limited to these analyses, some of which provided inconsistent results.

Evaluation and Comparative Analysis

A review of the existing approaches for calculating the emissions associated with cities and precincts is carried out using the evaluation and comparative analysis method. Evaluation research is a commonly used method within applied research, one that "aims to search for solutions to problems, assess the significance of existing policies and practices, and evaluate the need for new approaches, plans and programs" (Sarantakos,

[15] The thesis itself is not based on a case study method. This method only helps to guide one chapter.

1998, p. 107). The evaluation analysis undertaken in Chapters 5 and 6 reveal specific gaps and problems associated with current applications of carbon accounting at the local level. These results are used to address some of the current problems associated with calculation methods and certification processes and were used to inform the development of the proposed guidelines.

1.6 Limitations

A limitation of using a meta-analysis/synthesis methodology relates to the use of primary data. The way in which the primary data was collected, recorded and subsequently interpreted is outside the control of the person undertaking the meta-analysis. Incomplete reporting can therefore affect the overall outcome of the synthesised research. This is highlighted in Chapter 3, where various sources, in their review of the case studies in question, reported different results and findings.

Furthermore, having a restricted number of prior studies available to assess and compare (for example, since precinct-scale assessment schemes have not existed for long, only a few studies exist) can limit the conclusions that can be inferred from those studies.

Finally, as this research cuts across many disciplines and topics, an exhaustive literature review on all topics is impractical, and thus reviews are limited to providing examples of issues within each research area, as opposed to comprehensive evaluations.

1.7 Structure of Thesis

This thesis is organised into seven chapters, which collectively address the key research questions previously proposed. A preview of the chapters is provided below.

1.7.1 Preview Of Chapters

Chapter 2 - The GHG Contribution and Emissions reduction Potential of Cities and Urban Development

This chapter begins with an overview of research and key statistics relating to the greenhouse gas emissions attributed to cities globally, before focusing on Australia. The impact of climate change on cities is discussed as well as the potential of cities to address climate change. Urban form is examined in relation to emissions, and an overview of the current arguments for and against various types of urban form and their ability to reduce emissions, are provided. Several key opportunities to reduce emissions within our cities and built environment are identified, particularly around alternative approaches to managing energy, water and waste within cities. These help to inform the development of the carbon accounting framework discussed in Chapters 6 and 7. The chapter finishes by examining why the precinct is identified as the optimal scale for GHG abatement.

Chapter 3 - Low Carbon and Carbon Neutral Claims: Comparison of Case Studies Within the Built Environment

This chapter begins with an examination of the concept of eco-cities. It analyses their emergence, growth and their evolution into the new low- and carbon-neutral cities of the 21st century. The chapter provides a review of nine eco-cities and low carbon developments: six international case studies and three Australian case studies. The objective of this chapter is to better understand the areas targeted within each city or development, in terms of emissions, and how they compare with each other. The case studies are analysed in terms of their eco-claim, low carbon initiatives and overall success in achieving their goal.

Chapter 4: Carbon Neutrality and Measurement: Key Considerations

Chapter 4 examines the effect the rise in voluntary action is having when addressing climate change, particularly regarding the demand for 'green', low carbon and carbon neutral products. Issues around 'greenwashing' and the reliability of carbon claims are discussed. Various definitions of carbon neutrality are provided along with a discussion of the key issues that need to be considered when making carbon claims. Offsets are also examined, as they form an integral part of achieving carbon neutrality, and are the reason for the significant growth in the voluntary carbon market.

Chapter 5: GHG Accounting Frameworks and Rating Tools for Cities and Precincts

This chapter begins with a discussion of key literature pertaining to GHG accounting at the city scale. Several of the more prominent existing and proposed city-scale GHG methodologies, tools and inventories are identified and a brief description of the most recognised and utilised of these frameworks and initiatives is provided. This is followed by a summary of existing tools that target GHG emissions at the precinct scale. These frameworks and tools are examined in terms of their relevance and suitability for calculating precinct-scale emissions.

Chapter 6: Carbon Neutral Certification Schemes for the Built Environment

Chapter 6 investigates whether certification can lead to greater credibility in carbon claims, highlighting issues pertaining to the Australian Competition and Consumer Commission (ACCC). An overview of the organisational structures and key documents underpinning the certification industry is then provided, followed by a brief summary of several well-known existing Australian and international carbon certification schemes. Australia's National Carbon Offset Standard Carbon Neutral Program (NCOS-CNP) is identified as one of the leading independent certification schemes worldwide and is thus discussed in greater depth towards the end of this chapter. The chapter concludes by identifying and discussing several potential issues and challenges for urban development to achieve certification under this program.

Chapter 7: Framework and Guidelines for Certifying Carbon Neutral Urban Development

A new framework for calculating the emissions associated with precinct-scale development is proposed in this chapter, based on the carbon abatement opportunities identified in Chapter 2. Guidance is then provided on how to maintain carbon neutrality, or the desired carbon goal, within the context of urban development, in order to ensure carbon claims remain relevant and accurate. As the framework is largely based around the Australian National Carbon Offset Standard's (NCOS) Carbon Neutral program, this chapter addresses the unique issues and challenges identified in Chapter 6 that may prevent urban development from pursuing certification.

Chapter 8: Barriers, Benefits and Governance

The primary barriers preventing greater uptake of low carbon land development within cities are analysed in this chapter. Various opportunities are then highlighted which could assist in overcoming some of these barriers, many of which are underpinned by the need for a reliable system for determining eligibility for the incentives. A brief investigation is undertaken on whether certification could be used, not only as a way to acknowledge the carbon reduction potential of urban development, but also as a mechanism to determine a development's eligibility to receive incentives.

Chapter 9: Conclusions and Further Research

This final chapter presents a summary of the findings of this research, in a format that addresses the research questions posed at the beginning of the thesis. A discussion is provided on how the research undertaken contributes to improving our knowledge and understanding around urban development's potential to reduce emissions, and the importance of acknowledging the role of urban development in global decarbonisation. Recommendations on how this research can help to inform policy are presented, particularly around issues of implementation of a certification scheme for urban development. Ideas for future work are identified, which include how cities can be further engaged and encouraged to design and construct low carbon developments.

Chapter 2 - The Potential for Cities and Urban Development to Reduce Carbon

2 The Potential for Cities and Urban Development to Reduce Carbon

2.1 Introduction

This chapter aims to provide an understanding of the main GHGs associated with cities, based on their urban design and resource management infrastructure. It then examines the potential for reducing emissions at this level.

The chapter begins with an overview of the current GHG contribution from cities, which is discussed in relation to existing literature on the topic. Acknowledgement is given to variations in estimates, which differ depending on the approach adopted in measuring emissions. The discussion then focuses on why cities are fundamental in addressing climate change. Various aspects of city design and urban development are examined in terms of their impact on GHG emissions. These include urban form, transport, materials used in construction, and the various approaches for managing resources such as energy, water and waste. Decentralised approaches to resources management are compared to the centralised approaches that currently dominate our cities, as the smaller, decentralised scale appears to offer numerous efficiencies.

The concept of 'green infrastructure' is then examined, and used as an example of how to decarbonise cities and begin to close resource loops. Density and urban form are also highlighted as key factors in achieving this. Justification is given as to why the precinct level is increasingly being identified as the optimal level for decarbonising. The research undertaken in subsequent chapters focuses at this level.

2.2 Cities and Climate Change

2.2.1 Cities and their Greenhouse Gas Emissions

The broad contribution of urban areas[16] to global GHG emissions was outlined in Chapter 1. However, debate continues on their exact contribution (Dodman, 2009; Dhakal, 2010; Hoornweg, 2011; Satterthwaite, 2008; World Bank, 2010), with estimates varying between 40 per cent and 80 per cent based on how emissions are attributed or

[16] The terms 'cities' and 'urban areas' will be used interchangeably within this thesis.

apportioned to cities, for instance, whether a production- or consumption-based approach[17] is adopted. Other factors identified as contributing to the variation in city-based emissions include accounting methodologies, Scopes of emissions, emissions sources and how 'urban' is defined (Dhakal, 2010; UN Habitat, 2011).

Adopting a consumption-based approach towards calculating city emissions is useful for several reasons. It can improve understanding of the differences in emissions between regional towns, which often have a lot of primary industry and manufacturing, compared to larger cities with more people but fewer energy intensive industries (thus producing a lower per capita footprint). However, the latter cities often consume considerable amounts of the materials and services provided by the regional towns.

This issue is even more pronounced between countries, as a growing proportion of emission intensive industries are being outsourced to developing nations, to create products and material goods that are then imported and consumed within the developed countries (Satterthwaite, 2008). Therefore, allocating emissions based on what cities consume appears to provide a far more realistic and accurate picture. While this approach to carbon accounting is discussed widely by urban researchers, and is becoming increasingly accepted as the most useful approach, it has not yet really been translated or taken up by the policy-making community (Dhakal, 2010; Dhakal & Stretha, 2010). Indeed, most policy that targets carbon focuses on the front end of the economy, rather than the end user or consumer, as discussed in chapter one.

The single largest source of urban emissions, around 70 per cent, comes from the combustion of fossil fuels for energy use in buildings, transport, manufacturing and industry (IEA, 2008; UN Habitat, 2011). This is largely due to the 19th and 20th century fossil fuel-based energy technologies underpinning our cities (e.g., coal-fired power generation and oil for fuel used in transport), which together remain the biggest challenges for reducing emissions in cities.

Despite energy being the dominant source of emissions in most cities worldwide, the exact percentage of energy-related emissions varies between each city based on factors such as affluence, the economic base, climate and geography, population, density and urban form within a city (Dodman, 2009; Glaeser, 2011;

[17] Production-based approach captures emissions from the Front End of the economy (i.e. big polluters and energy intensive industries), while the consumption approach captures emissions as they enter the economy and are consumed by the End User.

Newman & Kenworthy, 1999; Roberts & Grimes, 1997; UN Habitat, 2011; Walker, 2006). Density and urban form are particularly important factors in determining emissions. Higher density urban form has been linked to lower GHG emissions, largely due to the reduced need for private transport, as well as greater efficiency in the operational energy of more compact buildings (Bartholomew & Ewing, 2009; Burgess, 2000; Ewing et al., 2008; Glaeser, 2008; Newman & Kenworthy, 1999; UN Habitat, 2011). Thus, many larger cities have been shown to have smaller average per capita carbon footprints than their country's national average (Dodman, 2009).

2.2.2 The Vulnerability of Cities to Climate Change Impacts

Cities are at great risk and are particularly vulnerable to the impacts of climate change. An increase in extreme weather events and new weather patterns is predicted, and this will have varying effects on cities, depending on their geographic locations. Some of the effects include an increase in precipitation, cyclones, flooding, glacial melt and thus sea level rise, as well as drought and extreme heat events (IPCC, 2007). These events will have significant social, economic and health impacts on cities, as well as severely affecting built infrastructure and urban management systems (Garnaut, 2008; Stern, 2006; UN Habitat, 2011). As the majority of our cities are based around large-scale infrastructure and management of resources (i.e. energy, water and waste systems), cities are particularly susceptible and vulnerable to climate change events, as disruptions to these systems affect extremely large areas of cities, and thus people (Greenpeace, 2005; CSIRO, 2009).

However, it is not only the resource management systems that will be affected by the increased frequency and intensity of storm events. The events are likely to cause significant damage to all sorts of infrastructure in cities, such as bridges, buildings, roads, subways and other transportation systems, in addition to sewer systems, transmission lines and mobile networks.

Heat events, which include extended periods of above average temperatures and which can lead to droughts and bushfires, are also expected to become more frequent in certain geographical areas (IPCC, 2007). Cities not designed to deal with these pressures can expect problems such as buckling of railway tracks, increased heat island effects, additional stress on power grids and more frequent power outages due to greater demand for air-conditioning, and higher levels of heat related mortality (Hennessy, 2011; UN Habitat, 2011).

The 2003 heatwave in Europe, Hurricane Katrina in New Orleans in 2005, the 2010 Pakistani floods, the 2010/11 Brisbane floods and Hurricane Sandy in North America in 2012 have all demonstrated how costly, both financially and in terms of human life, such weather events can be on cities, particularly in relation to large-scale infrastructure. Another significant risk to cities involves sea level rise. Around 13 per cent of the world's population currently resides in cities that are considered at risk of rising sea levels (UN Habitat, 2011). For some cities, adapting infrastructure to cope with this (e.g., building dykes, levees, sea walls and potentially moving buildings to comply with new planning regulations and building codes) will be costly and challenging. For many others, it may mean relocating. Climate refugees are expected to be one of the largest costs associated with climate change (Stern, 2006). Cities will need to be prepared to address this challenging, though less frequently discussed, and potentially costly issue (Garnaut, 2008).

2.2.3 Why Cities are Fundamental in Tackling Climate Change

Carbon has played an important role in the formation and reformation of cities for centuries. Cheap fossil fuels have been a driving force in the rapid expansion of cities and in shaping our urban form. It has enabled and facilitated the development of car-dependent suburbs and allowed houses to continually increase in size. The availability of cheap energy based on fossil fuels has meant little regard has been paid to things such as energy efficiency in buildings and other critical urban design features that were fundamental elements of older cities.

As a result, abundant carbon abatement opportunities are now being identified at this city level, particularly within the built environment (McKinsey & Company, 2010; The World Bank, 2010; UN Habitat, 2011). Consequently, cities and their built form are now identified as a "vital part of the global response to climate change" (Broto & Bulkeley, 2013, p.92).

Furthermore, a popular graph developed by McKinsey & Company (2010), (A Global Greenhouse Gas Abatement Cost Curve - see Figure 2.1), demonstrates how many of the global carbon abatement opportunities can be made on a cost neutral or positive basis; that is, the measures will have an immediate net financial benefit on the economy over their lifecycle. Most of these measures are from within the built environment. Other analyses show how longer term economic gains can be made from more fundamental shifts towards redevelopment in a more compact city (Trubka et al., 2010a,b,c).

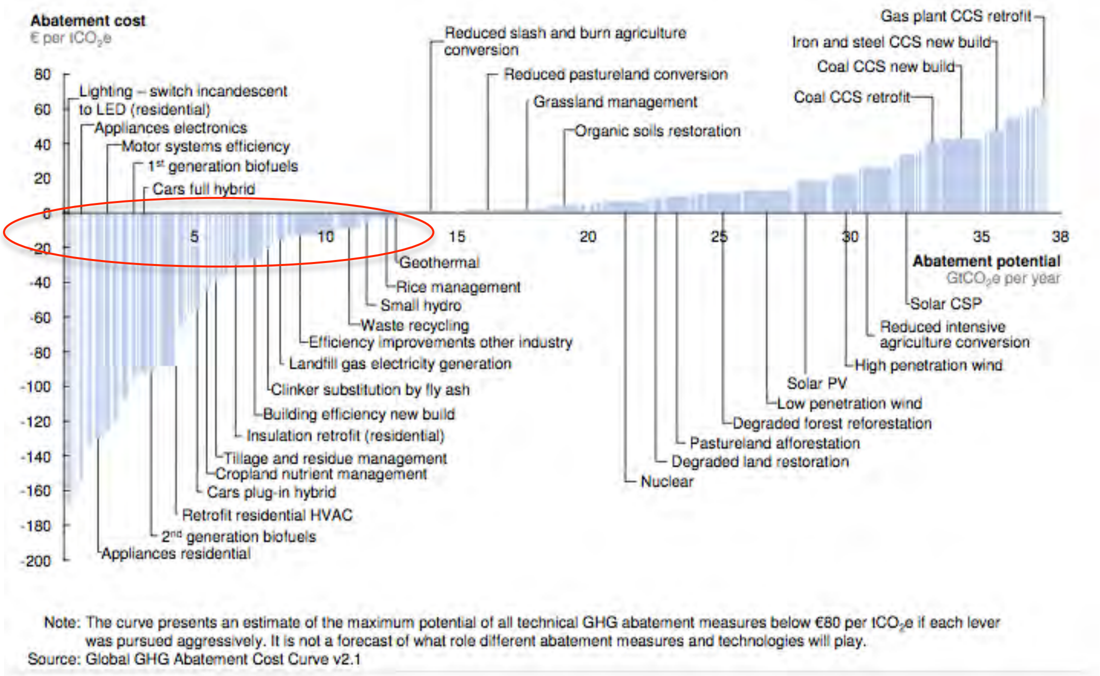

Figure 2.1. Impact on the financial crisis on carbon economies: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve. Source: McKinsey and Company (2010) [Reprinted with permission]

Fortunately, cities are well positioned to be able to take action and create change at the local level, particularly in response to climate change and other environmental issues. Being the closest level to the public, cities and local governments have greater capacity to make quick decisions because of the 'more immediate and effective communication' between citizens and local decision-makers, compared to higher levels of government (World Bank, 2010). This is critical, as the effects of environmental problems often directly impact cities, demonstrating the need for them to be more pragmatic and swift in their response. As a result, cities have in many cases been leading national governments and international agendas in terms of climate change mitigation and action (Bulkeley et al., 2011; Roseland, 2012; UN Habitat, 2011).

The dynamic and progressive nature of cities, due to their agglomeration economies, also makes them 'powerhouses' of social, environmental and technological innovation and change (Glaeser, 2011; Hollis, 2013; Trubka et al., 2010b). Cities are able to foster innovation through proximity and density, which allow the rapid transfer, exchange and development of ideas and knowledge within a small geographical area. Clusters of innovation can learn from each other, and this innovation has resulted in massive leaps in efficiency and reductions in the carbon intensity of urban systems, and has provided solutions to many environmental problems over the years (Brugmann, 2010; Glaeser, 2011; UN Habitat, 2011). Acting on climate change at the city level also helps to drive economic competitiveness through increased operational efficiency and investment in new technologies (Brugmann, 2010; Sassen, 1994).

Proximity and density are also the key to facilitating better public transport infrastructure and decentralised urban resource management options such as co- and tri-generation, as well as providing more efficient and compact housing options (CSIRO, 2009; Dodman, 2009; Glaeser, 2011; Newman & Kenworthy, 1999; Rauland & Newman, 2011). These aspects of a city (e.g., housing types, transport modes and energy, water and waste infrastructure) are all part of a city's built environment and create its urban form, which ultimately determines its resource consumption patterns and the greenhouse gas emissions associated with it (Ewing et al., 2008; Glaeser, 2011; Newton, 2012; Roseland, 2012). These sources of emissions are discussed later in this chapter.

2.3 GHGs and the Built Environment – An Australian Perspective

Australia currently has one of the largest per capita carbon and ecological footprints in the world (Garnaut, 2008; Global Footprint Network, 2010). The high carbon emissions are largely a result of the country's overall management of resources, primarily from stationary energy generation, as well as the excessive consumption patterns (Australian Conservation Foundation, 2007; Newton & Meyer 2012) and the current urban form of Australian cities (Droege, 2006; Garnaut, 2008; Newman & Kenworthy, 2011a; Newton 2008).

2.3.1 Urban Form

Urban form is shaped by transport. Newman and Kenworthy (1999) show how the Walking City with its dense, mixed urban form was based on the ability to walk everywhere in a one hour travel time budget. This was added to by the Transit City of the 19th century where corridors were developed around transit lines based on the same travel time budget. Since the mid twentieth century the Automobile City has spread out beyond the 5km Walking City and the 20 km Transit City to being over 50 km wide. Australian cities have a high proportion of Automobile City areas that are characterised by large, detached, single-family houses situated in low-density, dispersed suburbs

(Department of Sustainability, Environment, Water, Population and Communities [DSEWPC], 2010; Newman & Kenworthy 1999; Newton, 2008). Vast amounts of resources, including energy, water and raw materials, are required to sustain these low-density suburban environments. Many studies have demonstrated that higher carbon emissions are associated with low-density, sprawled settlements, compared to higher density, more compact urban form, largely due to electricity consumption and transport emissions (Bartholomew & Ewing, 2012; Dodman 2009; Fuller & Crawford, 2011; Glaeser, 2008; Glaeser, 2011; Glaeser & Kahn, 2008; Newman, 2013; Newman & Kenworthy, 1999; Newton, 1997; Newton, 2012; Roseland, 2005).

Glaeser and Kahn (2008) found that suburban houses consume up to 88 per cent more electricity than inner city apartments. This is due to several factors. Firstly, suburban houses, which are predominately stand-alone, detached structures, are less thermally efficient than compact, denser dwellings, which benefit from having shared walls (Ewing et al., 2008; Pitt, 2010). Suburban houses are also generally significantly larger than their urban counterparts, thereby requiring significantly more energy for heating and cooling as well as the running of additional appliances (Kahn & Glaeser 2010, Ewing et al 2008). This is particularly the case for Australia, where new suburban houses have already doubled in size since the 1950s, making them among the largest in the world (Hamilton, 2002; Kelly, 2010).

Despite improvements in energy efficiency of buildings over the years, research in Australia has shown that per capita energy consumption continues to rise in line with increasing house size (Newton & Meyer, 2012). This is being compounded by decreasing occupancy per dwelling, thereby intensifying the need for a greater number of large houses to sustain Australia's growing population (DCCEE, 2010; Fuller & Crawford, 2011).

Despite cities putting greater focus on infill development, single detached houses built on the fringe still remain the dominant type of new residential development in most of Australia's major cities (Australian Bureau of Statistics (ABS), 2012; DSEWPC, 2010; Newton, 2011). Sydney is an exception where infill redevelopment is now much more prevalent than new greenfields development indicating that the limits to the growth of the Automobile City may have been reached, as in many other large US cities (Newman & Kenworthy, 2011b). Interestingly, recent studies have shown that greenfields development costs significantly more than infill development when all the additional infrastructure costs are taken into account (Trubka et al., 2010a,b,c; Roseland 2005). However, these costs are not often taken into account or captured within the price of the land and houses. This type of development is also extremely land intensive, and often replaces prime agricultural land or natural, biologically rich areas.

Finally, the embodied energy, or the emissions associated with the materials used in construction, is also greater for larger dwellings. While embodied energy is often excluded from discussions on the emissions contribution of buildings or the built environment, a growing body of research is highlighting the importance of it (see Crawford & Treloar, 2005; Sturgis & Roberts, 2010). This is discussed further in section 2.3.3.

2.3.2 Transport

Location and type of housing is another major factor contributing to the greenhouse gas emissions associated with our cities (Fuller & Crawford, 2011; Glaeser, 2010; Kahn & Glaeser, 2008; Newman & Kenworthy, 1999; Newman et al., 2009; Naess, 1995; Newton, 1997). The low-density design of Australian cities, like many modern cities around the world, has meant they are overwhelmingly car dependent, thus contributing significantly to transport greenhouse gas emissions. Road transport currently accounts for 87 per cent of Australia's transport emissions with the majority attributed to passenger vehicles (DCCEE, 2009).

Extensive research has demonstrated the correlation between density and transport emissions (see Figure 2.2), showing that as density increases in cities transport emissions decrease due to a decline in car dependency (Kenworthy, 2013 personal communication with new data; Newman & Kenworthy, 1999). This is because public transport uses considerably less energy per person than private vehicles, and public transport is generally only economically viable where sufficient density exists.

While climate change mitigation is an important reason to address Australia's car dependence and ensuing emissions, it is not the only motivation for addressing the issue. Increasing traffic congestion in most major cities, together with rapidly rising fuel prices, are two additional problems that are making the cost of living for all Australians increasingly unsustainable.

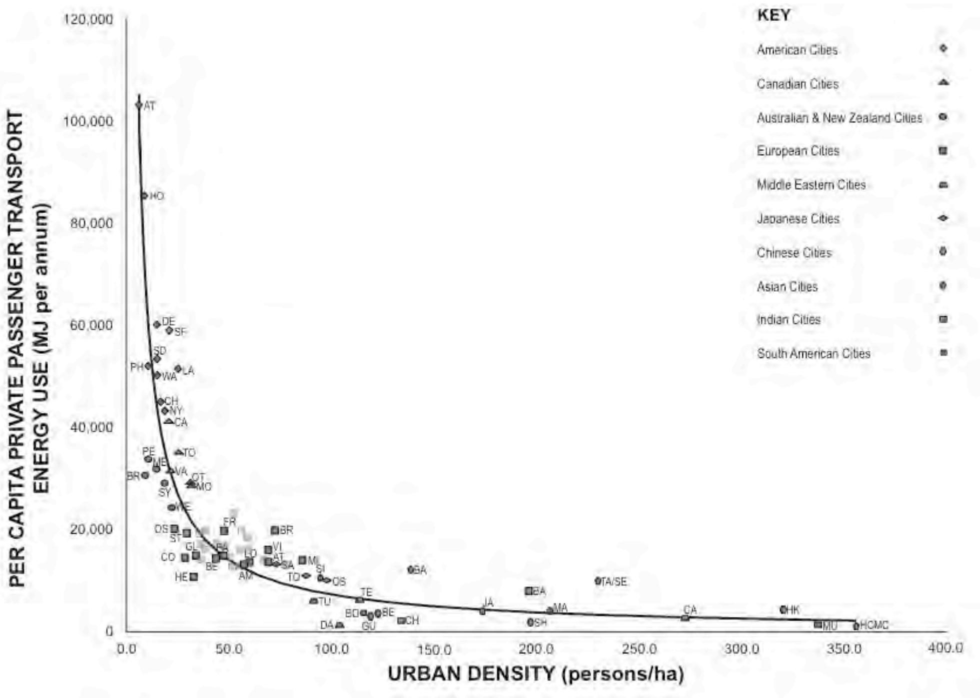

Figure 2.2. 1995 Per Capita Transport Energy and Urban Density.
Source: Kenworthy & Laube (2001)

The economic issues associated with automobile dependence are becoming increasingly clear. An influential report released in 2006 identified the most vulnerable suburbs in Australia's major cities in what was termed the VAMPIRE index, which stood for "vulnerability assessment for mortgage, petrol and inflation risks and expenditure" (Dodson & Sipe, 2006). The study examined the effect that rising mortgages, oil prices and inflation has on people living in different areas within cities. The results showed that lower socio-economic outer suburbs are far more car dependent than inner and middle suburbs, and thus are significantly more vulnerable to oil price increases, which is compounded by rising mortgages (Dodson & Sipe, 2006). When the GFC occurred, this exact situation happened and many vulnerable to the rise in fuel prices could not pay their mortgages - a situation that was much more marked in the US (Newman & Kenworthy, 2011). Australia's car-dependency, particularly in these outer suburbs, is now identified as a key public concern and is becoming an increasingly critical national issue (Department of Infrastructure and Transport, 2011).

Improving Transport

Ensuring that urban development is designed around, or has sufficient access to, affordable public transport options such as rail (light and heavy) and buses, and that adequate infrastructure is in place to encourage cycling and walking can dramatically reduce the emissions associated with transport in our cities (Newman, Glazebrook & Kenworthy, 2013; Matan & Newman, 2012). Encouraging car share schemes to operate within urban areas can also help to reduce car ownership and subsequent vehicle kilometres travelled (VKT) (PMSEIC 2010).[18]

2.3.3 Materials and Construction

The embodied energy[19] (EE) and subsequent emissions associated with buildings over their lifetime have been estimated to range from as low as five per cent to as high as 62 per cent of a building's total emissions (Cabeza et al., 2013; Sturgis & Roberts 2010; Thormark, 2006). While there are many reasons for this range[20], research is showing that the proportion of EE in buildings is increasing as a result of energy efficiency improvements in buildings and the amount of renewable energy used in a building's operation (Cabeza et al., 2013; Dixit et al., 2012). Sturgis and Roberts (2010) note that the proportion of EE compared to operational energy has been shifting from a general 20:80 ratio to a 40:60 ratio due to these improvements and energy switching and may approach 100 per cent when new policies, such as the UK's zero emissions housing policy, come into force.

While the percentage may be increasing due to the aforementioned reasons, there are also many opportunities to reduce EE in materials, which are discussed below.

Types of materials

The EE of building materials can vary greatly depending on whether materials are new, reused or recycled (see Thormark, 2006), where they are sourced, i.e. locally, regionally or internationally (affecting transport emissions), and the type of material used (e.g., wood versus concrete). A study by Preservation Green Lab (2011) investigated the differences in the carbon associated with demolition and new construction versus retrofitting/renovating and reusing buildings. It found that

[18] VKT is a common metric for understanding and comparing emissions from transport.

[19] Most studies use the term 'embodied energy' as opposed to 'embodied emissions' as energy has been the typical focus to date. As energy largely correlates with emissions, the term energy is used interchangeably and as a proxy for emissions within this section.

[20] What constitutes 'embodied energy' is currently not well defined or universally agreed upon in existing research. Most studies concur that embodied energy includes the energy associated with the production process of building materials, including the extraction and processing of raw materials, manufacturing and transport (Cabeza et al., 2013). However, others suggest EE also includes the onsite construction and demolition processes associated with buildings and final disposal of materials (Dixit et al., 2012). The differences in system boundaries can have a significant effect on the percentage of emissions attributed to EE of buildings.

"building reuse almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality" (Preservation Green Lab 2011: vi). This is an important though perhaps rarely considered factor when dealing with carbon in the built environment.

Thormark (2006) and Cabeza et al (2013) both discuss the effect choice of materials has on the embodied carbon associated with buildings, demonstrating that numerous options now exist for materials with a lower EE component. Buchanan and Levine (1999) argue that low emission construction materials such as wood can be substituted for more emission intensive materials such as aluminium and concrete.

Lehmann (2013) highlights the emission abatement potential of using low carbon, pre-fabricated timber panels to construct residential buildings of up to 10-storeys within an urban infill setting. This method not only cuts GHG emissions considerably through its design and construction, but can also have a significant impact on reducing the costs associated with construction, which can increase the affordability of such apartments (Lehmann 2013). Lu Aye et al (2012) also identifies emission savings from the use of prefabricated building modules, particularly when they are designed for reuse.

There are also many new ways of reducing the carbon associated with traditionally energy intensive materials, such as concrete and bricks, by supplementing them with industrial bi-products such as fly ash (Cabeza et al., 2013). Furthermore, if energy intensive materials are made using renewable or carbon free sources or energy, this could also reduce their embodied energy.[21]

The issue around choice of products or materials with lower EE is not only relevant to buildings but can be applied to a range of infrastructure projects within the built environment, including roads, pipes, and bridges.

Improved Operational Performance of Buildings

As the energy performance of buildings improves, due to more efficient design, better insulation and more energy efficient equipment and appliances, EE becomes an increasingly important aspect to consider in terms of the building's overall carbon footprint (Cabeza et al., 2013). The more operationally energy efficient a building is, the larger the embodied energy component becomes, and the more important it is to

[21] However, Dixit et al (2012) raise the question of whether this is a reliable way of measuring EE.

address in order to prevent 'excess negative environmental impacts' (Sturgis and Roberts 2010: 09).

It is worth noting, however, that the increase in operational efficiency can come at a cost to EE as materials with higher EE, such as concrete, often provide greater thermal efficiencies (Thormark 2006). It is therefore important to consider both aspects of a building's carbon emissions (i.e. EE and operational energy) in order to determine the optimal scenario for reducing a building's emissions over its full life cycle.

As EE increases in importance, new software and online tools are emerging[22], which can compare the GHG's associated with different construction materials, providing developers with a quick and robust GHG analysis to help guide decisions.

2.3.4 The Role of Energy Efficiency

Twenty three per cent of Australia's greenhouse gas emissions have been directly attributed to the built environment based on the energy consumed within buildings (Australian Sustainable Built Environment Council [ASBEC], 2008; Garnaut, 2008). Fortunately, studies have revealed that this sector also has some of the most cost effective GHG reductions available within the economy (Climate Works Australia, 2010; McKinsey & Company 2008).

A report by the CIE (2007) demonstrated that energy efficiency undertaken within the building sector could reduce GHG emissions by 30-35 per cent by 2050, even while accommodating new buildings, which they estimate has the potential to reduce the overall cost per tonne of abatement by 14 per cent.

Some of the vast energy efficiency opportunities within the building sector include improvements to air conditioning in both residential and commercial buildings, residential water heating, insulation, lighting and energy efficient appliances which have standby features (McKinsey & Company, 2008). Retrofitting these measures will always cost more than installing them up front, so they should always be considered a fundamental element in every new low carbon development.

2.3.5 Resource Management

Australia's high per capita urban footprints are not only a matter of excessive consumption patterns, but also the way resources are produced and managed.

[22] See, for example, eTOOL- http://etool.net.au/.

Australian cities, again like many other cities around the world, are managed by large-scale, centralised infrastructure and systems, many of which use antiquated technologies.

The following is a brief examination of the current management of energy, water and waste, and the emissions associated with these sectors.

Electricity Production

Stationary energy production is responsible for around 60 per cent of Australia's total emissions (DIICCSRTE, 2013a).[23] Over 90 per cent of Australia's electricity is currently supplied through centralised, coal-fired power generation based on a system designed in 1940s (CSIRO, 2009; Garnaut, 2008; Greenpeace, 2005). There were initially several advantages of this energy supply model, including the efficiencies gained from using larger economies of scale, the reduction in transport emissions from having power stations located closer to their fuel source (i.e. coal mines), and the relative ease in transporting the energy to cities through large transmission and distribution lines (CSIRO, 2009). However, there are now many issues making this large, centralised model increasingly unsustainable, impractical and a far less appealing option.

It is important to note that coal-fired power generation, which remains the dominant source of energy generation globally, was developed during a time when widespread concern around human induced climate change did not exist. As the science advanced and our understanding grew, it became evident that not only was this power generation extremely damaging to our global environment but it has been, and remains, the primary cause of climate change worldwide and a significant challenge for global climate change mitigation (IPCC, 2007).

Coal-fired power generation is particularly carbon intensive for several reasons. To begin with, coal is a particularly dirty fossil fuel when combusted, producing significant emissions. However, the main reason for the significant emissions associated with coal is to do with energy output. Coal-fired power generation is a remarkable inefficient process, whereby around two-thirds of the energy produced during this process (i.e. thermal energy used to spin turbines) is rejected and emitted as steam into the atmosphere. Further losses then occur, as the electricity is transported vast distances to where it is ultimately consumed within cities. These transmission and distribution (T&D) losses are a result of electricity changing form, usually converted from high to

[23] This amount includes fugitive emissions, representing 7.5 per cent of the total energy sector emissions.

low voltage as it nears the end consumer. Around seven per cent of the energy is lost through this process (Dunstan, 2010). Figure 2.3 illustrates the various transformations electricity goes through before it can be used by appliances within households.

Figure 2.3. A Simplified View of Electricity Generation and Transfer.
Source: CSIRO (2009, p. 69)

As a result of these combined losses, coal-fired power generation is only around 33-35 per cent efficient (Graus et al., 2007; Greenpeace, 2005; Onovwiona, 2006). A substantial amount of coal is, therefore, required to generate relatively little energy output. Power stations running on natural gas are slightly more efficient (45 per cent efficiency) and are less emission intensive as gas is a cleaner burning fuel (Graus et al., 2007). However, the process still discards more than half of the energy produced.

Adding to the resource-intensiveness of this type of generation process is the amount of water required. Electricity generation in Australia is currently responsible for approximately 1.4 per cent of the nation's water consumption, primarily for producing steam (PMSEIC, 2010; Smart & Aspinall, 2009). The unreliable nature of Australia's water supply (exacerbated by climate change) is resulting in a leniency towards energy-intensive desalination plants as dependable sources of water. If these trends are any indication of Australia's future water management pathway, the emissions connected to electricity generation (if current technologies prevail) will increase substantially in the future. This relationship between energy and water is discussed further later.

Alternative Approaches for Electricity Generation

There are various alternative energy technologies, which can supply cities with less emission-intensive forms of electricity, many of which are from small-scale, distributed energy systems. Solar photovoltaic, solar hot water and small-scale wind are some examples of renewable technologies servicing the individual household or building level, often referred to as micro-generation or distributed generation (Tan et al., 2013).

Options for larger scale and base load carbon-free energy include technologies such as solar thermal, large-scale wind power and geothermal energy. Intermittency in supply is an obvious issue facing these technologies, though many new storage options are becoming available (Beaudin et al., 2010; Evans et al., 2009; Steffen & Weber, 2013). Another increasingly popular option[24] for providing low carbon, base load energy at a district or precinct scale within cities is co- and tri-generation. While co- and tri-generation can run on bioenergy sources[25], thereby making them carbon free, currently the technology predominantly uses natural gas, which is still a far cleaner burning fuel than coal, enabling the electricity to be generated within the city without local air pollution.

Co-generation, also known as CHP (combined heat and power), captures the thermal heat energy produced during electricity generation and uses it to provide heating for neighbouring buildings and/or industrial processes. Tri-generation or CCHP (combined cooling, heat and power) adds an absorption chiller to the process to also turn the heat energy into coolth, thereby supplying air conditioning as well (City of Sydney, 2010; Greenpeace, 2005; Jones, 2008). Furthermore, as electricity can be generated at, or close to, the point of consumption (i.e. in urban areas), the transmission and distribution losses associated with the generation are drastically reduced.

As a result of these combined efficiencies (i.e. electricity generation, heating and cooling and reduction in transmissions losses), this energy generation process achieves around 75 per cent efficiency - far greater than large-scale coal-fired generation (City of Sydney, 2010; Ge et al., 2009; Greenpeace, 2005). Furthermore, as heating and cooling represent between approximately 30 and 40 per cent of the total energy needs in buildings in Australia (CIE, 2007) and just over 50 per cent globally (WBCSD, 2009),

[24] The Borough of Woking, City of London and City of Sydney have all implemented this technology (or, in Sydney's case, are in the process of installing) as a way to reduce emissions.
[25] Locally produced Biomass (i.e. waste from agriculture) and organic municipal waste can be used to create synthetic gas (or syn-gas), which would provide a carbon free source of electricity.

significant potential exists for co- and tri-generation to supply much of this demand, which would drastically cut emissions.

Although co- and tri-generation can in theory work at the micro scale (Pehnt, 2008), it is generally only economically viable where there is sufficient building density, and ideally mixed land use, to provide these additional services to (Jaccard et al., 1997; Naess, 1995). Therefore, in the Australian context, it may mean a shift in urban form from low-density, dispersed neighbourhoods to higher density activity centres, in order to facilitate the application of this transformative technology.

A report released by CSIRO (2009) identified co- and tri-generation, based on natural gas or biomass, as being the most cost effective, low carbon distributed energy supply option for Australia.

Smartgrids

A Smart Grid refers to an electricity network that operates much more efficiently than current grids by adopting and integrating information and communication technology (ICT) together with power control devices in appliances that are able to 'talk' to the grid, in order to manage loads more efficiently (PMSEIC 2010). A smart grid provides real-time information on energy costs to encourage end-user efficiency and better user-load management based on price signals.

An important aspect of a smart grid is that it also allows electricity to flow both ways. Enabling the two-way flow of energy will be fundamental to integrating more renewables and decentralised technologies into the grid, and thus being able to better balance intermittent supply with demand (Wissner, 2011).

Smart grids will also be essential to enable the storage of electricity. Went et al (2008) discusses the concept of renewable transport using vehicle-to-grid (V2G) technology, with plug-in hybrid electric vehicles (PHEVs) as a way to store intermittent renewable energy. This form of storage can provide greater opportunities for increased supply of renewables into the system, essentially allowing large-scale renewable energy sources, such as wind power, to provide base load power (Went et al., 2008). EVs combined with smart grids can thus provide a very intelligent solution to current problems with balancing electricity on the grid, particularly around renewable energy integration, as well as potentially providing carbon free transport. However, in the absence of a smart grid, the increasing adoption of EVs into the market is likely to pose a significant problem as EVs will increase the demand on the current grid system, most likely at peak times (i.e. when people get home from work and start charging EVs).

Water Management

Just as electricity generation is dependent on water, so too is the management of water dependent on energy. As a result, significant greenhouse gas emissions are attributed to the water sector (Rothhausen, 2011). Energy is required throughout the water cycle, from production (i.e. sourcing and treating) through to final disposal. The interdependence between the two systems is often referred to as the 'energy-water nexus', and is becoming an increasingly critical issue due to the 'positive feedback' loops that are leading to growing vulnerabilities within both systems (Kenway et al., 2008; PMSEIC, 2010; Rothhausen, 2011; Siddiqi, 2011).

The predicted increase in variability of rainfall due to climate change, for instance, is leading to greater demand for more reliable sources of water than current water supplies such as dams and reservoirs. Desalination and wastewater recycling plants are two options that can provide a more dependable supply of water, though both are considerably more energy-intensive (Medeazza, 2007). This means a greater proportion of greenhouse gas emissions are, and will continue to be, attributable to the water supply, which in turn further exacerbates climate change. Moreover, as the current production of energy requires significant amounts of water, the increase in energy generation will increase demand for water, which ultimately competes with other urban water needs within our cities (Kenway et al., 2008).

These issues, together with the increasing cost of carbon, are creating concern for the long-term viability of the two systems. Nevertheless, many opportunities and synergies exists that, if integrated in a more holistic way, could increase the resilience of the systems (PMSEIC, 2010). Furthermore, if greater focus is given to ensuring that water is only treated to the standard required for use[26], significant energy-related emissions reductions could be achieved (Chanan et al., 2009).

[26] The percentage of water actually used for potable purposes in urban areas amounts to less than 15 per cent (Chanan et al., 2009) suggesting that much of this initial treatment process is unnecessary.

Urban Water System

There are various components of the urban water system, which contribute to greenhouse gas emissions. Griffith-Sattenpiel and Wilson (2009) depict the full water cycle as consisting of five stages, all of which require energy (see Figure 2.4).

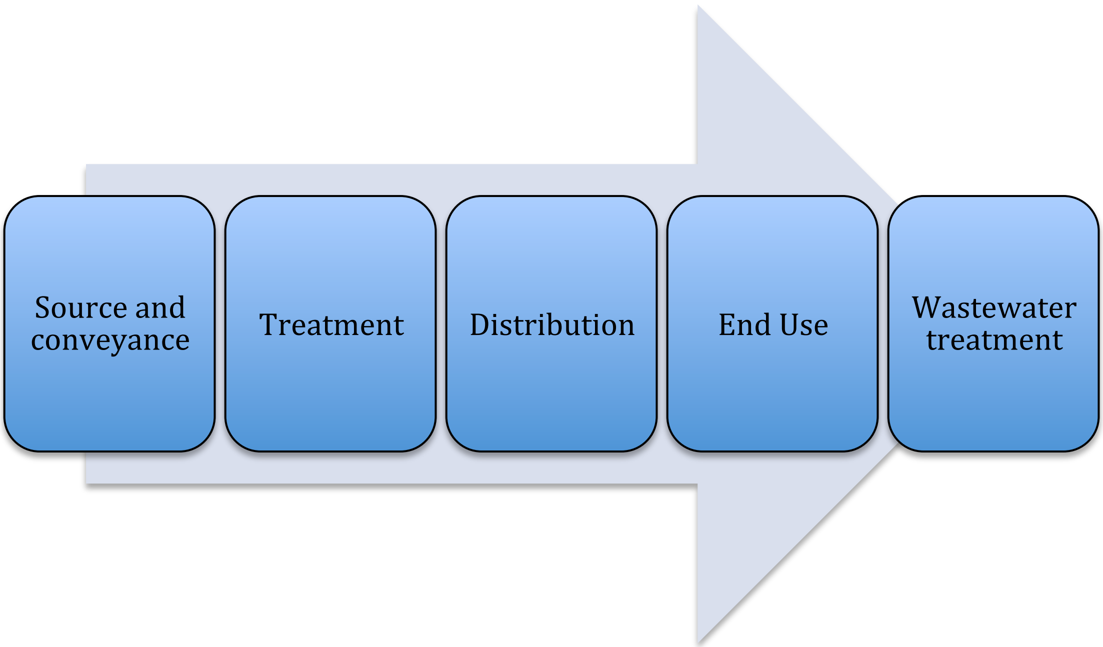

Figure 2.4. Stages of the Water Cycle. Source: Adapted from Griffiths-Satternspiel (2009)

Emissions within the water sector are generated from the production or sourcing of water (i.e. abstraction), the treatment process, distribution (i.e. pumping water to where it is consumed), wastewater treatment and final disposal.

In Australia, this process is primarily managed using a centralised system, whereby water is generally sourced in bulk from a central location, treated to drinking standard, pumped significant distances to where it is consumed, discharged, and treated again before final disposal, which is typically into rivers and/or out at sea. While the emissions associated with this process are significant, they can vary considerably depending on a range of factors such as topography, location, the water source and treatment method chosen, the level of treatment required (both for water supply and wastewater) and existing infrastructure, i.e. pipe dimensions and design (Kenway et al., 2008). Below is a discussion of the key emission sources associated with various aspects of the water cycle.

Dams and Reservoirs

Approximately 80 per cent of Australia's potable water is currently sourced from dams and reservoirs that use river catchment areas to collect surface water run off (ABS, 2007). This supply option requires the least amount of operational energy (providing it is gravity fed) due to the relatively little treatment required. However, there can be significant embodied emissions associated with the initial construction of reservoirs (i.e. dam walls), as well as the water distribution network, i.e. pipelines (Kenway et al., 2008; Reffold, 2008). Furthermore, the initial flooding of large tracts of land in the process of creating a water catchment can produce significant methane emissions as the organic material (i.e. soil and plants) decomposes under water (Hall, 2009).

Regardless of the benefits or limitations of reservoir/dam storage or river abstraction, the current and predicted declining rainfall patterns in Australia are making this option less attractive, and in many cases, unviable (ABS, 2007).

Groundwater

The second largest water supply option (around one fifth of Australia's water) comes from ground water (ABS, 2007). This is another comparatively low energy water supply option, again due to the minimal treatment required to bring water quality to potable standard. However, the emissions associated with this supply option are likely to increase in the future, as increasing energy is required for pumps to extract water from deeper boreholes as water tables decline.[27] Moreover, since groundwater supplies rely on adequate rainfall to replenish aquifers, which again is decreasing due to climate variability, this option is also likely to become less attractive for water utilities and unsustainable in the long term.[28]

Desalination

Desalination plants, which convert seawater into potable water for urban use, are becoming an increasingly popular alternative for water utilities that are searching for a culturally acceptable[29] and dependable source of water. Desalination, however, is considerably more energy- and therefore emission-intensive than traditional water

[27] Assuming energy is produced using fossil fuels.
[28] There are several trials being run in Australia looking at Managed Aquifer Recharge (MAR) to replenish ground water supplies. See Bekele et al (2013).
[29] Compared to reusing wastewater. Fullerton (2001) highlights the difficulty in attaining public acceptance of re-using wastewater.

supply options and has some additional environmental impacts associated with this process that are causing some concern (Medeazza, 2007).

Desalination is at present around four times more energy intensive as conventional sources of water (PMSEIC, 2010). If the energy used in the desalination process is sourced from fossil fuels, significant additional emissions can be expected. PMSEIC (2010) note that if all urban water in Australia were sourced from desalination plants, which draw energy from the national electricity grid, national emissions could be expected to rise by around 7.2 $MtCO_2$-e/y or 1.3 per cent (2010, p. 41). However, this could be mitigated if desalination plants source their power from renewable energy as has happened in Perth where 55 per cent of the city's water supply now comes from desalination. This is a good example of a city not only adapting to climate change (rainfall reductions have been ascribed to climate change for over a decade) but contributing to mitigation through its urban water policy (Stocker et al., 2012).

Wastewater Treatment

Significant emissions are associated with the treatment of wastewater due to the energy required during the treatment process and the methane produced from the decomposition of nutrient-rich organic matter. Research conducted by Kenway et al (2008), demonstrated that each time an additional wastewater treatment process was undertaken (i.e. from primary to secondary and secondary to tertiary), the energy requirement doubled, along with the associated emissions. This could be seen as a deterrent for utilising wastewater as a source of water supply in urban areas due to the high energy demand required for treatment. However, for cities that already require tertiary treatment of water before disposal (e.g., Melbourne), the additional treatment required to bring the water to potable standard is relatively minor compared with the treatment process already undertaken (Kenway et al., 2008).

Bi-products from treated effluent, which include biogas and biomass, could also be combusted to produce energy, which could be used onsite in the treatment process, thereby reducing demand for emission intensive grid electricity. In fact, Ainger et al (2009) suggest that the water sector could become carbon neutral in the future "by a careful balancing of generation from waste (methane in particular), generation from renewables and the management of its demand patterns" (2009, p. 12).

The high nutrient load in domestic wastewater offers great opportunities for nutrient recovery. Bi-products such as phosphate, nitrogen and ammonia can be extracted and used as natural fertilisers for agriculture, thereby helping to close resource loops (Giradet, 2004; Kenway et al., 2008; Newman & Jennings, 2008; van Lier & Lettiga, 1999). Installing third pipe systems in urban developments will enable the separation of black water from grey water, which will reduce the energy required in both treatment processes (Kenway et al., 2008).

Distribution

The other key contributor to greenhouse gas emissions on the supply side is the pumping and distribution of water through the centralised network within our cities. In some cases, water pumping and distribution can be responsible for the majority of a water utility's greenhouse gas emissions (see Figure 2.5) for example, where water needs to flow against gravity (Hall, 2009; Kenway et al., 2008).

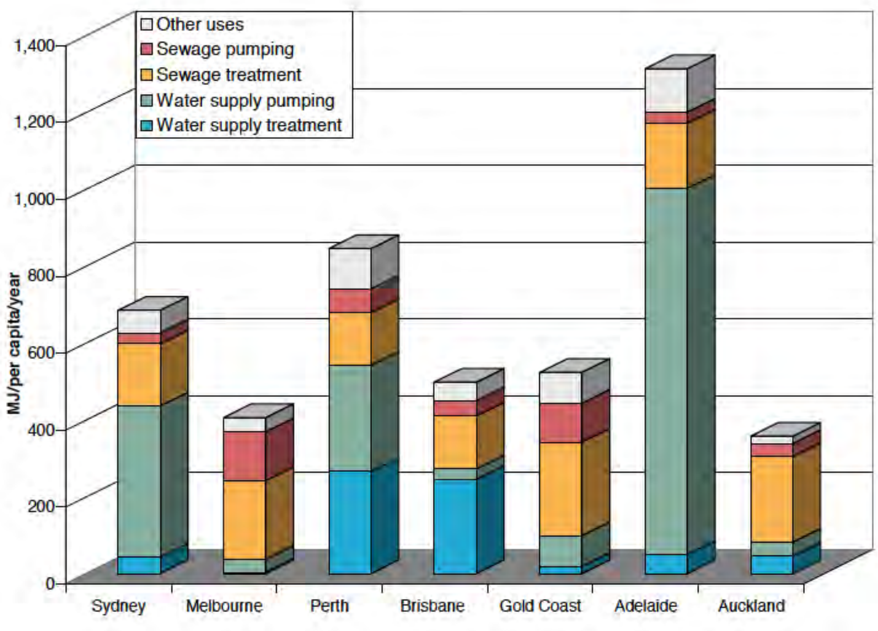

Figure 2.5. Energy Use for Water and Waste Services 2006/07. Source: Kenway et al. (2008)

End Use Water Emissions

End use emissions are generated primarily from the energy used for heating and cooling water in homes and commercial buildings (e.g., for showers, dishwashers, washing machines and kettles). Water efficiency measures and appliances that can reduce the amount of water consumed will directly reduce the amount of energy required to heat the water. Efficient hot water supply systems such as solar or gas hot water systems can also dramatically reduce emissions associated with end-use water. It is worth noting, however, that the emissions associated with energy in buildings, despite it being connected to water use, are captured within the energy sector's GHG accounting.

Improved demand side management (e.g., rainwater harvesting at the building scale), can also help to reduce consumption and therefore reduce emissions associated with supply.

Water and Urban Design

Research suggests there is significant potential for improving water management within cities by adopting a more decentralised approach that can promote greater integration of processes, help to close loops and increase the sustainability of the system (Newman & Jennings, 2008). Chanan et al (2009) refer to this decentralised approach as a 'soft path' for water management, one that promotes greater integration of demand side (i.e. end-user efficiency) and supply side initiatives. The supply side, involves sourcing, treating and managing water at a much more local level. This includes dramatically increasing rainwater harvesting and stormwater retention within cities, i.e., capturing stormwater runoff from rooftops and other impervious surfaces and treating it to the appropriate level to which it will be used, rather than allowing it to flow into the sewer system where it must then undergo an energy intensive treatment process.

Water sensitive urban design using natural and biological systems, such as swales and buffers to collect and filter stormwater on the edge of roads, can be implemented throughout cities as a natural method for basic treatment of water. Hatt et al (2006) notes, "The average annual volume of urban stormwater runoff in Australian cities is almost equal to the average annual urban water usage, of which at least 50 per cent is for non-potable use" (p.103). Considering most water in cities is used for non-drinking purposes (Chanan et al., 2009), there are significant opportunities to use this recycled water, which could dramatically reduce the amount of scheme water required in cities.

Managing these processes at the local level minimises the transport and distribution associated with large-scale delivery and treatment of water in cities. If the above-mentioned processes are utilised, emissions from water management can be dramatically reduced, and greater water security achieved by providing cities and communities with a reliable source of water suitable for a variety of different end uses, without the need for additional desalination plants.

Nevertheless, several barriers and limitations currently prevent greater adoption of the abovementioned options, particularly recycled water. These include: strict health regulations imposed by departments of health; public attitudes to recycled water, and high costs associated with wastewater treatment plants.

Waste Management

The amount of solid waste produced in Australia is currently around 44 megatonnes per annum, which represents around 11 MT GHG emissions (Department of the Environment, Water, Heritage and the Arts, 2010a). The volume of solid waste has doubled over the past 20 years and is growing by approximately seven per cent per year (Department of the Environment, Water, Heritage and the Arts, 2010b).

Around half of the materials and products that enter Australian cities exit as waste and are buried in landfill (DEWHA, 2010b). This is one of the oldest and most inefficient forms of waste management. It is also particularly emission intensive, as methane (CH_4) is produced by the anaerobic decomposition of organic materials, which occurs for decades after initial waste disposal (Lou & Nair, 2009). Methane has a considerably larger impact on climate change than carbon dioxide. There are also many issues surrounding toxic leaching (Ikehata & Liu, 2011), particularly into groundwater.

Further emissions are associated with the collection and transportation of waste from cities to landfill sites, which are generally situated outside of cities. This process, therefore, also requires substantial tracts of land, which can remain contaminated and unusable for years after (Ikehata & Liu, 2011).

Other forms of waste management that produce fewer emissions include waste to energy through incineration and various forms of gasification (Mountouris et al., 2006). However, there are countless options for managing solid waste, which produce varying amounts of GHG emissions depending on the technique adopted. The emissions associated with different treatment strategies have been reviewed in academic literature (Chen & Lin, 2008; Dulal & Akbar, 2013; Hughes et al., 2006).

Viewing waste as a resource (Tillman, 2004) and re-using, recycling and composting as much as possible is the optimal way of dealing with waste (Seadon, 2010). This not only has the potential to reduce emissions, but also helps to create a more circular metabolism within our cities as espoused by Wolmann (1965) and Giradet (2004). The concept of resource recovery within waste management will no doubt play an essential role in decarbonising cities into the future.

Materials that cannot be reused, recycled or broken down naturally can be treated by new technologies such as plasma arc gasification. This process reduces waste to 1/300 of its original size as well as producing syn-gas, a renewable form of natural gas (Lombardi et al., 2011). This gas can then be fed directly into a tri-generation system to create low carbon, renewable energy, thus providing a perfect example of a closed loop system (City of Sydney 2010). Such technologies are still relatively rare and therefore, expensive.

New waste collection techniques including municipal vacuum waste, which sucks waste through an underground network of pipes to one or several collection points within a city, can also dramatically reduce the transport emissions associated with waste collection, improve the efficiency of recycling and add amenity by reducing the number of garbage trucks on the road (City of Sydney, 2010).

The first step in any waste management process, however, should be to minimise or avoid the amount of waste generated in the first instance. In terms of urban development and the construction industry, many opportunities exist to reduce the amount of construction and demolition (C&D) waste being generated. The use of prefabrication for building materials, for example, can dramatically reduce C&D entering the waste stream. Approximately 35 per cent of all the waste that ends up in landfill across Australia comes from C&D waste (DEWHA, 2010b). Encouraging society to minimise waste is likely to be more challenging but can be facilitated in urban planning and design by ensuring sufficient infrastructure is in place to enable good behaviour to occur (e.g., clearly marked recycling points). Behaviour change programs at the local level are also likely to be required.

The very concept of waste is the problem lying at the heart of most cities' inability to adopt more sustainable resource management practices. Waste implies that a material has come to the end of its productive life and no longer has any functional purpose (Tillman Lyle, 2004). Thermodynamics and especially the concept of entropy explains how materials become less and less useful when they are passed through a system unless further energy is applied to them. The concept of waste, which does not exist in the natural world, has created the unsustainable linear flow of resources through our cities. However, materials often still contain significant uses that require minimal energy to recycle, though a point is reached where more energy is needed to recycle them than can be saved from the embodied energy in the materials.

With the expected population growth (Productivity Commission, 2010) combined with increasing per capita waste production, improving the management of waste within our cities (and most other global cities) is essential and needs be a national priority.

2.4 Centralised versus Decentralised Management Approaches

As illustrated in this chapter, resources in Australian cities are typically managed using centralised infrastructure systems. It is critical to acknowledge that many of these systems were developed using 19th and 20th century technologies that are not only are now out-dated and inefficient, but were not originally designed to deal with the problems facing humanity in the 21st century such as climate change and resource depletion.

While great efficiencies were originally associated with 'economies of scale', thus making large-scale systems desirable, many new technologies for distributed generation are now emerging that appear to achieve far greater resource efficiencies when combined at the local level (Chanan et al., 2009; CSIRO, 2009; Newman et al., 2009, Rauland & Newman, 2011).

Managing resources more locally can provide numerous benefits. Firstly, generating and managing resources closer to where they are being consumed can radically reduce transport and distribution emissions. Far greater integration between systems can also be achieved at the smaller scale, where for example, outputs from one process (e,g., methane from water treatment) are used as inputs for another (in this case generating energy). This results in better resource efficiencies, thereby reducing the overall amount of resources required and thus the emissions produced.

In terms of human behaviour and connection to the environment, Giradet (2004) argues that the centralised process for managing resources can leave many people disconnected, unaware of, or having little regard for, the origin or final destination of the natural resources they consume. On the other hand, decentralised processes and systems can bring people much closer to the life systems that support them. The increasing number of individuals, businesses and entire communities embracing opportunities for small-scale production and management of resources such as solar photovoltaic panels, rainwater tanks, community wind farms, biomass co-generation plants and community gardens are demonstrations of the willingness of people to move beyond the role of passive consumer.

Large-scale centralised processes are extremely vulnerable to disruptions. Bouffard and Kirschen (2008) identify several potential disruptive threats to supply, including terrorist threats, natural disasters, geopolitical disruptions, aging of complex infrastructure (e.g., transmission and distribution), climate change and regulatory and economic risk. Decentralised options ensure reliable, localised supply and hence greater security of resources (Ryan, 2013). Numerous recent natural disasters have demonstrated how devastating the widespread failure of power, water and waste systems can be for entire cities. New Zealand provided an unfortunate example where, despite a relatively small area being severely impacted by the 2011 Christchurch earthquake, whole neighbourhoods were left without power, sewerage disposal or clean water. Small scale, decentralised systems, connected to city wide networks, would effectively allow these local areas to continue to function in an island-type capacity. Bouffard and Kirschen (2008) argue that the most efficient network will be flexible and combine the best attributes of both centralised and distributed generation.

Having a larger variety of sources and systems for managing resources also adds diversity to the portfolio of supply options, thereby reducing the risk associated with dependence on a single source. Decentralised systems are also more economically viable and carry less financial risk as they avoid the hefty upfront investment costs associated with large-scale infrastructure such as power stations and dams. As smaller-scale options are generally easier and less costly to convert when more efficient alternatives become available, they also help to avoid lock-in (CSIRO, 2009).[30]

Cities that are able to substitute outdated, carbon intensive technologies and processes with new, innovative and more efficient ones will not only contribute to solving environmental problems such as climate change and resource depletion, but will also, through these actions, be essentially future-proofing themselves by increasingly their resiliency in the face of these problems (Kennedy & Corfee-Morlort, 2013; Newman et al., 2009; Newton, 2011; Sinclair, 2008).

[30] Lock-in is usually discussed in the context of technology. CSIRO (2009) refers to technology lock-in as a situation when "the dependence of a particular technology [i.e. standardisation of rail gauges] is reinforced by the market it is used in through positive feedback" (p.219). Lock-in is not always negative, though it can affect or reduce the speed of technological change and innovation.

2.5 Closing Resource Loops

The previous section reveals two important characteristics of centralised systems for resource management. Firstly, they allow resources to flow through cities in a horizontal or linear fashion where consumed resources are extracted as waste (Giradet, 2004; Newman & Jennings 2008). And secondly, they often tend to function in isolation, ignoring important synergies and the potential efficiencies achievable when systems are combined. This is vastly different to how natural ecosystems function, in that such systems are based on circular flows and closed loop systems, where processes are inherently interconnected and resources and nutrients are continuously recycled.

Giradet (2004) argues for a greater systems-based approach to urban management that can help to create a more circular metabolism within our cities. Newman et al (2009) define this metabolic city concept as the 'Eco-Efficient City', which demonstrates how various wastes can be turned into new resources for other processes to radically improve the overall efficiency of systems. Kennedy and Corfee-Morlot (2013) stress the importance of designing low carbon strategies for city based infrastructure that takes into account the interdependencies between infrastructure systems.

Many of these processes and systems are increasingly seen to be most effective at the smaller scale, usually at the district or community level (Newman et al., 2009; Newman & Jennings, 2008; Roseland, 2012). These small-scale, integrated systems form part of a concept defined here as decentralised green infrastructure.

2.6 Green Infrastructure

Green infrastructure is commonly referred to in American urban planning literature as natural or biological infrastructure within cities such as trees, waterways, parks and 'green spaces' (Benedict & McMahon n.d.; Vandermuelen et al., 2011). Here, however, the term green infrastructure is applied more broadly and defined as alternative infrastructure options for supplying power and water and treating wastewater and solid waste that can help to achieve sustainability outcomes and reduce a city's carbon footprint (Bunning et al., 2013; Walsh et al., 2010). Green infrastructure is typically based on the decentralised or distributed systems mentioned above, which help to create more integrated and resilient infrastructure systems within our cities. Figure 2.6 provides a conceptual model of green infrastructure, demonstrating how interconnected the systems can and should be. It was based on a case study that was conducted as part of the wider research project, which this research forms a part of.

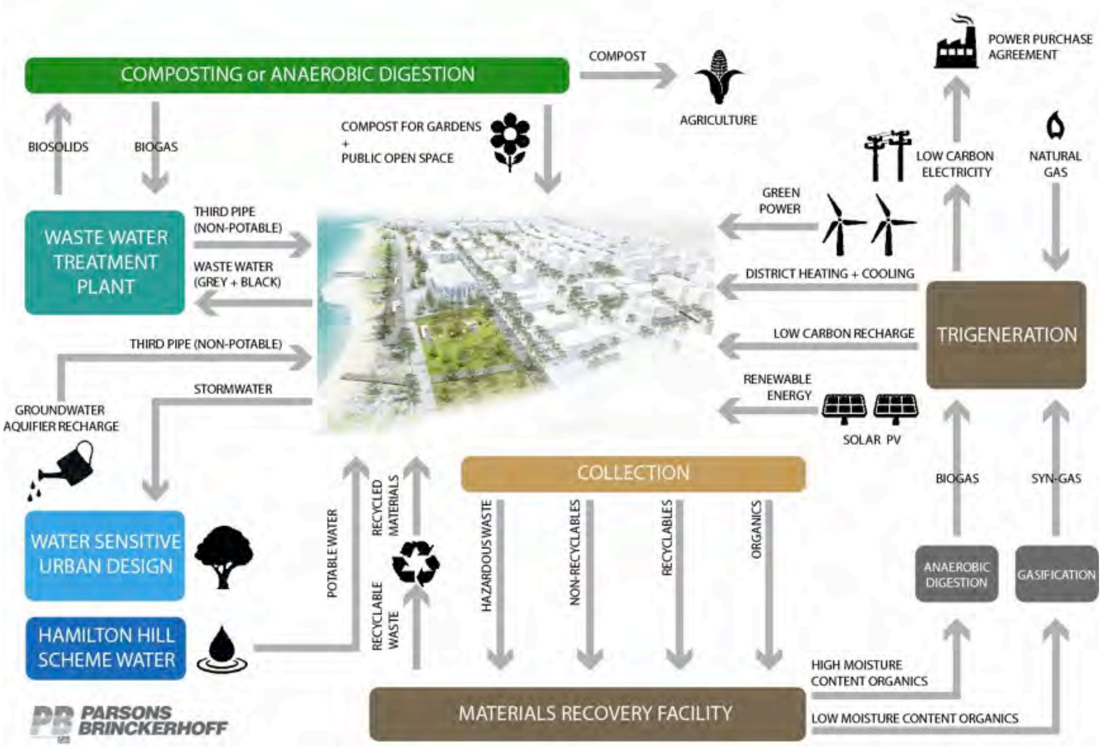

Figure 2.6. Cockburn Coast Green Infrastructure Eco-Cycle. Source: Walsh (2011)

The new green infrastructure outlined above is appealing to urban policy makers across the globe wanting to decarbonise their cities. This is especially so in mega cities like Jakarta and Dhaka which have no centralised water and waste systems and where energy supply is very unreliable; it is possible to leapfrog into the 21st century decentralised green infrastructure through a series of smaller systems and which can then be integrated. There are several factors, however, that must be addressed as part of the change including governance and urban form. New governance models will need to be developed to facilitate decentralised infrastructure (see Bunning et al., 2013). Urban form can also not be separated from these emerging technologies as precinct-scale technologies and systems generally require adequate density and mix to be most efficient and effective, as well as economically viable. This is particularly the case with decentralised energy infrastructure (Naess, 1995), and will be examined in more detail below.

2.7 Density and Urban Form

Density refers to the ratio of people or homes to area of land. Well-designed density, which incorporates mixed-use areas (i.e., spaces for living, working and recreational activities), is generally seen to provide numerous sustainability benefits (Jabareen, 2006). Density has long been identified as an enabling factor for more efficient public transport infrastructure, as well as increasing the walkability of cities (Newman & Kenworthy, 1999). This can drastically reduce the emissions associated with transport in a city or urban area, as well as improving health by providing opportunities for incidental exercise such as walking and cycling. Encouraging a reduction in car-based transport also reduces the amount of local air pollution, which can reduce the severity of respiratory problems and cardio-vascular illness (see Newman & Matan (2012) for an overview of the health implications of transport). Milner et al (2012) also highlight and discuss many health benefits associated with low carbon cities.

Increased proximity between home and work and better access to public transport can reduce the time spent commuting, which can also improve lifestyles and productivity at work (Trubka et al., 2010a,b,c). A ground-breaking study on housing in Melbourne revealed that, despite an ongoing preference by Australians for larger houses and gardens, most people were willing to trade off and sacrifice space for greater proximity and accessibility (Kelly, 2010).

Increasing building density usually results in a reduction in the size of houses, which can significantly decrease the overall consumption of resources, such as electricity, water and materials (Glaeser, 2011; Jabareen, 2006). There is some controversy about high rise causing increases in GHG but this is not generally accepted (Beattie & Newman, 2011). As shown in previous sections, density is also key to facilitating many of the new low carbon technologies (e.g., co- and tri-generation) that will be essential in helping to decarbonise our cities.

Not all agree with the density attributes discussed above, however. Mees (2009) argues that public transport does not necessarily rely on density, but can be added to suburban neighbourhoods if the right policy mixes are in place to support it. Public attitudes towards density can also pose a problem for developers attempting to build more densely. Negative perceptions of density have a long history, dating back to the 1800s where high density was associated with poor living conditions and poor health (Dempsey et al., 2012). Recent studies also show some dissatisfaction with the idea of density, suggesting that it is the cause of many neighbourhood problems such as crime, and that it provides less friendly environments, less access to public open space and less natural lighting, among other factors (Boyko & Cooper, 2011). However, many of these issues can and are increasingly being addressed by better design and planning in modern day high-rise developments (Boyko & Cooper, 2011; Dempsey et al., 2012).

Sarkissian (Jewell, 2013) suggests engaging the public more in the conversation about density can also help to alleviate worries and improve the chances of creating well-designed, higher density areas being accepted by the community. If the community has been involved in the creation of an urban area, they are less likely to oppose its development.

Overall, it appears that density and urban form is inherently connected to the green infrastructure described above and will be a crucial part of any decarbonising process.

2.8 Why The Precinct Level?

> The answer is the precinct. A smart building precinct is containable and do-able, in terms of regulations, utilities and physical infrastructure. And, with luck, it will sit in one metropolitan authority. (Barker, 2011, p. 78)

Cities around the world have long been leading the way in acting on climate change, thus demonstrating the effectiveness of addressing carbon emissions at the local level (ICLEI, 2010; UN Habitat, 2011). However, as Choguill (2008) states, "no single city can contribute to overall sustainability if its own component parts are found not to be sustainable" (p. 42). These component parts of a city are its neighbourhoods and precincts. They are what a city is built around in terms of their urban design, provision of infrastructure and community networks (Bunning et al., 2013; Ryan, 2013).

The neighbourhood level has been identified and discussed in literature as a critical element for urban planning for over a century (Brody, 2009; Patricios, 2002). While the Garden City movement (Howard, 1902) may have initially highlighted the significance of this scale, Clarence Perry (1929) is largely acknowledged as being the first to officially introduce the concept, and the importance, of the 'neighbourhood unit'.

Since then, scores of people have discussed, redefined, reinterpreted and further developed the concept, continually validating the benefits of this scale. Among the more prominent thinkers, were Lewis Mumford (1954), architects Clarence Stein (1951) and Henry Wright who developed the 'Radburn Model' (Banarjee & Baer, 1984), and more recently, the work of New Urbanists[31] (Brody, 2009).

Brody (2009), who provides a useful overview of the 'neighbourhood unit' literature, highlights how the concept has changed and evolved over the years as it was applied to various fields including planning, architecture, urban design, real estate, finance, law, education, transportation, public health and policing.

Despite the evolving nature of the concept, a century of literature has proven the value of this smaller scale. It is perhaps unsurprising, therefore, that it is at this neighbourhood level where most sustainability and carbon reduction opportunities are now also presenting themselves. The abatement opportunities, together with the effectiveness of implementation, makes the precinct level the optimum scale for addressing emissions within cities.

Recognition of the effectiveness of the precinct level is growing and is particularly evident when looking at building assessment tools and rating schemes. While efforts to reduce emissions from the built environment previously focused on individual buildings, as can be seen by the plethora of rating tools that exist to assess and encourage better building performance, a shift in focus has occurred in recent years to capture additional elements at the neighbourhood and precinct level (AILA, 2010). Such tools have demonstrated the larger emissions abatement potential when these bigger systems within the built environment are included, such as precinct-scale energy, water, waste systems and transport options (Ewing et al., 2008; The Climate Group, 2010). Buildings are thus no longer being seen in isolation, but as a part of an integrated and dependent wider precinct system.

[31] The New Urbanism movement, which has gained prominence over the years, was largely a reaction against the car-based, urban sprawl, which has developed rapidly and consistently since the 1950's and 60's, particularly in the US, Canada, the UK and Australia. New Urbanism sought to bring back the town centre, which included a more walkable, mixed-use urban design, allowing multiple transport modes (i.e. bike, public transit and car) and emphasising a stronger sense of community (Roseland, 2005). New Urbanism has many supporters as well as critics. See McCann (2009) for a detailed analysis.

2.8.1 Defining the Precinct

A precinct is loosely defined in this research as an area within a city made up of two or more buildings within a street, up to the size of a suburban development. Importantly, a precinct uses shared infrastructure, such as roads, energy, water and waste management systems. It can be a new development or a re-development and, while it can be purely residential or commercial, ideally it will incorporate mixed uses, thus providing a hub or agglomeration of activities and multiple participants.

Cutler (2009, p. 3) proposes that a successful precinct is one that:

- revolves around a clear core development proposition which can engage the sustained participation of multiple parties who have an expectation of and commitment to mutually beneficial interests;
- has a sound and sustainable funding model;
- develops a distinct identity;
- mobilises the supply of supportive infrastructure, facilities and resources;
- leverages individual participation and investment;
- delivers sustained impact and benefits;
- facilitates active collaborations and informal networking; and
- operates with clear and transparent rules of engagement.

Interestingly, these points largely relate to issues of governance, which will be critical to the success and ultimate uptake of low carbon precincts (Bunning et al., 2013).

Precinct, community, neighbourhood and settlement are terms that are all commonly used within the literature to denote the focussed urban area with the above characteristics, and they are thus used interchangeably within this thesis.

2.8.2 Key Reasons for Targeting the Precinct Scale

There are many advantages of moving beyond the individual building scale to a precinct scale when attempting to decarbonise the built environment. This research identifies five key reasons for targeting the precinct level, as illustrated in Figure 2.7. Firstly, by going beyond the building scale, additional elements that contribute to emissions can be factored into carbon-related decisions. Secondly, it is the scale at which communities function. Thirdly, it is the scale at which developers work. Fourthly, this level has greatest interaction with local government and finally, it is the scale at which emerging technologies appear to perform best. These are discussed further below.

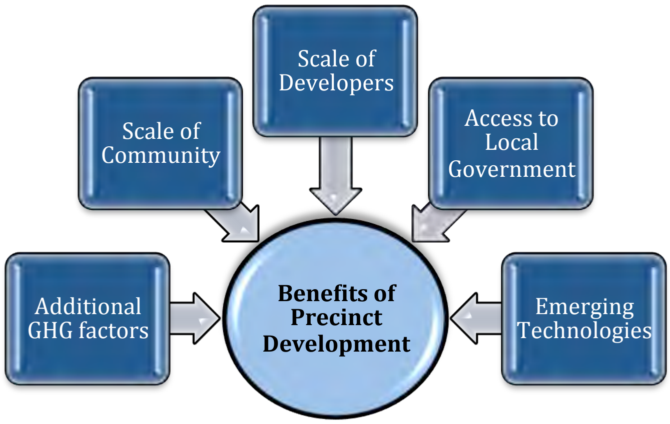

Figure 2.7. Key Reasons for Targeting the Precinct Scale for Emissions Abatement

Allows Additional Urban Factors to be Considered

When discussing the built environment in terms of sustainability and its emissions contribution, the traditional focus has predominantly been on buildings. However, broadening the Scope to the precinct scale allows a variety of additional factors to be taken into consideration, many of which contribute significantly to urban carbon emissions but are often seen as beyond a developer's immediate control. By incorporating these additional factors, such as the transport options within a precinct and its management of resources, a deeper understanding can be gained of the total carbon implications associated with the built environment.

A framework that allows a developer to assess and compare various design approaches based on their costs and benefits can enable developers to make more informed decisions on important precinct infrastructure (Newman et al., 2011). This will help to lower the overall footprint of the development, and thus make the process of becoming carbon neutral significantly easier.

Scale of Communities

The social and cultural dimensions of cities have been well recognised as a key factor in achieving sustainability outcomes (Choguill, 2008; Ryan, 2013). The social connections and interaction between people largely occur at the community scale. Middlemiss and Parish (2009) note that the 'community' is increasingly identified "as a space for realising pro-environmental change" (p. 7560). As a result, it is receiving greater attention by policy makers and academics, evidenced by the increasing number of behaviour change initiatives targeting and engaging the community on climate change and sustainability issues.

The community has also been identified as a place where organic social change occurs in the form of grassroots initiatives. Seyfang (2010) identifies communities as innovative niches with the potential for wider societal transformation largely due to the local networks, businesses and organisations that exist at the community level. The unique set of skills, experience and local knowledge that exists within local communities puts them in an ideal position to respond to local environmental challenges and issues more effectively (UN Habitat, 2011).

Communities also play an important role in shaping social norms and practices (Fuller, 2009). Moloney et al (2010) recognise that "normalised pro-environmental behaviour" (p. 7622) is a key factor in transitioning to low carbon communities. While having the right technical and infrastructural solutions in place is important to provide opportunities for people to make the right choices, societal transformation "has to include the interaction between social and cultural life and physical and technical systems" (Ryan, 2013, p. 193).

Scale of Developers

Precincts and neighbourhoods are the scale at which development generally occurs (Sharifi & Murayama, 2013), and therefore the scale at which developers are used to working. Developers are also used to interacting with local governments on regulatory and planning issues, which can create opportunities for greater collaboration and working together to share both the costs and benefits associated with creating low carbon communities.

Local Government

Local government has long been identified as an ideal scale for tackling climate change. The development of Local Agenda 21 and ICLEI - Local Governments for Sustainability, along with the introduction of various sustainability initiatives such as Cities for Climate Protection (CCP), are evidence of the willingness and effectiveness of local councils in addressing sustainability and climate change issues (Broto & Bulkeley, 2013; Brugmann, 1996; Brugmann, 2010; ICLEI, 2010; The World Bank, 2010).

Since local governments have authority over many of the planning controls within their local government areas, such as land-use zoning, buildings, waste management and other common infrastructure (The World Bank, 2010), they are well positioned to create strategic policies for developers that ensure certain sustainability outcomes. Furthermore, as local governments already manage many of the systems and infrastructure and are increasingly being seen as 'early innovators and adopters of efficient technologies' (Burch, 2010, p. 7575), this can provide an excellent basis for developers in creating low carbon developments.

Local government is not only the closest level of government to developers, but also to the community. They therefore have the greatest ability to influence individuals and affect change within the community, by enabling better dialogue between citizens, developers and local decisions-makers (The World Bank, 2010).

Scale of Emerging Low Carbon Technologies

Precincts provide an ideal platform to trial and deploy existing technologies and systems in an integrated manner to achieve the greatest environmental, economic and social outcomes. They provide the scale to test commercial viability and the ability to evaluate and replicate solutions. Working at the level of the precinct affords an opportunity to test the 'systems thinking' needed to better understand the many and varied interactions between the infrastructure and systems that underpin urban life.

The precinct is increasingly being identified as an ideal scale for new and emerging low carbon technologies (The Climate Group, 2010). Examples of the efficiency gains available through localised systems include the use of co- and tri-generation, renewables, localised water systems, solid waste recycling systems and many technologies associated with resource efficiencies. These were discussed previously. This scale provides great opportunities to test multiple technologies and systems in an integrated fashion at this smaller city level. Integrating technologies, systems and planning in a strategic way can provide numerous economic and environmental benefits and efficiencies that can be "an order of magnitude greater than when they are pursued in isolation" (The Climate Group, 2010, p. 9).

The precinct scale can allow new business cases and models to be developed and trialled, many of which are or will be far more viable than at larger scales. Figure 2.8 below demonstrates the financial and environmental savings generated from various technologies and infrastructural measures implemented at the precinct level on the Cockburn Coast project described in 2.6 above.

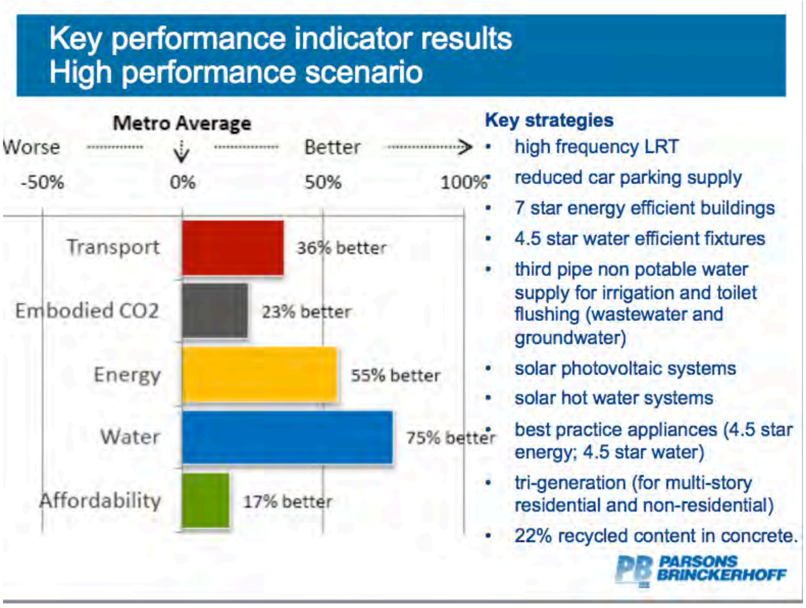

Figure 2.8. Key Performance Results from Integrated Low Carbon Infrastructure in the Cockburn Coast. Source: Walsh (2011)

Targeting the precinct level helps not only to mitigate climate change by offering significant emissions reduction opportunities, but also to build resilience in terms of adapting both to climate change impacts and to broad resource availability issues. Communities that are able to meet more of their resource needs from their local environment will decrease their risk of global resource and commodity price shocks.

2.9 Conclusion

This chapter analysed the carbon implications associated with various types of urban form and resource management infrastructure within cities. Australia was used as an example to illustrate some of the inefficiencies associated with particular car-based city designs. The analysis demonstrated that the current design of Australian cities based on large houses in low-density dispersed car dependent suburbs, are extremely resource and emission intensive. The large scale, centralised management of resources in cities, based on out-dated technologies and compounded by aging infrastructure, are further exacerbating the problem.

This low density, sprawled urban form based around centralised infrastructure, which has dominated western 20th century urban planning, remains the focus of countless cities around the world. Many global reports, highlighting the strong interconnection between climate change, urbanisation and infrastructure, have warned of the environmental consequences if new and expanding global cities, particularly in developing countries, adopt traditional 20th century low-density city design based around the car and centralised power, water and waste infrastructure (UNEP, 1996).

If cities around the world continue along a 'business as usual' pathway, and if new cities adopted similar patterns of design, then a significant increase in emissions, along with numerous resource concerns can be expected. However, it is argued that many opportunities exist to transform cities, which will involve embracing new low carbon designs and more efficient and resilient urban systems and processes.

It has not been the intention of this chapter to argue for, or recommend specific technologies or the most optimal set of solutions for decarbonising cities. Rather, the aim has been to demonstrate that, while significant emissions may currently be attributed to cities and the built environment, substantial emissions reductions are also possible if alternative designs and approaches are adopted.

The discussion provided in this chapter has helped to identify the key areas within urban development and the built environment that offer the greatest potential for carbon reduction. This knowledge has been used to inform the development of the carbon accounting framework discussed further in Chapters 6 and 7.

Chapter 3 - Eco-Cities and Carbon Claims: Comparison of Case Studies Within the Built Environment

3 Eco-Cities and Carbon Claims: Comparison of Case Studies Within the Built Environment

3.1 Introduction

The concept of an 'eco-city' has its roots in the early 20th century (Roseland, 1997). However, interest in the concept grew rapidly in the late 1980s when people began exploring how the newly defined notion of 'sustainable development' (World Commission on Environment and Development, 1987) could be interpreted within an urban context and at a city scale. Numerous articles began investigating what eco-cities may look like and the many elements that should be incorporated into their design and management. These writings were instrumental in helping to popularise the concept (Roseland, 1997).

Fast-forward two decades, and the previously aspiring eco-city concept[32] (Engwicht, 1992) has become reality with countless demonstrations around the world. A recent eco-city survey conducted by the University of Westminster identified over 170 eco-cities globally (Joss, 2011, p. 135). The cities range in size and scale, as well as in ambition. Several have drawn considerable attention over the years due to their progressive nature, inspiring and impressive goals and successful realisation. Best known examples of these include BedZED in the UK, Vauban in Freiburg, Germany and Hammerby Sjostad in Stockholm, Sweden.

This process of rapid adoption of eco-city innovations and models has all the marks of a social movement (Roseland, 1997; Snow et al., 2004). The importance of eco-cities being a social movement is that they are likely to grow from a broad base and influence governments to facilitate them further in their planning, governance and, hopefully, certification processes.

Several factors are likely to have contributed to this rise in eco-cities. For some cities, the threat of climate change and their unique vulnerability to the varying impacts of it are enough motivation to take action. For others, it may be a response to the lack

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[32] Terms such as "towards" were often used in describing the development of eco-cities, implying that they were still only an aspirational concept.

of action being taken at higher levels of government, and the encouragement and empowerment provided by international initiatives such as ICLEI (Newman et al., 2009). For many cities, however, it is simply a chance to differentiate and showcase themselves in an increasingly ambitious and competitive world. Whatever the reason is, larger and grander environmental targets and goals for cities are constantly being set.

Unsurprisingly, various new terms have emerged from this highly diverse set of cities to help describe what they are seeking: Carbon Zero (or Zero Carbon), Zero Emission, Carbon-Free, Low Carbon, Carbon Negative, Carbon Positive, Climate Positive and Climate Neutral. However, the myriad of names are rarely well defined, and the methodology used for calculating emissions associated with the developments, or the process by which a development has achieved its stated carbon goal, often remains unclear. This lack of consistency in information has led not only to confusion, but also to scepticism and mistrust in claims. Environmental claims that are considered misleading or false, are commonly characterised by the term 'greenwash', and have become increasingly prevalent in recent years (Monbiot, 2006).

The purpose of this chapter is to investigate several of the more widely known and celebrated eco- and low-carbon cities and developments around the world, in order to gain a better understanding of the specific areas (e.g., energy, water, waste, transport) that have been targeted and how each area is reflected in their eco- or carbon claim. Focus is given to carbon emissions, as this is a growing area of concern and thus increasingly exhibited in claims.

The developments analysed include: BEDZed in the UK; Vauban in Germany; Hammerby Sjostad in Stockholm and Western Harbour in Malmo, Sweden; Dongtan in China; and Masdar City in the United Arab Emirates. In Australia, two municipalities – the City of Sydney and City of Fremantle – have claimed carbon neutrality, and a proposed new development off the coast of Fremantle (North Port Quay) claims to be carbon free. A brief analysis and comparison of these nine cities and precinct developments is provided below.

3.2 International Case Studies

3.2.1 BedZED – UK

BedZED is a small, dense, mixed-use eco-development located in the southern suburbs of London. It is built on a brownfield site and situated close to a rail station.

From its inception, it pushed the boundaries, testing and showcasing several new low carbon technologies and urban design elements. Completed in 2002, BedZED is one of the original and hence most well-known global examples of a grassroots sustainable development.

Eco-Claim

The name BedZED originates from Beddington Zero (Fossil) Energy Development, and was originally designed to be a carbon neutral precinct (Hodge & Haltrecht, 2009). The aim was to generate enough zero-carbon energy onsite to meet the electricity, heating and hot water needs of the development, while feeding excess energy into the grid.

Figure 3.1. BedZED. Credit: Jan Scheurer

Low Carbon Initiatives

Despite an overarching focus on operational energy, the designers of the development integrated a variety of sustainability measures and initiatives that targeted emissions from a wide range of areas, including water, waste, materials and transport. The development's broad focus on sustainability made it an outstanding example of what is possible at a small-scale and very local level. Some of the initial low carbon, sustainability features included:

- highly energy efficient three-story townhouses that use solar passive design; including passive ventilation and daylighting to reduce the need for artificial heating, cooling and lighting;
- low carbon materials sourced locally where possible;
- energy and water efficient appliances;
- greywater recycling facilities onsite as well as rain water tanks;
- solar photovoltaic panels on roofs;
- biomass fuelled Combined Heat and Power (CHP) plant providing zero carbon electricity and district heating to the development (later changing to a gas district heating system);
- mixed used, combining office space and residential dwellings, to reduce transport emissions from commuting;
- transit-oriented (i.e. situated next to a train station to promote low carbon transportation) to reduce personal transport emissions; and
- provision and encouragement of local food production (including rooftop gardens), reducing food miles and associated emissions.

In addition to the numerous low carbon initiatives, many other broad sustainability features were included such as affordable housing and a range of other housing tenures (Williams, 2012), community facilities and open space, and the preservation and promotion of biodiversity in the surrounding area (Newman et al., 2009; Newman & Jennings, 2008).

Success

BedZED continues to be one of the most widely documented and celebrated case studies demonstrating successful, holistic, sustainable precinct design. However, as Hodge and Haltrecht (2009) point out, despite thousands of articles and reports written about the development[33], only a few contain performance-related information. From the information available, the main issue BedZED experienced concerned the malfunctioning of the biomass plant (Williams, 2012), which the development relied

[33] A google search of 'BedZED 'on the 26/03/12 listed 45,200 results.

upon to provide the zero-carbon energy to the precinct, and hence to support the development's name.

Since the biomass plant ceased operation in 2005, electricity has been sourced primarily from the national (i.e. coal-fired power) grid, with a small contribution coming from onsite solar photovoltaic panels. A new district heating system using natural gas now supplies heating (Williams, 2012) that is far cleaner than electricity from the grid. This, together with the highly energy efficient buildings and appliances, means the amount of grid electricity consumed by the development is around half of that of the neighbouring areas (Hodge & Haltrecht, 2009).

Nevertheless, the use of grid electricity means that carbon emissions *are* now associated with the development, demonstrating the potential legal implications that could arise from what now appears to be a false carbon claim.

The initial wastewater treatment system was also decommissioned early on, although a new MBR reactor has since taken its place. The reason provided for the initial decommissioning was unsustainable operating and maintenance costs. It is not yet known how the newer technology will fare in comparison, though it is expected that rising water costs associated with climate variability and water scarcity will make this technology more commercially viable in the near future (Hodge & Haltrecht, 2009).

The impact of this system on the development's carbon emissions needs to be investigated, however, since the energy required to run small-scale wastewater systems can be greater than the energy needed in conventional municipal wastewater treatment plants (Medeazza, 2007). If energy required to operate the system is not sourced from renewables, higher emissions will result.

Despite the challenges and issues experienced, BedZED has demonstrated that massive carbon abatement opportunities are possible at the precinct scale and continues to be a shining example for other developments.

3.2.2 Vauban, Freiburg – Germany

Vauban is another relatively compact, sustainable neighbourhood development located on the southern edge of the city of Freiburg, in Germany. Redeveloped on a former military base, Vauban is largely residential, designed to meet rising housing demand (Williams, 2012). It is connected by a light-rail, providing residents with a short commute to the city centre and is virtually car-free with limited parking provided at each house and full walking and cycling-orientation.

The development is renowned for its passive and active integrative solar design onsite, biomass co-generation plant and car-free or share-zoned streets (Newman et al., 2009; Newman and Jennings, 2008; Williams, 2012). Designed and built between 1995 and 2008, with considerable community consultation, this development demonstrates what is possible when citizens and residents are involved and empowered through the planning process.

Eco-Claim

Figure 3.2. Apartments in Vauban. Credit: Author's photograph

Vauban is often referred to as an eco-village, sustainable urban district or 'model sustainable neighbourhood' (Newman & Jennings, 2008). While it does not make any specific carbon claim, studies have shown that Vauban has reduced carbon within its district considerably. Williams (2012) notes that Vauban residents produce around 0.5 tonnes CO_2/per person/year compared to the average 8.5 tonnes CO_2/per person/year for typical Freiburg residents. The list of initiatives below offers insight into how they were able to achieve this.

Low Carbon Initiatives

Vauban's low carbon features include:

- energy efficient houses (with all buildings meeting at least the Low-Energy Standard, though 200 are Passive houses/units and 59 Energy-Plus houses);
- expansive solar photovoltaic systems on roofs of houses, public and commercial buildings and car parks;
- biomass fuelled co-generation plant (together with solar supplying 25 per cent of districts electricity needs);
- heavily restricted car parking facilities deterring car ownership (with only 16 per cent of Vauban residents owning a car);
- a mix of car-free and shared-zone streets (with the majority of travel being by foot or bike);
- light-rail connection to the city;
- adoption of housing co-operatives[34] and associations, which allows residents to have responsibility for the management of their building, and thereby increases their awareness around issues such as energy consumption; and
- mixed-use development (around 600 jobs and 5000 residents).

Figure 3.3. A Mixed-Use Street in Vauban. Credit: Peter Newman

While it is unclear which measures were included in the carbon footprint, it is likely that the low per capita footprint would be largely attributable to the buildings in

[34] Co-operative housing is a situation where citizens join together to design, build and own a shared housing estate – often in the form of an apartment block.

Vauban – all of which meet high energy efficiency standards. Although the houses are extremely energy efficient from an operational perspective, it is unclear whether the embodied emissions in materials used in the construction of the buildings have been accounted for.[35]

Another reason for the low carbon footprint in Vauban would be related to the energy system supplying the precinct's electricity. Described by Williams (2012) as LZE (low or zero energy system), co-generation using biomass and solar photovoltaics supplies one quarter of the district's electricity.

Success

Vauban adopted a very different approach to developing this community, which has largely contributed to its success. As Williams (2012) notes "Vauban was conceptualised through a highly participative planning process with residents, planners, housing companies, Baugemeinschaften/Baugruppen [housing co-ops and associations], utilities all working together to achieve a sustainable neighbourhood" (p. 139). This collaboration became a critical factor, particularly in helping to deliver such high energy efficiency standards, as the higher upfront costs associated with many of the initiatives were more accepted and supported by the residents and locals who, having a long term, vested interest in the development, could clearly see the benefit of the energy savings and lower overall running costs. This approach provides a great model for overcoming the problem of split incentives (discussed in more depth in Chapter 8).

Allowing residents to co-design and co-manage their buildings, energy systems and community infrastructure has led to greater sense of responsibility for and ownership of the overall success of the sustainability initiatives, and this sets it apart from most other developments. While it provides a brilliant and important example and model for other developments, it is worth noting that such a development relies on the 'greenness'[36] of residents and their willingness to be active in the decision-making process.

[35] Indeed, high operational efficiency often requires more energy intensive materials such as concrete or bricks.

[36] Willams (2012) notes that most residents that chose to move to Vauban had ethical concerns for the environment and around 70 per cent vote Green.

3.2.3 B001, Western Harbour, Malmo – Sweden

B001 is an eco-development built in the Western Harbour district of Malmo in Southern Sweden. It is a mixed-use, high-density precinct, currently home to 3,000 residents as well as some light retail, commercial and tourism businesses. By 2020, the development is anticipated to house between 15,000 and 20,000 residents and attract several eco-businesses to the district (Oresund Committee, 2009; Williams 2012).

The development is positioned in a prime location on the Harbour, a 10 minute bus ride to the town centre of Malmo and a 20 minute train ride to Copenhagen from there. It was previously an industrial precinct and thus in need of decontamination renewal. It is now a popular and attractive residential and tourist location.

Eco-Claim

B001 is most often cited as an eco-district, but has also been labelled as carbon neutral, climate neutral and energy neutral (The Oresund Committee, 2009). Interestingly, there appears to be little information about, or comparison of, the residents' carbon footprints, which seems to be a common metric used by other eco-developments. Most literature pertaining to B001 discusses the various initiatives in place, particularly focussing on the energy efficiency standards of the buildings and the low-carbon energy system employed (Williams, 2012).

Figure 3.4. B001, Malmo, Sweden. Credit: Author's photograph

Low Carbon Initiatives

Some of the low carbon initiatives implemented at B001 include:

- 100 per cent locally generated sustainable energy;

- a wind turbine in the harbour, 3 kilometres from the development, supplying energy to houses;
- solar PV embedded into the development;
- green roofs;
- heating/cooling systems using a local aquifer as storage;
- high energy efficiency standards of buildings (105kW/m2); and
- a waste to energy system.

Success

The design and development of the precinct, including the low carbon energy system supporting it, were achieved through a highly collaborative process involving the municipality and its specially created 'sustainability unit', together with planners, developers and a local utility company. Unlike Vauban, B001 did not engage the community in this process.

The residents who ultimately moved into the area were relatively affluent and less concerned or aware of the environmental status of the development, but they chose to live there based on the aesthetic quality and location of the development. This most likely contributed to the higher than expected energy consumption of the buildings within the development (Nilsson & Elmroth, 2005). Whether this was the fault of the developers not meeting the correct energy efficiency standards, or of the modelling not accounting for the affluent people moving into the district, the high energy standards (105kWh/m^2) set for the first phase of the development were not met.

Nevertheless, the low carbon energy supply system for B001 has experienced relative success and, despite the overconsumption of energy, the fact that the districts energy comes from low carbon sources ensures that the carbon footprint remains low. What the development's carbon footprint actually is remains to be seen, as little research is available. A drawback from the energy system, as Williams (2012) notes, is that it allows residents to be passive consumers (unlike in Vauban where they have a more active role in energy management), which is most likely leading to the higher energy usage.

Being municipality-owned land, the process of converting Western Harbour to an eco-development and enforcing environmental standards was made much easier than if the site had been privately owned. However, as demonstrated by post-occupancy evaluation (Nilsson & Elmroth, 2005; Williams, 2012), such enforcement does not always ensure delivery of the desired outcome.

3.2.4 Hammarby Sjostad, Stockholm – Sweden

Hammarby Sjostad is a 200-hectare site located in a close proximity to the city centre of Stockholm. Previously contaminated municipal owned land with poor transport connectivity, Hammarby Sjostad has now become a vibrant, desirable and celebrated eco-district within Stockholm. The district houses 20,000 residents in a relatively dense area (50 units/hectare), and boasts one of the most celebrated and discussed 'closed-loop' systems for integrating energy, water, waste and transport at the local level. This has contributed considerably to the reduction in the district's emissions, and Hammarby's prime location (waterfront and close to the city) has been optimised by the extension of a light rail to the development.

Eco-Claim

Hammarby Sjostad is well-known as an 'eco-district' with its eco-claim predominantly centred around its innovative eco-cycle model or closed-loop resource management system. The development set the goal of reducing per capita emissions within the development to 2.5-3 tonnes CO_2/per person/year compared with the average Stockholm citizen's emissions of 4 tonnes CO_2/per person/year (Williams, 2012).

Figure 3.5. Hammerby Sjostadt, Stockholm, Sweden. Credit: Author's own photograph

Low Carbon Initiatives

Some of the low carbon initiatives implemented in Hammarby Sjostad include:

- a closed-loop system that utilises the waste products from various processes such as waste water and municipal solid waste to create energy (biofuel, biogas and waste heat), which is used for electricity generation, district heating and fuel in cars;
- micro generation, i.e., from solar PVs and solar collectors;
- energy efficient buildings;
- vacuum waste collection;
- light rail connected to city;
- a car share scheme; and
- an Environmental Advice Centre to inform and educate residents about living a low carbon lifestyle.

(Sources: Newman, et al., 2009; Takahashi & Onishi, 2011; Williams, 2012)

As Stockholm residents already have one of the lowest per capita carbon footprints for a developed city (largely because of the low carbon energy grid, district heating network supported by relatively high density, and thermally efficient buildings), it was difficult to find and implement further reduction measures.

Success

The design and development of the closed-loop system came about from a collaboration between the various city-owned utilities (Stockholm Energi, Stockholm Water Company and Stockholm Waste Management Administration) and facilitated by the municipality (Williams, 2012). Sweden has a long history of municipal-owned utilities, as well as decentralised infrastructure, both of which would have contributed significantly to the initial success in setting the system up. While the system has now been privatised, it continues to operate on a profitable basis.

The entire development was planned using a highly collaborative process, which involved developers, planners, utilities and the municipality's environmental unit. Initially, strict requirements were placed on the energy performance of the buildings, which was possible because the municipality owned the land and would only permit developers who met their criteria. However, a change of government saw the land sold off to the private sector, which meant environmental standards were lowered and harder to enforce. As a result, the energy efficiency targets for buildings (50 per cent less energy) were not met, though there was a reduction of approximately 30 per cent (Williams, 2012).

Despite the environmental credentials of the Hammarby Sjostad and the Environmental Advice Centre offering information and advice on low carbon living, it appears that the residents are less concerned about environmental performance or their own footprint than are the residents of Vauban or BedZED. As was the case in B001, Williams (2012) notes that residents moved there primarily based on the 'location, aesthetic quality and services' (p. 126), and the design of the low carbon system (very automated with little personal engagement required) allowed residents to continue as passive consumers of energy and resources.

Despite this, research suggests citizens of Hammarby produce less than half the $C0_2$ of other parts of Stockholm (Takahashi & Onishi, 2011), though this research fails to elaborate on what emission sources are included, again making comparisons with other developments tricky.

3.2.5 Masdar – United Arab Emirates (UAE)

Masdar City is located on the outskirts of Abu Dhabi in the United Arab Emirates. Situated in a desert environment with average summer temperatures of 35 degrees, limited supply of fresh water and only road access (currently)[37], it is vastly different to the other case studies. Nevertheless, it has highly ambitious aspirations to be a zero carbon, zero waste city. The concept, first conceived of in 2006, was designed to push the limits and provide a test-bed for new technologies (Kansara & Ridley, 2012).

The idea for the development stemmed from the acceptance that the source of UAE's prosperity and subsequent excessive carbon footprint, i.e., fossil fuels, would not last forever. Masdar is an attempt to build capacity and a new income stream for Abu Dhabi in a post-carbon world through attracting green economy businesses to locate there (Reiche, 2009).

Once completed, Masdar is expected to house 40,000 residents and support a further 50,000 daily commuters, making it the largest low carbon, eco-city in the world to date (Reiche, 2009).

[37] A train line is proposed into the future.

Figure 3.6. Solar Chimney, Masdar, Abu Dhabi, UAE. Credit: Peter Newman

Eco-Claim

Masdar has had countless carbon distinctions attributed to it, with many journalists, researchers, designers and locals preaching its environmental credentials. Some of the titles include carbon neutral, net zero carbon emissions, low carbon and a zero waste city. The development has the aim of reducing energy consumption by 80 per cent compared to the average Abu Dhabi resident (Kansara & Ridley, 2012), and it is to be powered by 100 per cent renewable energy.

Low Carbon Initiatives

Unlike the previously discussed low carbon developments, where it was unclear as to which emissions were calculated in the carbon footprint and thus underpinned their eco-claim, Masdar is very transparent and thorough in its calculation of emissions. There are six areas that are taken into account and calculated as part of the development's carbon footprint. These are represented in the diagram below.

Figure 3.7. Elements of Masdar's Sustainable City Concept. Source: Adapted from Masdar City (2011)

The following initiatives all contribute to reducing the development's emissions to zero:

- highly energy-efficient buildings using at least 30 cm thick insulation;
- traditional narrow streets for optimum shade and cooling, and funnelling of cool breezes;
- solar chimney's to draw hot air out of urban area's;
- absorption chillers run on solar-heated hot water to provide air conditioning;
- waterless urinals and low-flow fixtures in buildings;
- the treatment of wastewater for re-use; with the bi-products used for electricity generation;
- vacuum waste collection, sorting and recycling;

- gasification of waste to produce energy, with the bi-product to be used in construction (and thus zero waste);
- solar PVs supplying the development's electricity during the day;
- an electric PRT (personal rapid transit) system for transport around the city;
- light rail linking Masdar to Abu Dhabi; and
- ongoing data collection and monitoring of all initiatives and technologies to test for improvements and to verify carbon claims.

Success

The first phase of the development has been completed, consisting of six buildings including student accommodation that is already housing students.[38] While this could be viewed as a success, plans to develop it further (i.e. to complete the vision of accommodating 40,000 residents) have recently stalled due to the Global Financial Crisis (GFC) with no further notice of resumption, questioning the overall viability of the project.

While many are impressed and inspired by what Masdar is attempting, others see Masdar as an unhelpful case study as the budget far exceeds what most ordinary cities could afford. However, it does represent an important test bed for emerging technologies and new building techniques and, with its ongoing data collection and reporting of emissions, it can help to inform new models of city development into the future.

In terms of carbon claims, Masdar provides the most comprehensive carbon analysis of all the developments - compiling data on the carbon emissions associated with every foreseeable aspect of the development including the flights and taxis of international consultants. The development is being very transparent and sets an excellent precedent, demonstrating what is possible when calculating the carbon footprint of a development.

Nevertheless, it is likely that this amount of measurement was only achievable because of the available funds. Such a rigorous and comprehensive process would no doubt be extremely time consuming and unaffordable for most eco-developments.

[38] See http://www.renewablepowernews.com/archives/2736.

3.2.6 Dongtan – China

Dongtan was to be a new sustainable city located on Chongming Island in the Yangzte River Delta, close to Shanghai. Phase one of the development was going to accommodate 25,000 people and was planned to be completed by 2010. Once finished, Dongton was anticipated to be home to more than 500,000 residents (The World Bank, 2009).

Eco-Claim

Dongtan had various environmental commendations bestowed upon it and eco-titles ascribed to it. It was heralded as an eco-city, zero carbon city, sustainable city and ecologically sustainable city.

The development was credited for encouraging biodiversity, reducing car use and promoting low-consumption lifestyles, and was predicted to have less than half the carbon footprint of Shanghai's residential areas (Williams, 2009).

Low Carbon Initiatives

Initiatives were going to include:

- zero-energy and passive structures;[39]
- recycling of 80 per cent of waste;
- electricity and heat provided from renewable sources onsite, including a combined Heat and Power (CHP or Co-generation) plant running on biofuels;
- mixed-use, medium density development (up to eight stories), with most residents expected to work within the city;
- public transport available within seven minutes walk of all housing;
- emission free vehicles; and
- locally produced food.

Success

While the planning and design of Dongtan began more than eight years ago, the only construction that has occurred on the site was the clearing and preparation of the land (which included relocating 650,000 people) and the development of a small

[39] For more information, see http://www.dac.dk/en/dac-cities/sustainable-cities-2/show-theme/energy/dongtan-the-worlds-first-large-scale-eco-city/?bbredirect=true

information centre, which has also since shut down (Williams, 2009). The site has lain dormant since.

There are several possible reasons for the failure of the project. While corruption is often rumoured to be a major cause of its demise, other reasons given include the over-prescriptive nature of China's planning industry (progressive, innovative development required changes to rules, which is hard in the Chinese context) and political fallout (i.e. rumours of corruption lead to lack of support).[40] With global engineering firm Arup leading the design and construction, few appeared to critique the development's design, or suggest it as a potential reason for the failure.

Though, one of the few who did criticise the development was international journalist Austin Williams (2009), who suggested that the development was: "squat, low-rise, parochial, carbon-fetishising, architecturally unappealing, unworkable urban eco-clichés." The design perhaps contributed to its demise and as Williams concluded: Dongtan "is a recipe for future disasters".

It is reasonable to expect that problems would have ensued from the proposed densities for Dongtan, which were indeed similar to many English new towns, many of which have also turned out to be highly car dependent despite their architectural drawings which showed most people walking and cycling (Dac and Cities 2012).[41]

While a maximum of eight stories may represent high density in some European locations, the Chinese market is likely to require significant expansion and increase in density for it to be considered economically viable and representative of typical Chinese cities. A city of 500,000 (the expected population on completion) is still paltry in comparison to the megacities expected, and indeed planned, in China in the coming years. For a Chinese eco-city to be successful and replicable, it should be representative of realistic future cities, including through the application of realistic densities.

Nevertheless, Dongtan was very successful in promoting and publicising the project, and thus was able to put the eco-city idea and concept onto the wider agenda in China. As a result, over 100 eco- and low-carbon cities are now planned (Wu, 2012).

[40] See http://www.guardian.co.uk/environment/2009/apr/23/greenwash-dongtan-ecocity

[41] See http://www.dac.dk/en/dac-cities/sustainable-cities-2/show-theme/energy/dongtan-the-worlds-first-large-scale-eco-city/?bbredirect=true

3.3 Australian Case Studies

While there have not been any notable demonstration projects implemented in Australia that are similar to those highlighted above, there are two local councils that have become carbon neutral, as well as an ambitious proposed carbon neutral island development on the coast of Western Australia. These three innovative case studies are discussed below.

3.3.1 City of Sydney – NSW

The City of Sydney encompasses a land area of 26 square kilometres, which includes Sydney's Central Business District (CBD), as well as 30 surrounding suburbs, all of which the local government authority has responsibility over. Although the city has a residential population of 183,616, the overall population of the district expands to over one million on a daily basis. The city is therefore responsible for a large number of operations and services to manage the large number of people living, working and visiting the city. Sydney CBD is the most important part of Australia's economic infrastructure in terms of GDP generated.

In 2008, after significant community consultation, a new strategic plan called 'Sydney 2030' was developed, which set ambitious environmental targets of reducing emissions by 70 per cent by 2030. The city also adopted a renewable energy target of 30 per cent by 2030. Subsequently, a significant amount of work was undertaken to determine how the city would be able to reach this target, including the modelling of key emissions reduction technologies and interventions.

Figure 3.8. City of Sydney Local Government Area. Credit: ©The Council of the City of Sydney

Eco-Claim

In 2008, the City of Sydney became the first local government to claim carbon neutrality.[42] It was based on a carbon audit undertaken by Hyder and was largely achieved through switching to GreenPower and purchasing carbon offsets.

In November 2011, the City of Sydney became the first and only officially certified LGA under the Federal Government's National Carbon Offset Standard's (NCOS) Carbon Neutral Program.[43] By achieving this official status, the city's carbon neutrality claim is well substantiated and given greater credibility, as the audit and management follows a very rigorous process as required by Low Carbon Australia, which administer the program. It is important to recognise that the status is only applied

[42] For more information, see: http://www.sydneymedia.com.au/html/3689-australia39s-1st-carbon-neutral-government.asp?orig=Home
[43] The media release is available here: http://www.sydneymedia.com.au/html/4772-its-official-sydney-is-first-carbon-neutral-council.asp

to the council's operational activities and not to the entire community, which the other case studies generally include.

The city's carbon footprint is similar to the other case studies in that it does not take into account the emissions associated with the embodied emissions in materials, although it does account for the emissions associated with subcontract work, which may involve construction activities.

Low Carbon Initiatives

The City of Sydney has many low carbon initiatives in place and a well-developed 'Green Infrastructure Plan', which outlines the course of action over the coming years. Below is a list of some of the current and previous measures that have been implemented, followed by future planned measures.

Current and past initiatives

- Significant lighting retrofits throughout councils owned facilities (i.e., de-lamping, replacement of old lights with LED's and other energy efficient lights, lighting controls & motion sensors);
- Air conditioning and heating upgrades and better controls and management
- Installation of variable speed drives (VSD);
- Installation of solar photo voltaic panels on council owned buildings.

Planned Initiatives

- Decentralised energy generation, with tri-generation systems planned at the precinct-scale in numerous locations throughout the city;
- Solar photo voltaics to be installed at Council sites;
- Wide-scale LED lighting retrofit,replacing 6,450 streetlights with energy efficient LED lighting;
- Fleet eco driver program and biofuels;
- Energy and water efficiency retrofit of the city's buildings and operations;
- Automated waste collection systems to be implemented, reducing transport emissions from garbage collection and increasing recycling efficiency;
- Advanced Waste Treatment (AWT) system to increase recycling.

Success

The first comprehensive carbon emissions audit was undertaken in 2006/07, which has set the baseline for the emissions reduction measures. Several targets were then established including the ambitious 70 per cent emissions reduction target by 2030 based on 2006 levels (City of Sydney, 2011).

When the City initially claimed carbon neutrality in 2008, the reduction was met largely through the purchase of GreenPower (100 per cent renewable electricity) and offsets. Nevertheless, the City of Sydney had also identified and has been implementing significant emissions reduction measures since the initial carbon audit in 2007. Fifty-three actions were recognised in the City's Environmental Management Plan (City of Sydney, 2007), the majority of which have an impact on the city's emissions. All actions have now been initiated and the City is on track for meeting its 2012 target of a 20 per cent reduction on 2006 levels (City of Sydney, 2012).

In 2011, the city sought and became the first officially certified Carbon Neutral Government in Australia under the Federal Government's NCOS Carbon Neutral Program. The program requires continual demonstration of emissions reduction measures (as opposed to purely offsetting). In light of this, as well as for financial reasons, the city decided to redirect the funding that was going towards GreenPower into installing city-owned renewable energy infrastructure within the city.

The City of Sydney currently remains the only government certified as Carbon Neutral under the NCOS standard.

3.3.2 City of Fremantle – Western Australia

Fremantle is a port city in Western Australia located on the mouth of the Swan River, 20 kilometres from Perth, the state's capital city. It has a residential population of approximately 28,000, though as a local employment and tourist hub, the daily population is much higher.

The City of Fremantle has had a long history of being an environmental leader, having won numerous environmental awards over the years.[44] In 2009, the City of Fremantle elected a new Mayor based largely on his sustainability credentials and the City began adopting stronger environmental targets and implementing a greater range of

[44] For more information, see http://www.fremantle.wa.gov.au/sustainability

sustainability measures. In 2009 the City also became the first carbon neutral government in Western Australia and the second in Australia, following Sydney.

Figure 3.9. Aerial View - City of Fremantle. Credit: LoveFreo (2013)

Eco-Claim

Fremantle's carbon neutral status and claim is based on, and compliant with, the ICLEI framework developed specifically for local governments. This framework focuses on the emissions generated from the local government's own operations (i.e. not those of the wider community).[45] While the status is not an officially certifiable one (like NCOS), the City of Fremantle's emissions inventory, or carbon footprint, has been verified by an independent third party, which brings a degree of credibility to the claim.

Low Carbon Initiatives

The City has implemented a variety of emissions reduction measures over the years. Some have directly reduced the council's own operational emissions and some have targeted the wider community, but the latter are not included as part of the council's carbon footprint. Below are some of the more prominent initiatives that have been implemented over several years.

[45] A new framework has since been developed for community-scale emissions. See http://www.ghgprotocol.org/files/ghgp/GPC_PilotVersion_1.0_May2012_20120514.pdf

Current and Past Initiatives

- Installing pool blankets over the pools in the City owned Fremantle Leisure Centre, reducing heat loss;
- Installing over 40kW of solar arrays and a 1kW wind turbine on council owned facilities;
- Purchasing 100 per cent NaturalPower (from 100 per cent renewable, emission free energy) for Council operations;
- Installing voltage reduction devices in the civic administration and library building (saving an estimated 15 per cent of the building's total energy use);
- Upgrading the City's computers with desktop LCD screens and small energy packs;
- Increasing recycling from the council's administration office (more than doubling the original rate);
- Providing a free CAT (central area transport) bus service around Fremantle, encouraging the use of public transport;
- Decreasing the City's vehicle fleet by 10 cars and converting 18 vehicles to LPG;
- Installing free charging points for electric vehicle in a council owned car park
- Tripling investment in bicycle infrastructure and providing bikes for council staff to attend local meetings;
- Providing Transperth Cards (WA's public transport SmartRider card) to council staff to encourage public transport use;
- Helping to establish the award winning Living Smart program, which is now run by community members; and
- Sending Fremantle's community waste to the South Metropolitan Regional Council's (SMRC) Regional Resource Recovery Centre (RRRC), which diverts waste away from landfill, thereby reducing greenhouse gas emissions.

City of Fremantle, 2011Planned Initiatives

Table 2 illustrates some of the planned carbon reduction initiatives to be undertaken by the City of Fremantle.

Action Area	Actions to achieve council emission reductions	Actions to facilitate community emission reductions
Energy efficiency	Upgrade streetlights, an ongoing process of facility audits and revise the City's existing procurement policy	Living Smart household and Living Smart community
Commercial buildings	Air conditioning and lighting upgrades	Innovative financing mechanisms and mandate green star certified buildings
Residential buildings	Upgrade the councils residential building stock	Regulate for insulation in all houses at point of sale and develop a sustainable design policy
Transport	Increase cash alternative to staff parking permits and investigate more fuel efficient vehicles	Improve cycling facilities and work with neighbouring councils to develop rapid transport
Waste	Divert more waste from landfill	Waste education, e-waste collection and expand commercial recycling
Food, parks and gardens		Promote community gardens
Renewable energy	Install 180kW of solar PV and renewable pool heating	Reduce regulatory and institutional barriers to uptake, investigate tri-generation and promote Green Power
Offsets	Continue to offset all remaining emissions	Promote the use of local offsets

Table 2. Planned Carbon Reduction Actions. Source: Adapted from the City of Fremantle's 'Low Carbon City Plan' (City of Fremantle, 2011).

Success

The city has been very successful in implementing the environmental and emissions reduction initiatives over the years. This is most likely influenced by the support provided from the relatively environmentally-focussed local community.

Initially, there was some controversy over the council's carbon neutral claim, as it was not made clear that the carbon neutral status only referred to the council's own operational emissions. There was also confusion over how the council achieved carbon neutrality, i.e., what emissions were calculated and what types of offsets were purchased. In response and after significant community consultation, the city released a Low

Carbon City Plan (City of Fremantle, 2011), which detailed the actions and measures the local government was taking in reducing emissions, how it was claiming carbon neutrality, and how it planned to tackle the carbon emissions of the wider community into the future.

The City of Fremantle identified two specific targets to reach by 2020: firstly, a 20 per cent reduction in emissions through energy efficiency, and secondly, a 20 per cent reduction in emissions through switching to renewable sources of energy, all the while maintaining carbon neutral status. The 40 per cent reduction equates to a projected 3000tCO_2e/yr reduction from now until 2020 (City of Fremantle, 2011).

3.3.3 North Port Quay – Western Australia

North Port Quay (NPQ) was a proposed coastal island development located near Fremantle, Western Australia, with a bold vision to be 'carbon free' and provide an international benchmark in sustainability. The proposed development was to be located on the seabed attached to the Fremantle harbour and will cover a total land area of 245.5 hectares, protected by a 3.5 kilometre breakwater, which will also provide protection from erosion to the current beaches. It was proposed to be a mix-use development providing over 10,000 residential dwellings. The islands were to be completely powered by renewable energy and employ new and innovative low carbon options for managing resources.

Figure 3.10. Aerial View of Proposed Position of NPQ.
Credit: Benchmark Projects Australasia

Eco-Claim

North Port Quay concept has had numerous carbon claims attributed to it, amongst them, 'carbon neutral' and the more ambitious title, 'carbon free'. The developers contend it would be a self-sustaining port-city and first carbon free development in the world.[46] Though, as with most ambitious claims, scepticism soon arose with many questioning the reliability of the claim, particularly regarding the emissions associated with the creation of an island (Fernandes, 2009). Nevertheless, the developers contend that the measures taken to reduce emissions cover the cradle to grave life cycle of the island.

Low Carbon Initiatives

In order to be carbon free, North Port Quay development intended to implement a variety of low carbon of initiatives. The initiatives would not only reduce the operational carbon footprint of the site, but will help to offset other unavoidable emissions associated with development, making the entire development carbon neutral approximately 11 years after construction and carbon positive thereafter. These initiatives included:

- using low carbon, local materials for the creation of the island including dredging spoil transported to the site using barges;
- energy and water efficiencies ranging across thermal design, appliances and lighting within buildings;
- 69 MW of solar PV on roof tops;
- 10.8 MW of commercial scale wind;
- improved public transport (including a light rail connecting to Fremantle) and 100 per cent electric vehicle uptake by NPQ residents;
- waste to energy through incineration and bio-digestion; and
- recycled water for irrigation, toilet and laundry uses.

Success

The concept for North Port Quay was proposed in 2008 by a consortium of land developers eager to showcase a state of the art, sustainable city concept.

[46] See http://www.northportquay.com.au

While the project's sustainability vision, ambition and intent were commendable, the project nonetheless attracted significant public and political opposition and became a highly controversial issue in Western Australia at the time. The main issues concerned the location of the development, with many vehemently opposed to the creation of an island. There was concern over the environmental degradation of the seabed during construction, the unquantified amount of GHG's that would result from the creation of the island, the degradation of current beaches and reduced amenity for the current local community (Kerr, 2011).

Many of the concerns were addressed during public consultation and were available under a "FAQ" section on the project's website.[47] Modelling and research undertaken within the ARC Linkage Project 'Decarbonising Cities and Regions' also found that NPQ could indeed become not only carbon neutral, but carbon positive, providing enough carbon free renewable electricity to power the island and well as feeding additional electricity into the grid to power a 9,300 homes in the neighbouring community (Newman et al., 2012). The development would be able to offset the emissions associated with the embodied energy in the materials used for the creation of the island and construction of buildings and infrastructure onsite in approximately 11 years.

Independent market research showed community support for the project sitting at approximately 70% in favour of the project, however, due to significant political opposition[48], the consortium decided to shelve the project indefinitely (Macdonald, 2012).

3.4 Discussion

3.4.1 Variations in Claims

As evidenced from the case studies above, the way in which each development, local council or city describes and asserts its carbon claim varies greatly. While some have a broader focus on sustainability (e.g., Vauban and B001), others have more carbon specific aspirations and targets (e.g., Masdar, NPQ, City of Sydney and Fremantle). For the developments that have a greater focus on carbon, further variations exist around the approach taken to measure emissions, i.e., whether they have

[47] See http://www.northportquay.com.au/FAQs/sample-faqs.html
[48] There are differing opinions about the level of support shown by the community.

adopted an operational perspective or a life cycle approach, and thus the sources of emissions they include in their analysis. Each development reported on various carbon related aspects, but the areas seemed to be chosen based on what was relevant to each individual case (i.e., as a way to demonstrate something they did well).

3.4.2 Comparison of Emissions Sources Included in Claims

In order to illustrate the differences between the emissions sources included in the case studies discussed, each case has been compared on the basis of six areas of emission sources. The results are demonstrated in Table 3 below. The analysis is based purely on whether measures were implemented within the case studies that addressed the selected areas, not on whether they actually calculated the emissions associated with that area.

Based on this comparison, energy and transport are the two most targeted areas. Every development targeted stationary energy in one form or another.

Transport was also mentioned relatively consistently, with many developments prioritising access to public transport, as well as ensuring that sufficient amenity existed close by and thus helping to discourage unnecessary travel by residents. Nevertheless, this is not consistent amongst all, nor was it clear how transport emissions were calculated. Some, like Dongtan, may indeed be much worse on transport than business-as-usual development.

Waste is also seen as relatively important. The two areas that were least considered were the construction process and embodied emissions in the materials, despite the growing percentage of emissions attributable to this area because of the improvements in operational energy efficiency (Sturgis & Roberts, 2010). This demonstrates that few developers or local councils adopt a full life cycle approach when targeting or reporting emissions.

Water was also frequently targeted, but the focus was often due more to the eco-system benefits than emissions reduction opportunities.

	Embodied Emissions	Construction	Energy	Water	Waste	Transport
BedZED	✔	✔	✔	✔	✗	✔
Vauban	✗	✗	✔	✗	✗	✔
B001	✗	✗	✔	✔	✔	✔
Hammerby Sjostad	✗	✗	✔	✔	✔	✔
Masdar	✔	✔	✔	✔	✔	✔
Dongtan	✗	✔	✔	✗	✔	✔
City of Sydney	✗	✗	✔	✓	✔	✔
City of Fremantle	✗	✗	✔	✗	✔	✔
North Port Quay	✔	✔	✔	✔	✔	✔

Table 3: Comparison of Emission Sources within Case Studies

The terminology used to describe the claims is also inconsistent, and common terms are not always well defined. Without having a set of clearly communicated and universally accepted definitions, terms will continue to confuse and lack meaning. This, together with the absence a common metric or framework for undertaking the carbon analysis, has made comparisons between the developments difficult and is likely to continue to result in suspicion and distrust in carbon claims, as evidenced in the cases of NPQ and Dongtan. Furthermore, the lack of follow-up and on-going evaluation also adds a layer of controversy and complexity as claims can quickly become out-dated and inaccurate, as shown in the case of BedZED. In Australia, false or misleading claims are liable for fines of up to $1.1 million from the Australian Competition and Consumer Commission (Australia Competition and Consumer Commission [ACCC], 2011).

3.4.3 Inconsistent Reporting

Another issue, which can lead to inaccurate claims, relates to the way case studies are documented. Ambitious, progressive and unprecedented case studies tend to draw significant attention and are widely documented and described in literature. However, as stories are reiterated and retold, facts, statistics and descriptions often become distorted with little follow-up or investigation into the claims being carried out. This was evident within this literature review, where conflicting numbers relating to emissions reductions were presented without original data sources being provided (e.g., in the case of Takahashi & Onishi, 2011). This can lead to varying, confusing data and exaggerated claims.

Williams (2009) acknowledged this problem and, using Dongtan as an example based on the considerable attention it drew worldwide, suggests that figures are often picked up and used without sufficient background research or investigation of where the figures came from, how goals are intended to be achieved or if they are indeed being achieved. Dongtan thus provides an apt example of the need for tangible carbon metrics that can demonstrate how even a proposed development is going to meet its carbon goals.

3.4.4 Problems with Scaling Up Low Carbon Developments

From the case studies examined, it appears there may be some additional issues associated with scaling up low carbon developments (Nader, 2009). Most of the developments examined had a population less than 10,000. Masdar and Dongtan are examples of attempts to create larger-scale eco-cities, but both have experienced difficulties. Masdar appeared to run out of funds after having completed only the first stage of the development, while Dongtan, which was going to be one of the largest eco-developments built, never actually began construction.

With increasing scale, comes increasing complexity, particularly around the management of resources. Currently, larger developments generally consume more than they can generate onsite. While this may not necessarily be the case into the future, we are yet to be presented with an example of an ideal, broadly replicable large-scale, low carbon development. However, Masdar, although often considered an unrealistic example of a low carbon city due to the large financial costs associated with the development, is nonetheless likely to be a great test bed for new low carbon technologies that can cater for larger populations, particularly if the development reaches the second stage. The fine grain data currently being collected by the ongoing monitoring and evaluation process of the largely experimental city, will help to inform and develop improved future designs of low-carbon cities.

3.4.5 Direction Needed

Regardless of the size, having frameworks and processes in place to direct developers to the areas that need to be targeted in terms of overall design and management of resources can help to create greater understanding of what makes a truly low carbon development.

3.5 Conclusion

From the case studies presented in this chapter, it is clear that significant variation currently exists in what developers target in terms of emissions reduction and, thus, which sources of emissions have been included in achieving their low carbon status. The lack of a common metric or framework for conducting carbon analyses, together with inconsistent terminology and lack of universally accepted definitions makes it difficult to compare developments and their claims. This can lead to suspicion and distrust in carbon claims, as evidenced in the North Port Quay example. Furthermore, without continuous follow up and evaluation, claims can quickly become out-dated and inaccurate.

This chapter highlights the need for a universal carbon accounting framework for precinct-scale development that identifies the specific areas that need to be considered and targeted by developers making carbon claims, as well as a standardised approach and methodology for quantifying those emissions. This will help to make carbon claims and assertions much more meaningful and comparable, bring greater credibility to the concept of low carbon developments and thereby increase the opportunity for them to become mainstreamed. Without this, certification will never be possible.

Chapter 4 – Carbon Neutrality and Key Measurements

4 Carbon Neutrality & Measurement: Key Considerations

4.1 Introduction

As outlined, there has been a significant increase over recent years in individuals, businesses, local governments and nations taking voluntary action to reduce greenhouse gas emissions. The motivation for voluntary action may vary from an intrinsic desire to protect the planet and the environment, to promoting corporate social responsibility (CSR), or simply wanting to take a lead in progressing climate change mitigation, often spurred on by the lack of action taken by governments worldwide (Rowell, 2010).

Voluntary climate change action can take many forms. It can be simple, inexpensive measures such as behaviour change initiatives like turning off lights and cycling to work, or it can be more investment-oriented action such as purchasing GreenPower™ or investing in energy efficient technologies (Newman et al., 2009).

Another voluntary emission abatement option that has grown significantly in popularity over recent years is the concept of carbon offsetting. Offsetting is based on the premise that carbon emissions from one activity can be effectively neutralised by investing in another low carbon or carbon free activity or carbon sequestration[49] in a different location, where it may be more cost effective or practicable than reducing emissions onsite from the original activity (Stern, 2006). The concept stems from the recognition that climate change is a global issue and greenhouse gas emissions have the same effect on the atmosphere wherever they are produced or abated (Garnaut, 2008). One of the most common reasons for purchasing carbon offsets is to claim carbon neutrality.

This chapter examines the rise in popularity of the concept of carbon neutrality as a way to voluntarily address climate change, and it highlights some of the main issues that have emerged as a consequence of its rapid growth. The lack of guidance around carbon accounting is identified as a significant problem, particularly for those working

[49] Carbon sequestration involves activities that absorb carbon emissions from the atmosphere such as tree planting.

within the built environment and specifically at the precinct scale. From the literature, a list of key considerations is provided, which, it is argued, should be taken into account and publicly disclosed by anyone making a carbon claim.

4.2 Evolution of the Carbon Neutrality Concept

4.2.1 The Rise of Carbon Neutrality

The concept of carbon neutrality emerged at a time of exceptionally high public awareness of climate change due to numerous government reports, e.g., the IPCC Fourth Assessment Report in 2007, the UK Stern Review in 2006, Australia's Garnaut Review in 2008, and prominent public figures such as Al Gore (An Inconvenient Truth in 2006). People and businesses eager to contribute and take action on climate change readily embraced the idea of carbon neutrality.

Countless companies and organisations around the world soon began offering the option of becoming carbon neutral. Online carbon calculators started to proliferate on the Internet, allowing people to calculate their carbon footprint, offset their emissions and become carbon neutral all in a matter of minutes (Murray & Dey, 2008). Businesses and organisations soon offered carbon neutral certification, providing a much sought-after branding opportunity for many carbon neutral customers. The Australian Federal Government also introduced the 'Greenhouse Friendly' initiative, which ran from 2001 until 2012[50], allowing businesses to market carbon neutral products and reward greenhouse gas abatement within various sectors of the economy (DCCEE, 2011a).

Carbon neutrality is now available for products, services, activities such as car use, air travel, household energy consumption and entire business activities (Wiedmann & Minx, 2008). Indeed, the concept became so popular that in 2006, 'carbon neutral' became the New Oxford American Dictionary's Word of the Year.[51]

4.2.2 Benefits of Carbon Neutrality

While the motivation for pursuing carbon neutrality may have originally stemmed from environmental concerns and the desire to promote green credentials,

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[50] Greenhouse Friendly has since been replaced with the National Carbon Offset Carbon Neutral Program, which commenced in July 2010 and is discussed more in Chapter 5.
[51] See: http://www.climatesciencewatch.org/2007/01/08/carbon-neutralnew-oxford-american-dictionarys-2006-word-of-the-year/

there are several other reasons why businesses and individuals are now choosing to go carbon neutral.

To begin with, understanding and reducing your carbon footprint - the first step in achieving carbon neutrality - can help save considerable costs on utility bills by identifying areas where wastage is occurring (see Box 1). Many individuals and businesses are often unaware of the inefficiencies associated with their homes, office buildings and operational activities. Understanding where the biggest sources of emissions are helps to identify potential problems areas and where to prioritise reduction efforts. Identifying leaks and inefficient appliances and equipment, as well as choosing the right electricity tariff, can save substantial costs on utility bills. Investa Property Group, a leading Australian Real Estate company, demonstrated how they managed to cut over $5 million in utility costs from better managing their buildings and facilities (Roussac & Kuiper, 2009). For many businesses, these financial savings can be significant and are often the primary motivation for seeking carbon neutrality.

Box 1. South Fremantle Senior High School: The first certified carbon neutral school in Australia

In 2012, South Fremantle Senior High School (SFSHS), a public school located in Western Australia, celebrated a momentous achievement: they became the first certified Carbon Neutral school in Australia under the Australian Federal Government's NCOS Carbon Neutral Program.

The school had been working towards this goal since 2007 when Curtin University Sustainability Policy (CUSP) Institute's Director Professor Peter Newman, and father of a student at the time, proposed the idea. The idea was readily embraced by the principal and several key community members and soon after created a Carbon Neutral Working Group, which has met fortnightly since its inception and has been paramount to the project's success.

Figure 4.1. SFSHS Carbon Neutral Working Group. Credit: Kathy Anketell

A Carbon Neutral Project Officer was employed to drive the carbon reduction initiatives including energy efficiency retrofits and renewable energy measures, all of which led the school to reduce emissions by approximately 15 per cent from 2007 levels. In 2008, the school switched their electricity to GreenPower – 100 per cent renewable energy – eliminating the emissions arising from traditional coal-fired power generation, dramatically reducing their overall emissions. This was supplemented with the planting of 30,000 trees in the wheat belt by students.

In 2011, the school decided to seek official Carbon Neutral Certification. Professor Peter Newman, who remains a key player within the committee, approached a fellow PhD candidate, Samantha Hall and I, to see whether we would assist with the certification process based on our knowledge of carbon accounting and GHG reporting. Together we undertook a comprehensive carbon audit of the school, ensured they purchased certified carbon offsets to eliminate the remaining emissions and helped them through the certification process.

In May 2012, the school successfully gained the official Carbon Neutral Certification through Low Carbon Australia, making it the first school and not-for-profit organisation in Australia to be certified. The achievement was celebrated with the Prime Minister in September 2012. At the event, the Prime Minister warmly expressed her appreciation that a community-based initiative had now demonstrated how to both save greenhouse gas emissions and save money.

The NCOS certification is a vehicle by which the school is fulfilling their vision. Their journey, including the establishment of a committee, the appointment of a Carbon Neutral Project Officer, the way they financed their program, how they are empowering staff and integrating carbon neutrality into all aspects of the curriculum, thus, providing innovative and practical learning opportunities for students, provides a valuable and inspiring model which can be applied to other schools.

Samantha and I felt privileged to be able to assist with the process and were delighted to receive an award from the Prime Minster recognising our involvement in the project. We are now exploring ways to help to make this a reality for all schools.

Box 1. South Fremantle Carbon Neutral Journey

There are also numerous ancillary benefits associated with reducing emissions, particularly within office environments. For example, emissions reduction measures, such as improving access to natural light and fresh air, not only help to reduce the electricity demand for artificial lighting and ventilation, but can also dramatically improve indoor environment quality (IEQ) (Fisk & Sepanen, 2007). Several studies and reports have linked improved IEQ to an increase in staff productivity (Fisk & Sepanen, 2007; Kubba 2012), and some of the observed IEQ effects include fewer sick days, greater staff retention rates and improved employee productivity. Greener buildings also often benefit from increased market value and higher rents (Eichholtz et al., 2008).

Finally, the process of going carbon neutral can help to minimise vulnerability to the financial risks associated with carbon, water and electricity price increases, and future legislation. With a price on carbon already in place in Australia, managing and reducing carbon within many sectors of our economy is already critical. For those not currently mandated to report and/or pay the carbon price, voluntarily choosing to go carbon neutral, and thereby calculating and reducing carbon emissions, will help prepare businesses for future regulatory and legislative requirements. These may include increasingly stringent building codes and the expansion of both mandatory energy disclosure for buildings in Australia and the National Greenhouse and Energy Reporting Scheme (NGERS). For many companies, the multiple benefits associated with pursuing carbon neutrality as outlined above simply make good business sense.

4.2.3 Voluntary Carbon Markets

The sudden popularity in the concept of carbon neutrality led to increasing demand for offsets, which contributed to the rapid emergence of the international voluntary carbon offset market.[52] This voluntary market, which began as a small, niche market around two decades ago, grew substantially as a result of the surge in voluntary action, and was supplemented by pre-compliance carbon markets.[53] It is now a multi-billion dollar industry (Department of Communities and Local Government, 2009a).

However, the rapid expansion of the unregulated, voluntary market also led to mounting credibility and validity issues over the 'Wild West' nature of the industry (BBC News, 2006). Businesses, individuals and governments became increasingly dubious of carbon claims, as well as of the legitimacy of the offsets being provided (Department of Communities and Local Government, 2009a). Numerous unscrupulous offset providers were exposed and a spate of offset scandals further eroded consumer confidence (Cubby, 2011; Struck, 2010).

To combat this, many new measures were put in place globally, such as rigorous carbon accreditation and certification schemes[54] and international greenhouse gas accounting standards to provide greater confidence in the quality of offsets. New registries and trading platforms[55] were also created to track and publish offset transactions so as to provide greater transparency to the international market. The Australian Competition and Consumer Commission (ACCC) released the 'Carbon Claims and the Trade Practices Act' (ACCC, 2008), a document which aimed to assist businesses to avoid false carbon claims and 'green-washing', and to increase consumer confidence in carbon claims.

The growing rigour and stringency of standards now underpinning the voluntary system is clearly having a positive effect on the market, with a recent international report stating that offset suppliers "transacted the largest market-wide volumes (131MtCO_2e) ever tracked" (Peters-Stanley et al., 2011, p. iii).[56]

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[52] The Voluntary Market involves transactions that are not required under regulation.
[53] Companies likely to be captured within compliance markets in the future, sometimes invest in voluntary markets as a way of preparing and future proofing themselves.
[54] For example the Verified Carbon Standard (VCS), The Gold Standard etc.
[55] For example The Carbon Trade Exchange (CTX), the Chicago Carbon Trade Exchange Offset Registry (CCX) and Markit®
[56] A larger number of transactions may have occurred in previous years, however, it is near impossible to determine without a tracking system in place.

Just as the international voluntary offset market has been significantly transformed over the past decade, so too has Australia's domestic voluntary carbon market. This is largely a result of significant changes to the political landscape in Australia, particularly over the past five years, which has seen:

- Australia's ratification of the Kyoto Protocol;
- the cessation of the Australian Greenhouse Friendly Initiative and introduction of the National Carbon Offset Standard and Carbon Neutral Program, which aims to bring greater standardisation to the offset market and to carbon neutral claims;
- the development of a set of guidelines, "Carbon Claims and the Trade Practices Act", released by the Australian Competition and Consumer Commission to help businesses avoid making false claims;
- new carbon price legislation, which includes a mandatory carbon tax, which will transform into an emissions trading scheme (ETS) in 2015, again impacting the eligibility of offsets; and
- the introduction of the Carbon Farming Initiative (CFI)[57], which will provide government-certified domestic offsets eligible for use under Australia's ETS, as well as supplying offsets to the voluntary market, which are eligible under the NCOS Carbon Neutral Program. (The national carbon offset standard and carbon neutral programs are discussed further in Chapter 5.)

The combination of these events has fundamentally changed the legal requirements around eligible offsets in Australia, thus altering the overall functioning of Australia's voluntary carbon market. This has repercussions for the concept of carbon neutrality in the Australian context.

4.2.4 Defining Carbon Neutrality

Despite the widespread use and prevalence of the term carbon neutrality within the public domain, there remains no universal definition, nor any widely accepted international certification system. As Murray and Dey (2008) note, the term currently appears to be 'defined by popular usage' (p. 238). Table 4 lists nine definitions of carbon neutrality.

[57] Offset projects eligible under the Carbon Farming Initiative must be in sectors not covered by the Carbon Price Mechanism.

SOURCE	DEFINITION OF CARBON NEUTRALITY	REFERENCE
Oxford Dictionary	"Making or resulting in no net release of carbon dioxide into the atmosphere, especially as a result of carbon offsetting."	Oxford Dictionary. (no date). Definition of Carbon Neutral. Retrieved from http://oxforddictionaries.com/definition/english/carbon-neutral?q=carbon+neutral [accessed 15/03/12]
Wikipedia	"Achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset, or buying enough carbon credits to make up the difference."	Wikipedia. (no date). Carbon Neutral. Retrieved from http://en.wikipedia.org/wiki/Carbon_neutral [Accessed 15/03/12]
Low Carbon Australia	"A situation where the net emissions associated with a product or an organisation's activities are equal to zero through the reduction of emissions and the acquisition and cancellation of carbon offsets that meet stringent criteria, to offset the remaining emissions."	Low Carbon Australia. (2011). Carbon Neutral Program Guidelines. Retrieved from http://www.climatechange.gov.au/government/initiatives/low-carbon-australia/ncos-carbon-neutral-program/carbon-neutral-program-guidelines.aspx [Accessed 22/08/12]
ICLEI	"A state where no net emissions are produced by a particular entity or activity during a particular time period."	ICLEI. (2009). Carbon Neutrality Framework for Local Governments. Retrieved from http://www.climatemayors.com/fileadmin/site_files/CarbonNeutral/Carbon_Neutrality_Framework-Aust.pdf [Accessed 02/11/12]
UK Department of Energy and Climate Change	"Carbon neutral means that – through a transparent process of calculating emissions, reducing those emissions and offsetting residual emissions – net carbon emissions equal zero."	Department of Communities and Local Government. (2009a). Guidance on Carbon Neutrality. Retrieved from http://www.decc.gov.uk/publications/DirectoryListing.aspx?tags=3
Murray, J. and Dey, J. (2008)	"Cancelling out the harm done to the earth's atmosphere by one type of greenhouse gas – generating human activity, through another human activity that: either reduces CO_2 emissions by an equal amount; or prevents an equal amount being generated by an essential CO_2 producing activity by substituting a non- or low carbon producing alternative."	Murray, J., and Dey, C. (2008). The carbon neutral free for all. *International Journal of Greenhouse Gas Control* 3:237-248
Rauch and Newman	"…no net carbon emitted to the atmosphere from institutional operation due to zero net fossil carbon use".	Rauch, J, N., and Newman, J. (2007), Defining sustainability metrics in an institutional setting. Retrieved from http://sustainability.yale.edu/sites/default/files/rauch_newman_2009.pdf [Accessed 26/10/12]
Zuo et al., 2011	"Carbon emissions from the energy consumption for materials and construction process, operation energy use, and those from tenant activities associated with building such as transportation requirements".	Zuo, J., Read, B., Pullen, S., and Shi, Q. (2012). Achieving carbon neutrality in commercial building developments – Perceptions of the construction industry, *Habitat International*, 36: 278-286.
Carbon Neutral Company	"Carbon neutrality, or having a net zero carbon footprint, refers to achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered, avoided or offset".	Carbon Neutral (UK Private Offset company). Retrieved from http://www.carbonneutral.com/knowledge-centre/carbon-glossary/

Table 4. Selected Definitions of Carbon Neutrality

As evidenced by the definitions above, the broad intention of carbon neutrality is to create a balance of carbon in the atmosphere in relation to the inputs and outputs of a product or service, or in the context of this research, a community, precinct or a city.

It generally involves reducing emissions as much as possible through means such as energy efficiency measures, or in relation to the built environment it may be through better building design, transport infrastructure, behaviour change or switching to renewable sources of energy, before offsetting the remaining, unavoidable emissions (for example, emissions embodied in materials of buildings and infrastructure) (DCCEE, 2011b; Newman et al., 2009).

The process of achieving carbon neutrality consists of three main steps as illustrated in Figure 4.2 measuring, reducing and offsetting emissions (DCCEE, 2011b; Department of Communities and Local Government, 2009a).

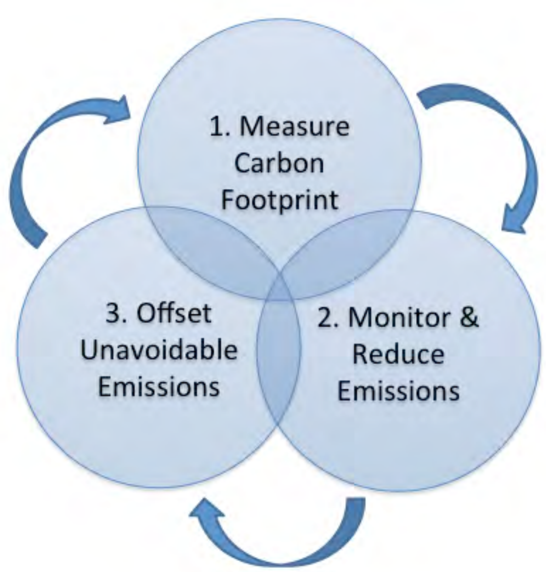

Figure 4.2. Graphical Representation of Carbon Neutrality

Calculating emissions is the first fundamental step in achieving carbon neutrality or any carbon reduction goal. As is commonly stated by those working in the field, 'you can't manage what you don't measure'. Identifying emission sources and calculating an initial carbon footprint is the first critical step in managing emissions, and is essential to the understanding and recording of where reductions can be made. The next step involves implementing measures to reduce emissions to the extent possible, before finally offsetting residual, unavoidable emissions. The process is generally undertaken on a regular (usually annual) basis in order to calculate and document the reductions.

Despite apparent consensus over the broad definition of carbon neutrality and the process involved, there remains significant variation in how the task is approached specifically, for example, how the carbon footprint is calculated (e.g., what sources are included) and to what extent emissions are reduced before being offset. This is discussed further in section 4.4.

4.2.5 Carbon Neutrality: How it has been Applied

Having evolved rapidly over recent years, the concept of carbon neutrality is now applied to emissions from a range of stakeholders and for a variety of different activities. Carbon neutral claims can be made for individuals, products, projects, services and entire businesses. Carbon neutral has even begun to permeate public policy, featuring in the 2007 UK Climate Change Bill, which required all new residential buildings from 2016 to be carbon neutral[58] (BBC News, 2006; UK Department for Communities and Local Government, 2008).

Several cities and developments around the world have also claimed carbon neutrality[59], as seen in Chapter 3. Even regions and entire nations are claiming the status. In 2007, the Vatican pledged to become the first Carbon Neutral state (Lean & Kay, 2008; Rosenthal, 2007)[60] and it was joined by New Zealand, Costa Rica, Norway and Iceland, all pledging and competing to be the first country to become carbon neutral (Lean & Kay, 2008). However, the way in which each has achieved, or intends to achieve, their claimed status often differs considerably, if it is explained at all.

New terminology has evolved as people have sought to create a point of difference and explain their carbon achievement in a unique way. The lack of consistency in definition remains a problem, even amongst those working in the building industry (Zuo et al., 2012), as does the lack of clarity regarding the emission inventory process, and how carbon neutrality (or the respective term) is ultimately achieved.

For example, Newton and Tucker (2010) propose a definition for carbon neutral residential buildings as primarily involving the operational energy requirements of the building (i.e., ensuring that a building produces enough carbon free energy onsite to

[58] This term later changed to become 'zero carbon'. The requirement has also been eased to a more voluntary standard.
[59] This is often as an aspirational target or goal to be reached in the future.
[60] However, carbon neutrality was never realized, highlighting the seemingly ubiquitous issue of green washing (Struck, 2010).

balance the fossil fuel energy drawn from the grid over a one year period), and others support this 'operational-focus' definition for buildings (see Sartori et al., 2012 and ABSEC, 2012). On the other hand, a growing body of research is calling for the embodied energy of buildings to also be taken into account (Crawford, 2009; Dixit et al., 2012; Hernandez & Kenny, 2009; Nassen et al., 2007; Zuo, 2012).

Despite considerable discussion occurring around the carbon definitions related to buildings, there has been little academic discussion on what this might mean or look like at the precinct or city scale - despite the growing industry focus on carbon reductions at this level (Ewing et al., 2008; Roseland, 2012; The Climate Group, 2010).

4.2.6 Precinct-Scale Carbon Claims

Countless developments around the world are demonstrating how to reduce carbon at the precinct level. However, as Chapter 3 has demonstrated, there is currently no consistency in the way to go about the process, how to measure and report emissions, or how to assert a carbon reduction or claim.

Most developments appear to concentrate predominantly on the carbon emissions associated with onsite energy production and use. Although many also take into consideration additional factors such as water and waste, these are not always represented in terms of carbon. The embodied emissions associated with the materials used in developments are rarely accounted for in carbon analyses, despite this being a growing area of emissions (Sturgis & Roberts, 2010).

Transport appears to play a significant role in lowering the per capita carbon footprint of residents living within the case studies discussed, particularly when compared to the citywide average. However, again this is not consistently documented in all developments, nor is it clear how emissions have been calculated.

The process to achieve carbon neutrality within the built environment as documented in the literature also varies. Boake (2008) suggests a three-step process as demonstrated in Figure 4.3.

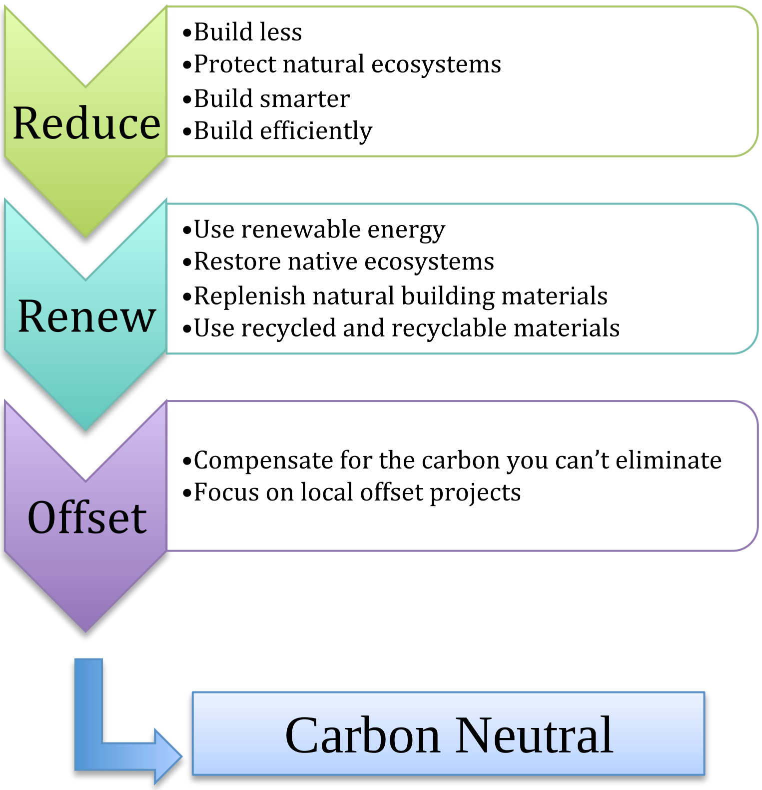

Figure 4.3. Process to Achieve Carbon Neutrality. Adapted from Boake (2008).

The inconsistent terminology, together with the lack of a common metric or framework for the carbon analyses, or a common process to reduce emissions, makes it difficult to compare developments and cities in terms of their carbon reduction. Therefore, in order to make any such assertions meaningful, comparable and legitimate, a standardised approach to quantifying the carbon emissions arising from precinct-scale development needs to be developed and promoted, as well as an ongoing evaluation process.

The following sections look at some of the main issues currently associated with carbon neutral claims, and provides an analysis of current and proposed GHG accounting frameworks, methodologies and initiatives aimed at bringing standardisation to the quantification of emissions at the precinct and city scales. An examination of some of the issues surrounding offsets is also provided.

4.3 Clarifying Carbon Neutral Precinct Claims

4.3.1 The Need for a Universal Definition and Accounting Framework

Despite the largely accepted, broad definition of the term carbon neutrality, the precise approach and methods required to undertake each specific step of the process, particularly in the case of urban development, remains unclear on several levels including:

- the specific GHG emissions that are covered (i.e. the types of gases);
- the various Scopes (i.e., direct or indirect emission sources – also known as Scope 1, 2 and 3 Emissions)[61] and boundaries of emissions; and
- whether or not carbon offsets are included and, if so, the degree to which emissions have been offset before being reduced.

Further detailed information around offsets is required, for example, whether they are produced onsite or purchased from a third party, and in the latter case, how credible the offset provider is (Department of Communities and Local Government, 2009a; Wiedmann & Minx, 2008). These and other factors are outlined in Table 5.

The case studies analysed in Chapter 3 illustrate that developments currently do not address these questions systematically, resulting in significant variation in their carbon definitions, goals and achievements. A universal process for determining what factors need to be addressed and clarified when making carbon claims at the precinct level would therefore go a long way in helping to overcome these issues. Kennedy and Sgouridis (2011) also identify the lack of definition and need of a carbon accounting framework for urban development, stating:

> Given the complexity of material and social interactions on an urban scale, we find that currently there are no concrete definitions upon which these claims can be measured and compared. Therefore, in order to make the ambitious targets of low and zero carbon emissions meaningful concepts in the context of urban planning, a carbon accounting framework needs to be rigorously defined and adapted to the urban scale (p. 5259-60).

[61] Scope 1,2 and 3 Emissions are defined by the Kyoto Protocol regulations & GHG Protocol as discussed later.

Determining the extent of the 'urban scale' in terms of emission boundaries is a challenging and often arduous process as boundaries can extend almost indefinitely. Moreover, the intricate and continually changing nature of cities, urban areas, precincts and the systems sustaining them, as well as the activities going on within them, make carbon calculations extremely complex (Brugmann, 2010; Kennedy & Sgouridis, 2011). Nevertheless, several attempts and proposals have been made to define these boundaries and calculate the carbon footprint of entire cities and urban areas (C40/ICLEI/WRI, 2012; ICLEI, 2009; Kennedy & Sgouridis, 2011; Ramaswami et al., 2008). These will be discussed shortly. First, however, an overview of the key issues associated with carbon footprinting/GHG accounting is provided, along with the methodologies currently underpinning the practice.

4.3.2 Defining the Carbon Footprint

Calculating the carbon footprint and establishing an emissions baseline is the first step in the process of achieving carbon neutrality and should be the basis for any carbon claim. To begin with, however, it is important to note the broad difference between a carbon footprint and GHG accounting.

A carbon footprint generally utilises a life cycle approach to calculating emissions and is most often applied to products. GHG accounting, on the other hand, focuses more on assessing the operational GHG emissions and is commonly represented in the form of a GHG inventory. The inventory approach is usually applied to organisations, services or individuals (Bolwig & Gibbon, 2009), and is predominantly based on The GHG Protocol (WRI & WBCSD, 2004). It is this approach that is most often applied to cities and local governments.

When calculating the emissions associated with a precinct-scale development, a carbon footprint approach appears to be a more appropriate choice, as it allows greater attention to be given to the physical aspects of the built environment as opposed to only focusing on the business activities within its boundaries. It can thus provide a far more detailed analysis of the precinct, including the choice of materials and resource management systems, thereby encouraging additional GHG abatement opportunities to be sought and thus stimulated throughout the economy. It should not just be buildings and infrastructure in isolation, it also needs to include the operational emissions associated with buildings, transport and resource management systems. Therefore, a combination of the two approaches is required. Some of the models being proposed that assess carbon within precincts are starting to include both of these emissions approaches (Beattie et al., 2012).

Nevertheless, the term 'carbon footprint', similar to the term 'carbon neutrality', is rarely adequately, rigorously or universally defined (Lean & Kay, 2008; Struck, 2010; Wiedmann & Minx, 2008). Wiedmann and Minx (2008) identify and discuss numerous issues that should be considered and clearly communicated when defining a carbon footprint or a GHG inventory. These issues, along with other key issues identified in the literature (Australian Sustainable Built Environment Council [ASBEC], 2011; East, 2008; Department of Communities and Local Government, 2008, 2009; Kennedy & Sgouridis, 2011; WRI & WBCSD, 2004), are provided in Table 4 and discussed in more detail below.

	Issue	Description
	GASES	*Which gases are included? For example, only carbon dioxide (CO_2) or multiple greenhouse gases (CO_2-e)?*
	MEASUREMENT UNITS	*What unit is the carbon footprint measured in? Is it in weight (e.g., tonnes) or area (e.g., global hectares)?*
	ACCOUNTING METHODOLOGY	*Is an inventory approach or a Life Cycle Analysis (LCA) used? If LCA is chosen, which methodology, i.e. Process Analysis (PA), Environmental Input-Output (IEO) Analysis, Hybrid EIO-LCA?*
	BOUNDARIES	*What are the overall system boundaries? I.e. Does it include only operational emissions or are supply chain emissions, such as the embodied emissions in materials included?*
	SCOPES	*Which Scopes of emissions are included? Direct and indirect? Scope 1, 2 and 3?*
	TIMEFRAME	*If LCA is used, what is the lifetime given to the embodied emissions in buildings and infrastructure?*
	EMISSIONS REDUCTION	*Are there targets set for emissions reduction? What are the allowable emissions reduction options?*
	OFFSETS	*Are offset included? If so, is there a limit? What offsets are eligible? Are they certified, credible offsets?*

Table 5. Key Considerations for Carbon Footprint and Definitions. Adapted from ASBEC (2011), East (2008), Kennedy & Sgouridis (2011), Wiedmann & Minsx (2008), WRI & WBCSD (2004)

The degree to which carbon footprints and inventories vary depending on the inputs and decisions made in relation to the issues outlined above can be substantial. These issues need to be sufficiently addressed and clearly articulated within the definition and/or description of the process of how a carbon goal is achieved.

A brief analysis of these key issues is provided below, specifically in the context of the built environment and urban precinct development.

4.3.3 Key Considerations for Carbon Footprint Definitions

Gases

The first clarification required when defining a carbon footprint relates to the types of gases covered. In their paper 'A Definition of a Carbon Footprint', Wiedmann and Minx (2008), question whether a carbon footprint, to be represented accurately, should include only gases that contain the carbon molecule (i.e. CO_2, CH_2, CH_4). However, this would mean disregarding other potentially potent GHG's such a N_2O. The authors, however, confine this even further by proposing their own definition of a carbon footprint as consisting exclusively of carbon dioxide, largely for simplicity. They suggest that for calculations involving multiple greenhouse gases, a more appropriate title would be 'climate footprint' (Wiedmann & Minx, 2008). Nevertheless, most carbon footprint calculations and definitions within the public domain consider a range of greenhouse gas emissions, predominantly the six GHG's identified and covered under the Kyoto Protocol (see Table 5).

Kyoto Greenhouse Gas	Chemical Formula	Global Warming Potential	Major sources (examples)
Carbon Dioxide	CO_2	1	Fossil fuel combustion, land use change, cement manufacturing
Methane	CH4	21	Natural gas, coal mines, anaerobic decomposition of organic waste
Nitrous Oxide	N2O	310	Fertilisers, agriculture, combustion
Perfluorocarbons	(7 types)	7,000	Electronics, aluminium production
Hydrofluorocarbons	(13 types)	11,700	Refrigerants
Sulfur Hexafluoride	SF6	23,900	High voltage switchgear

Table 6. The six Kyoto Greenhouse Gases and their Global Warming Potential

As each GHG has a different effect on the atmosphere, a specific global warming potential (GWP) is given to it. The GWP is determined based on the impact each gas has on the atmosphere over a 100-year period, compared to a reference gas. Carbon dioxide has been elected as the reference gas and thus has a GWP of one (East, 2008; Garnaut, 2008). This ensures that all gases are comparable and additive (Galli et al., 2011). The GWP for the six GHG's covered under the Kyoto Protocol, which are the most common choice of gases for GHG reporting, are listed in Table 5.

By standardising the units, more consistent and straightforward emission calculations can be made using a single calibrated unit. These gases are thus represented as carbon dioxide equivalents (CO_2-e), and this is the dominant unit used in carbon calculations.

This thesis proposes that a carbon footprint (and any subsequent carbon claim) for the built environment and precinct-scale development should contain the six main GHGs as outlined in the Kyoto protocol. There are several reasons for this.

Firstly, as demonstrated in Chapter Two, emissions attributable to the built environment stem from a variety of different emission sources, and these produce various types of emissions. Therefore, in order to obtain a comprehensive emissions profile, as many of these sources should be included as practicable. For example, many of the emissions reduction opportunities existing within the built environment often involve switching gases (e.g., from coal to gas), each with a varying GWP, or managing resources more efficiently (e.g., capturing the methane from organic waste to use as energy), thereby demonstrating the need for a range of gases to be incorporated into carbon calculations.

Secondly, by ensuring that the carbon accounting process aligns with already established protocols and mandatory emission reporting frameworks (such as the Kyoto Protocol, Australia's NGERS Framework and the Government's NCOS Carbon Neutral Program), participants who are already required to comply with or are voluntarily using an existing scheme can benefit by using the same information and accounting methods and tools. Organisations, local councils and developers who voluntarily undertake a carbon audit or footprint that is based on methods used in existing regulatory frameworks (i.e. NGERS) help prepare and future-proof themselves for a time when changes to regulations occur.[62]

Measurement Units

The concept of a carbon footprint originated from the ecological footprint model developed by Rees and Wackernagle (1996), which was measured in global

[62] As stipulated in the National Greenhouse Gas and Energy Reporting Scheme guidelines, the reporting threshold will reduce over time to capture additional sectors and organisations.

hectares. However, in order to be consistent with other types of GHG or carbon measurement and reporting processes, the measurement unit chosen for carbon footprinting has been in weight or mass (i.e. kg or tonnes of CO_2 or CO_2-e). Therefore, as Hammond (2007) suggests, a more accurate term would be 'carbon weight' as opposed to 'footprint', which intuitively makes one think of land area. However, the term 'footprint' is likely to remain the popular and preferred word despite its unusual measurement unit, as it is much more visual and easier to understand and hence, more meaningful than the idea of carbon as weight. Another benefit of using the term footprint is the underlying connotation of a footprint representing a legacy, i.e., the long-term impact carbon has on the earth and atmosphere.

Carbon footprints are primarily measured in metric tonnes as they usually represent significant quantities of gas. However, they are generally converted to kilograms during the calculation process as emission factors are primarily provided in this smaller unit (DCCEE, 2011c). If the measurement is being used to describe small quantities, such as the carbon footprint of a product, the measurement unit is usually kept in kilograms (Bolwig & Gibbon, 2009).

A recent carbon footprint undertaken for a local high school (Box 1) demonstrated that many of the emission factors provided in publicly available Australian documents were not suitable for small-scale operations and thus made emissions calculations difficult (Rauland & Hall, 2012). This is most likely due to the fact that most of the GHG emissions factors, calculations and reporting guidelines are geared towards large emission-intensive industries such as energy generation, refining, mining and other energy-intensive materials-based manufacturing. These companies and activities are generally captured under mandatory reporting (i.e. NGERS) and the recently introduced carbon pricing legislation. This lack of data available for smaller scale activities, such as the appropriate emissions factors, may prove to be an issue for land developers wishing to report emissions for their developments.

Accounting Methodology

As discussed earlier, GHG accounting methodologies vary depending on the entity being assessed. Organisations, services and personal carbon footprints generally follow an inventory style GHG accounting approach, which focus primarily on the operational emissions. This approach is largely based on The GHG Protocol: A Corporate Accounting and Reporting Standard (WRI & WBCSD, 2004), which also underpins the various Australian and international GHG accounting Standards, e.g., ISO 14064-1 (ISO, 2006) and AS/NZS I46064-1 (Standards Australia, 2006). More information about the boundaries and Scopes of emissions associated with this GHG accounting methodology are provided in sections 3.3.4 and 3.3.5 below.

Cities and local governments tend to adopt this operational inventory approach when measuring their emissions, as it is far less complicated than undertaking a full life cycle GHG assessment (Hoornweg et al., 2011; ICLEI, 2010). This is particularly important for cities, which are already such large and complex systems (Dhakal, 2010; Kennedy & Sgouridis, 2011).

A life cycle inventory analysis is the other predominant GHG accounting methodology, and involves examining emissions along the entire supply chain, from production and acquisition of raw materials, to transport, manufacturing, storage and ultimate disposal. This approach is most often applied to products (DCCEE, 2011b, Matthews et al., 2008).

It is argued that precinct-scale development would benefit from using both approaches; a life cycle approach in quantifying emissions would be needed due to the significant emissions attributed to factors such as materials, construction processes and the resource management systems underpinning a development. At the same time the design of buildings, density and mix of the development will largely determine the operational GHGs, including transport GHG outcomes and the building GHGs. Understanding the entire footprint of a development allows developers to identify the easiest carbon abatement opportunities (i.e. switching materials, processes or technologies as well as the density and mix issues). Developers are therefore able to make the greatest reductions to their carbon footprint through more informed purchasing and planning decisions (Matthews et al., 2008).

There are several methodologies and ways to undertake a Life Cycle Analysis, which can lead to very different GHG outcomes (Nässén et al., 2006). The main approaches include Process Analysis (PA), Economic and/or Environmental Input-Output (EIO) Analysis, or a Hybrid EIO-LCA (Berner-Lee et al., 20011; Matthews et al., 2008). Process Analysis is the most commonly applied method for conducting a Life Cycle Analysis and involves systematically identifying and quantifying all emissions along the supply chain, beginning with direct emissions before tracking all indirect emissions. While this process provides superior specificity in terms of data collection and overall numbers, the comprehensiveness of the process (i.e., including each section of the supply chain that has its own additional set of inputs/outputs) means that the analysis is very time consuming as it could theoretically continue indefinitely (Berners-Lee et al., 2011).

Economic Input-Output Analysis is another widely used approach, which uses large-scale, aggregate data based on industry sectors within an economy. The information is gathered using financial expenditure, i.e., by examining each sector's interdependence based on their financial transactions.[63] If the EIO data for each sector is available and a sufficient accounting system is in place for the product being examined, this method can prove relatively easy compared to the PA approach (Berners-Lee et al., 2011). Nevertheless, such large data sets mean averages must be used, which limits the overall accuracy of the approach.

The EIO is often referred to as a top down approach while the PA is seen as a bottom up approach. A hybrid of these two models has also been suggested as a way of overcoming the limitations and weaknesses of both approaches and benefitting from their strengths. A Hybrid EIO-LCA involves using the basic EIO approach but, instead of utilising the broad sector data, it is "augmented with impact data for specific goods, services, and organisations" (Matthews et al., 2008, p. 5840).

A typical life cycle assessment approach may not necessarily be the most appropriate choice for precinct development, given the complexity associated with assessing multiple emission sources within a precincts boundary. It is therefore suggested that a hybrid approach would be the most suitable option for development, which effectively follows the Hybrid EIO-LCA described above. Adopting a hybrid approach for calculating the emissions associated with construction is also recommended in the Federal Government's National Carbon Offset Standard Carbon Neutral Program (DCCEE, 2011b).

There are several tools that can assist in undertaking the calculation process. These are discussed in Chapter 5.

[63] By analyzing the financial transactions of one industry, additional industries and sectors can be identified that may need to be included in the analysis. This is essentially identifying supply chain emissions.

Boundaries

Determining the boundaries of a carbon footprint or GHG inventory is one of the first steps in any carbon accounting process and the absence of agreed boundaries is one of the key causes of inconsistency among carbon precinct claims. Boundaries can be set at various levels. If the focus is on corporate carbon accounting, two levels of boundaries need to be established - the organisational boundary and the operational boundary. If a life cycle carbon analysis is the chosen methodology, boundaries are not generally associated with organisational or operational control but with the supply chain. As highlighted above, determining clear boundaries associated with the life cycle approach is critical as boundaries are essentially infinite (Matthews et al., 2008).

An organisational boundary is determined based on full ownership or financial control of the organisation. The GHG Protocol: A Corporate Accounting and Reporting Standard (WRI & WBCSD, 2004) outlines two approaches for establishing organisational boundaries, the 'Equity share approach' and the 'Control approach'. The equity share approach requires corporations who have equity in other organisations, subsidiaries, partner or joint ventures to report emissions from those companies depending on the percentage they own. The control approach only requires corporations to report on emissions from organisations, subsidiaries, partner or joint ventures that they have financial or operational control over (WRI & WBCSD, 2004).

The organisational boundary is not applicable to precinct-scale land development if the aim is to achieve carbon neutrality. While a developer will be responsible for the majority of the emissions associated with the construction of a development, there are several additional emission sources that would not be captured under this boundary approach, such as the emissions generated from the utilities supplying resources to the area (e.g., energy, water and managing waste).

The operational boundaries outlined in The GHG Protocol (WRI & WBCSD, 2004) are those emissions associated with the operations of the company/corporation, once they have identified their organisational control. These emissions are generally identified using 'Scopes', which are discussed in more detail below. Taken together, the organisational and operational boundaries represent the overall system boundary of an organisation.

Again, in relation to precinct development, neither of these boundaries are likely to be relevant, as a precinct, particularly after construction, is likely to consist of multiple owners, stakeholders and organisations, which all ultimately contribute to the emissions profile of the precinct.

An additional boundary that is often discussed in relation to local governments and cities is the geographic and geopolitical boundary, which consists of the official jurisdictional boundaries of the physical land area associated with a local government or city (ICLEI, 2009). Kennedy and Sgouridis (2011) also discuss the issue of geographic boundaries in relation to carbon accounting in cities, stating that:

> A city is a dynamic and complex system, defined in part by its geographic boundaries, but also by its interconnections with a much broader region through exchanges of materials, energy, and information. This interconnectedness complicates the task of determining which emissions should be included in a city's carbon balance. (p: 5261)

The boundary issue often stimulates discussion around GHG attribution (i.e., whether emissions should be accounted for at the place of production or consumption), and this is discussed further in 5.

With respect to transport, a precinct can only have limited responsibility from an organisational perspective, but from a local government's perspective it is very important. Thus, in order to achieve compliance with local governments carbon reduction goals, a developer may have to accept that there is a role for them in terms of urban design, density and mix, which will have an impact on the carbon outcomes. While the provision of infrastructure for public transport has historically been a state or federal responsibility, in the future it is likely to require some kind of partnership approach and will cross boundaries beyond most precinct plans.

Scopes

Emission sources are broadly split into two categories, direct and indirect emissions. Direct emissions are those that occur onsite or through activities that are under the full control of an organisation. Indirect emissions are those that are produced by a separate organisation/entity (e.g., electricity production or emissions from aircrafts) but still occur as a result of demand by the first organisation/product (WRI & WBCSD, 2004).

The concept of Scopes for emissions was introduced as a way of dealing with direct and indirect emission sources in order to avoid issues associated with double counting. Double counting occurs when the same emission sources are counted twice by different organisations, and is principally only an issue if the emissions are being reported under a mandatory reporting or emissions trading scheme (WRI & WBCSD, 2004). It is less consequential if emissions are being voluntarily reported, and indeed, it is argued that the more indirect emissions that are included under voluntary reporting, the better (DCCEE, 2011b).[64]

Emissions are thus defined as Scope 1, Scope 2 and Scope 3 emissions as depicted in Figure 4.4. Scope 1 emissions are direct emissions from sources within an organisation's direct control. Scope 2 are indirect emissions from electricity production and Scope 3 emissions are indirect emissions from all other activities related to the organisation. Mandatory reporting in Australia (i.e. under the National Greenhouse and Energy Reporting Act) requires covered sectors and organisations to report only their Scope 1 and 2 emissions. This is because the majority of the emissions produced in large, emission intensive industrial companies come from Scopes 1 and 2 sources.

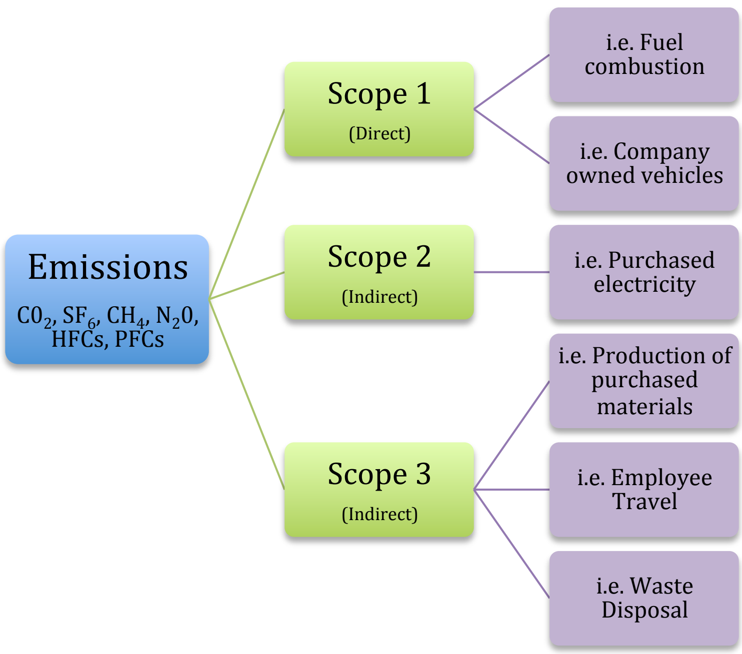

Figure 4.4. Overview of Scopes and Emissions. Source: Adapted from WRI & WBCSD (2004)

[64] This provides a more accurate representation of the entire emissions attributed to an organisation or product.

For the goods and services sectors, however, Scopes 1 and 2 can represent less than 25 per cent of their total emissions (Matthews et al., 2008). Therefore, if companies voluntarily choose to report or make carbon claims, particularly, for carbon neutrality, certain Scope 3 emissions should be reported. However, there is still a degree of flexibility in terms of which Scope 3 emissions are accounted for.

While a GHG inventory approach to calculating emissions may include some Scope 3 emissions, depending on the organisation's discretion, a life cycle approach must include all Scope three emissions contained along the supply chain and within the boundary of the product. More discussion on Scopes is provided in Chapter 5, in examining Australia's Carbon Neutral Certification.

Timeframe

Another aspect requiring clarification is the timeframe in which a development will reach carbon neutrality. Buildings are often given a 'lifetime' (i.e., typically 50 years), which forms the basis for the Life Cycle Analysis. This ultimately determines how the emissions that are attributed to the building are spread over the lifetime of that building, and thus how long it will take to achieve carbon neutrality (ASBEC, 2011).

Furthermore, timeframes are also needed when determining payback periods, which is particularly significant considering green buildings and developments generally require higher upfront financial expenditure due to the more innovative technologies and designs. It is important to understand the relationship between the higher upfront costs and the long-term savings that occur as a result.

It is likely to be considerably more difficult to establish a timeframe for an entire development compared to a building, due to the different lifetimes associated with different types of infrastructure, for instance, buildings, roads, technologies and resource management systems (Sturgis & Roberts, 2010). However, it is a critical element to understand and establish, as it will determine the timeframe by which the development can legitimately reach carbon neutrality and the offsets required to attain it. Operational energy is an important part of this timeframe.

In terms of GHG reporting and particularly carbon neutrality claims, the timeframe applied is generally annual, as it is often based on operational emissions. This thesis therefore recommends a combined life cycle and operational approach to calculating GHG emissions, as a development claiming carbon neutrality is likely to be required to report annually.

Emissions Reduction

Reducing emissions can be done internally or externally. Internal emissions reduction may consist of onsite energy efficiency measures, fuel switching, changing suppliers (i.e., choosing suppliers with the lowest carbon footprint), installing renewable energy onsite and purchasing certified green electricity (Department of Communities and Local Government, 2009b). External emissions reduction is generally identified as offsetting, which is discussed below.

Internal emissions reduction forms a critical part of the carbon neutral process and is generally required by most schemes to be demonstrated prior to offsetting (City of Sydney, 2011; DCCEE, 2011b; Department of Communities and Local Government, 2009a; The Carbon Neutral Company, 2012).

Offsets

The term offsets typically refers to the purchase of carbon abatement credits from projects that are outside the operational control of the organisation wishing to reduce their emissions. The Federal Government has defined carbon offsetting as "reductions or removals of greenhouse gases from the atmosphere by sinks, relative to a business-as-usual baseline. Carbon offsets are tradeable and often used to negate (or offset) all or part of another entity's emissions" (DCCEE, 2012b).

In terms of the built environment and urban precinct development, it is likely that offsets will be required, at the very minimum, to neutralise the emissions associated with the embodied energy within the materials used to create the development. Offsets could also be used to counteract emissions associated with other aspects of the development (e.g., operational emissions, if the developer chose to source the energy required for the precinct from the current fossil fuel-dominated electricity grid). However, as mentioned above, most carbon neutral schemes and standards specify that internal emissions reductions should be pursued as much as possible prior to offsetting, which often means addressing operational emissions.

There are currently no specified limits regarding the amount of offsets that can be purchased compared to onsite emissions reductions, although there are guidelines around which offsets are eligible under certain standards (see Chapter 6).

It is common within the development industry to classify surplus renewable energy generated onsite and fed into the grid as a carbon offset that can then be used against other emissions sources within the development, such as embodied emissions in materials (Williams, 2012). This is often referred to as 'netting' (Sustainability Victoria, 2012), and involves balancing the carbon used onsite with sufficient carbon free renewable electricity *produced* onsite and exported to the grid over a one year time period. The development is thus, 'net zero' on an annual basis (Hernandez and Kenny 2009, Williams 2012).

However, this concept is generally not accepted under official carbon neutral certification schemes, which use internationally recognised protocols for offsetting, such as the Australian Government's National Carbon Offset Standard (discussed in greater depth in Chapter 6). This is because such offsets (i.e., energy related) are not considered to be additional forms of abatement[65], as the energy sector in Australia is a covered sector under the Federal Government's current Carbon Pricing legislation, and thus any action to reduce emissions from this sector is argued to have occurred anyway due to the mechanism already in place (DCCEE, 2012b).

A developer can still use this 'netting' concept as a way of generating their own offsets to achieve carbon neutrality, but they will not be able to achieve this status through the Government's NCOS Carbon Neutral scheme or other schemes that require stringent offsetting standards.

The development of other kinds of local offsets (i.e. those created within a precinct or community) may seem like a logical option to pursue, however, all such offsets need to meet the 'additionality' criteria defined under the standards to be deemed eligible. Unfortunately, there are few options available for developing offsets from city/community-based activities under NCOS, although, there is nothing preventing communities from developing and using these offsets (as long as they provide a clear methodological approach to calculating emission reductions) to claim carbon neutrality without NCOS branding/certification. More information about offsets is provided in the following section.

4.4 The Offset Polemic

As discussed at the beginning of this chapter, the concept of carbon offsetting has grown considerably over the last decade, leaving in its wake a thriving voluntary carbon offset market. However, there have been concerns and issues along the way, particularly relating to transparency and credibility resulting from the initial unregulated

[65] As required by the National Carbon Offset Standard.

nature of the voluntary carbon market[66] (Lovell et al., 2009; Moore, 2009; Murray & Dey, 2008). However, this market has rapidly matured over recent years with radically improved processes, structures, standards and regulations now underpinning it (Peters-Stanley et al., 2011). Nevertheless, there are still many who oppose offsetting, contesting the fundamental principle and concept of it. These issues and others are discussed below.

4.4.1 The Perceived Fundamental Flaw

The rapid development of the voluntary offset market clearly demonstrates the appeal of carbon offsetting by companies and individuals as a way of exhibiting environmental commitment and action. However, not everyone remains convinced of the virtues of it. Smith (2007) relates the concept to the story of the Pardoners in the Middle Ages who sold the benefit of their good deeds to sinners who could purge themselves of their indulgences for a fee, allowing sinners to continue transgressing. More recently, a parody of carbon offsetting was made using cheating as the commodity (see cheatneutral.com), which allows one couple to offset their infidelities using another couple's fidelity and faithfulness. Murray and Dey (2008) point out that in both situations, there is no net reduction of the sinning, transgressions or heartache, there is only a balancing of the commodities.

Friends of the Earth also stand deeply opposed to the concept of offsetting, arguing that it causes more harm than good (see Bullock et al., 2009). They contend that it will not lead to overall emissions reductions, suggesting it merely legitimises the idea that people who can afford to pay others to reduce their emissions, can do so and thus continue to pollute as normal. They also suggest that it delays investment in essential infrastructure, particularly in developed countries where investment may have gone ahead regardless, but now waits to determine if a project is eligible to generate offsets. Finally, they argue that carbon offsetting institutionalises the idea that emissions reductions can occur in either developed ***or*** developing countries, ignoring the scientific recommendation that reductions are urgently required in all locations (Bullock et al., 2009).

[66] The mandatory offset market, represented by offsets generated under Kyoto Protocol's Clean Development Mechanism and Joint Implementation, have had a significant degree of regulation and stringency since their inception.

However, as carbon offsetting is based on the premise that emissions have the same effect on the atmosphere wherever they are produced or abated in the world, it is argued, particularly by economists, that the least cost carbon abatement opportunities should always be pursued first, regardless of their location. Thus, if it is cheaper to reduce emissions offsite through offsets than through onsite emissions reduction measures, the cheaper option should always be the preferred choice. It naturally follows that the price of offsets will increase over time as offset projects become scarcer (e.g., tree planting) or projects become ineligible (e.g., if replacing light bulbs in India becomes the norm and no longer considered 'additional'), making domestic, onsite carbon abatement more financially viable.

Both arguments are valid, and will no doubt continue to be contested. Most carbon neutral schemes, however, do strongly recommend that in-house emissions reduction options be pursued prior to offsetting.

Lovell et al (2009) also analyse the concept of offsetting in relation to sustainable and ethical consumption. They examine both the notion of nature as a commodity, which looks at the implications of marketing 'the environment', as well as the effect offsets have on driving behaviour and consumer's choice of products. Their analysis proposes that the voluntary offset market is indeed a complex and uncertain one, but that ultimately it can help to shape behaviours by making people aware of the effect their everyday, often mundane actions, such as driving a car, has on the environment and atmosphere.

It is also worth mentioning that some offsets, such as biomass plantings (e.g., CDM projects in developing countries and other voluntary offsets in developed countries) can have substantial co-benefits such as increasing local biodiversity and the reducing land degradation (Karousakis, 2009).

4.4.2 Structure of the Offset Market

There are two types of offset markets, the regulated, compliance market and the voluntary offset market. Compliance markets include mandatory regimes such as the Kyoto Protocol as well as regulated trading schemes such as the European Union Emissions Trading Scheme (EU ETS). The primary offset standards eligible under the compliance market are the Clean Development Mechanism (CDM) and Joint Implementation (JI), which produce offset units called Certified Emissions reductions, or CERs. There is generally a limit within compliance markets regarding the amount of offsets allowed to be purchased to meet a company's or country's obligation (Moore, 2009).

The voluntary market allows a range of offset standards, which produce various tradable units. Broadly grouped as Voluntary (or Verified) Emissions reduction units (VERs), they also include VCUs, RMUs and Australia's ACCUs and are traded through what is broadly termed the Over-The-Counter (OTC) Market (Peters-Stanley et al., 2011).

Table 6 highlights some of the primary offset standards and schemes as well as the markets they trade in, showing that many standards are used in both voluntary and compliance markets.

Certification Scheme	Type of Credit	Voluntary Market	Compliance Market	International
Clean Development Mechanism (CDM)	Certified Emissions reduction (CER)	√	√	√
Joint Implementation (JI)	Emissions reduction Units (ERU)	√	√	√
Reducing Emissions from Deforestation and forest Degradation (REDD) >Developing Countries Land Use, Land Use Change and Forestry (LULUCF) > Developed Countries	Removal units (RMU)	√	X	√
The Gold Standard	Verified Emission Reduction (VER)	√	X	√
The Verified Carbon Standard (VCS)	Verified Carbon Unit (VCU)	√	X	√
National Carbon Offset Standard (NCOS)	A range of voluntary units acceptable	√	√	X
Australia's Carbon Farming Initiative	ACCU	√	√	X

Table 7. The Primary Offset Standards and Their Types of Credits.
Adapted from Carbon Offset Guide Australia (n.d.)

4.4.3 The Voluntary Carbon Market - Integrity of Offsets

While offsets generated for use in the compliance market have been relatively well regulated from the beginning, Murray and Dey (2008) expressed concern about the rapid expansion of the voluntary carbon market. They questioned the integrity of offsets generated in this market, suggesting there was insufficient infrastructure, standards and frameworks in place to deal with a range of issues such as additionality, eligibility requirements of offsets (e.g., how long should a tree be in the ground), carbon accounting methodologies (i.e., how to calculate the emission abatement potential of specific projects) and how to trade voluntary offsets, with the assurance that offsets are not sold twice. Fortunately, since expressing this original concern in 2006, most of these issues have been addressed with a relatively high degree of rigour (Peters-Stanley et al., 2011). There are increasingly stringent standards now underpinning the voluntary carbon market and new internationally peer-reviewed methodologies are constantly being developed for a range of carbon offset projects. Furthermore, a growing number of offset providers (over 66 per cent in 2010) are using reputable carbon registries to retire their transacted carbon credits in order to demonstrate greater transparency and credibility (Peters-Stanley et al., 2011).

Another option for voluntary market participants proposed by Kollmuss and Lazarus (2010) involves the voluntary purchasing of tradable 'allowance units' from compliance markets (i.e., government administered emission allowances that are distributed under a cap and trade scheme), instead of offsets generated in the voluntary market. Allowing voluntarily purchases of compliance units avoids issues of double counting and other integrity issues often associated with voluntary offsets (Bullock et al., 2009; Moore, 2009), as well as having the added benefit of compelling covered sectors to undertake greater in-house emissions reductions since the overall amount of units available to the compliance market would be reduced (Kollmuss & Lazarus, 2010).

Moore (2009) discusses the key issues surrounding voluntary carbon offsets in depth and clearly lays the foundation on why a standard needed to be introduced. In 2010, the Australian Federal Government introduced the National Carbon Offset Standard, which effectively addressed the issues highlighted in her paper. This standard is discussed in Chapter 7.

4.5 Conclusion

This chapter examined the rise in popularity of the concept of carbon neutrality, which was largely a result of the sudden emergence and growth in the voluntary carbon offset market.

A review of carbon neutral definitions highlighted a common understanding of the term and broad consensus over the general process (i.e. measure, reduce, offset/neutralise), few definitions explained in detail how carbon neutrality should be achieved. This was particularly evident in the case of the built environment and precinct development, as most carbon neutral definitions were tailored more to businesses and individuals.

A variety of factors that need to be considered when undertaking a carbon analysis were identified, which, without a consistent approach in addressing them, could result in different carbon outcomes for the same project. The main issues requiring consideration specifically in the context of precinct-scale urban development in Australia were discussed, along with some current issues associated with the generation of offsets for the urban development sector.

These issues raised in this chapter made it clear that a consistent approach and framework for determining the GHG emissions associated with urban development is required. It also highlighted the need for a specific process that can acknowledge the unique opportunities for innovative onsite carbon reductions that exist at the urban precinct level, which are currently not accepted under voluntary carbon offset schemes.

Chapter 5 – GHG Accounting Frameworks and Rating Tools for Cities and Precincts

5 GHG Accounting Frameworks and Rating Tools for Cities and Precincts

5.1 Introduction

Determining the carbon footprint or greenhouse gas emissions associated with a product or organisation can be a complex undertaking, as demonstrated by the variety of issues discussed in Chapter 4. However, addressing these issues at a precinct, community or a citywide scale is a considerably more difficult task as the magnitude of each issue increases. Nevertheless, despite this challenge numerous attempts have been made by academia, industry, cities and local communities to classify these emissions in order to better understand the GHG contribution of urban development at the various levels.

The following is a discussion of key literature pertaining to GHG accounting at the city and precinct scales. Several prominent existing and proposed city-scale GHG methodologies, tools and inventories are highlighted, and a brief description of the most recognised and utilised of these frameworks and initiatives is provided. This is followed by a summary of existing tools that target GHG emissions at the precinct scale. Finally, a discussion of the suitability of the tools for the purpose outlined in this thesis is provided.

5.2 Determining the GHG Contribution of Cities

Cities and urban areas are increasingly being identified as major producers of global GHG emissions (Dhakal, 2010; Dodman, 2009; Hoornweg et al., 2011; Satterthwaite, 2008; World Bank, 2010). However, the perceived extent of their contribution varies depending on which emissions are included in the GHG analysis of any given city. For example, Satterthwaite (2008) contends that a significant proportion of the emissions that are often attributed to cities actually occur outside a city's official legislative boundaries (e.g., from fossil fuel power stations, waste management or agricultural practices), but occur as a result of a city's demand for resources or their urban activities. A question that therefore arises is: should emissions be assigned to the location of their production or at the place of their consumption?

The issue of boundaries thus forms a major component of the discussion around city GHG inventories. Assigning emissions to consumption acknowledges the fact that emissions generated in one city or country (particularly the case for developing nations) are often produced primarily to satisfy demand for commodities in other cities or countries (particularly industrialised nations) (Dhakal, 2010; Hoornweg et al., 2011; Satterthwaite, 2008). Nevertheless, accounting for consumption is particularly tricky and thus most GHG frameworks have tended to focus predominantly on the production side.

The concept of urban metabolism, first introduced by Wolman (1965), clearly explains how resources flow in and out of cities, and the subsequent environmental impacts associated with them. Later research led to the development of a useful tool based around this flow of materials (Materials Flow Analysis, or MFA). While this could potentially provide an appropriate methodology for determining emissions associated with cities, Kennedy and Sgouridis (2010) note that, as the analysis often uses a region's physical boundary, it is not suitable for cities and urban precincts, which are usually dependent on several emission sources outside their boundary (i.e. electricity production), but that they are directly responsible for.

Numerous GHG accounting frameworks, methodologies and inventories have been developed in recent years, and countless more have been proposed. These have attempted to address a variety of urban scales, including communities, local governments and cities, as each level acknowledges and accepts the importance of their role in addressing climate change (Carbon Disclosure Project, 2012; Hoornweg et al., 2011).

The GHG frameworks and inventories are being developed and/or proposed by a range of entities including cities and individual communities[67], NGOs, municipal associations and organisations (e.g., ICLEI Local Governments for Sustainability, World Bank and C40 Cities), as well as the private sector - often in the form of industry partnerships (e.g., ARUP and C40 cities, and CDP Cities and AECOM) and academia (Dhakal, 2010; Dixit et al., 2012; Dodman, 2009; Hoornweg et al., 2011; Satterthwaite, 2008; Sovacool & Brown, 2009; World Bank, 2010; Xi et al., 2011).

[67] See the report "Measurement for Management: CDP Cities 2012 Global Report" (Carbon Disclosure Project, 2012) for an analysis of the various inventories that participating cities use to disclose emissions.

Name of tool/protocol/ framework	Country focus	Organisation Responsible	Framework/ Tool Focus	Released
GHG Protocol Standards	International	WRI/WBCSD	Corporate and Project level	Original: 2001 Updated: 2004/5
C40 Cities Climate Leadership Group	International	C40 Cities & Clinton Climate Initiative	Mega-cities	2006
Resources and Energy Analysis Program (REAP)	UK	Stockholm Environment Institute	Consumption based emissions at the local, region and national levels	2006
Local Government Operations Protocol	USA	ICLEI-USA	Local Government	Original: 2008 Updated: 2010
Low Carbon Cities Program (LCCP)	UK	UK Carbon Trust	City-wide (public & private sector and community)	2008 (project only ran for 6 months)
International Local Government GHG Emissions Analysis Protocol (IEAP)	International	ICLEI – Local Governments for Sustainability	Local Government	2009
Carbon Neutrality Framework for Local Government – Australian Version	Australia	ICLEI Oceania	Local government and/or community	2009
WALGA GHG Reporting Platform	Australia	Western Australia Local Government Association & Greensense	Local Government	2009
Draft International Standard for Determining Greenhouse Gas Emissions for Cities	International	UNEP/UN-HABITAT/World Bank	Cities	2010
carbonn Cities Climate Registry (cCCR)	International	The Bonn Center for Local Climate Action and Reporting	Local Governments	2010
CDP Cities GHG reporting platform	International	CDP Cities, C40 Cities, Clinton Climate Initiative, Aecom	Cities	2010
Global Protocol for community-scale GHG emission (GPC)	International	C40 Cities, ICLEI, WRI, World Bank, UNEP, UN-HABITAT	Local government and community	2012 (Pilot Version)

Table 8. Primary Tools and Frameworks for GHG Measurement Relevant to Cities. Adapted from ICLEI (2010).

Most frameworks and inventories have drawn from previous experience and earlier institutional standards and protocols. Some key existing documents include the International Local Government GHG Emissions Analysis Protocol (IEAP) developed by ICLEI, the Draft International Standard for Determining Greenhouse Gas Emissions for Cities, developed in partnership between UNEP/UN-HABITAT/WB, the GHG Protocol Standards (WRI/WBCSD), the Baseline Emissions Inventory/Monitoring Emissions Inventory methodology (EC-CoM JRC), and the Local Government Operations Protocol produced by ICLEI-USA (C40/ICLEI/WRI, 2012).

Twelve of the most prominent existing and proposed GHG methodologies, tools and inventories for urban areas and cities are listed in date order in Table 7. Additional tools and inventory approaches have been analysed in other studies (Bader & Bleischwitz, 2009; ICLEI, 2010; Sugar et al., n.d.), but these are not relevant to this thesis. A brief description of the most recognised and utilised of these 12 international and Australian frameworks and initiatives relevant to the city scale is provided below.

5.3 Frameworks and Initiatives for Calculating City-Based Emissions

5.3.1 ICLEI – Local Governments For Sustainability

ICLEI – Local Governments for Sustainability was one of the first organisations to draw attention to the GHG abatement opportunities available at the local level (Sugar et al., No date). ICLEI was formed in 1990 as the International Council for Local Environmental Initiatives, and was the outcome of a summit that brought together more than 200 local governments to discuss how they could best promote and implement environmental action at the local level. This local government association rapidly grew as governments and councils around the world realised the potential for knowledge sharing and capacity building around local environmental programs and initiatives. By 1998, local governments from more than 240 cities around the world had committed to reporting their greenhouse gas emissions and putting in place management plans to reduce emissions as part of a global campaign called 'Cities for Climate Protection' (CCP) (Sugar et al., n.d).

In 2003, ICLEI members elected to change the name to better reflect where the association was heading and thus ICLEI became 'ICLEI – Local Governments for Sustainability'. There are now over 1220 members of ICLEI representing local governments from 70 countries around the world that are committed to achieving sustainable development (ICLEI - Local Governments for Sustainability, 2012a).

Over the years, ICLEI has developed several guidelines and protocols designed to assist local governments in reporting their GHG emissions and in better understanding how these emissions contribute to and compare with emissions at national and global levels. ICLEI has also collaborated with, and has been a key player in, other international campaigns and initiatives such as CDP Cities and Clinton Climate Initiative/C40 Cities (discussed below).

ICLEI – Cities for Climate Protection

Cities for Climate Protection (CCP) was a global campaign initiated by ICLEI in 1993 (ICLEI, 2012b). This campaign largely focussed on local governments and smaller cities to help with addressing GHG emissions and adapting to climate change. Larger cities were subsequently targeted through other international campaigns such as the C40 Cities and CDP Cities initiatives discussed below.

In Australia, the CCP campaign was managed through a partnership between ICLEI Oceania, the Australian Federal Government's Department of the Environment, Water, Heritage and the Arts, and local councils. By 2008, over 184 Australian councils were participating in the program and had abated over 18 million tonnes CO_2-e and thus saved themselves and their communities over \$95 million in energy costs (ICLEI Oceania, 2008). In 2009, however, the Federal Government withdrew its funding support for the program resulting in its abrupt cessation. While ICLEI still has a presence in Australia and continues to produce documents to assist councils, such as the 'Carbon Neutrality Framework for Local Government' (ICLEI Oceania, 2009), ongoing, hands-on support for councils is no longer available, nor is the Australian CCP program's data collected or disseminated.

Nevertheless, to ensure that councils continued their progress, new innovative local government GHG reporting platforms and support have emerged to replace ICLEI's CCP program. One such platform is the Western Australian Local Government Association (WALGA) 'GHG Reporting Framework', which is supported by local climate change consultancy Greensense™. This online platform and program allows local councils who are members of WALGA to upload their emissions data, share information with other councils and have access to, and be supported by, a dedicated person at WALGA and Greensense™.

On the international level, The Bonn Center for Local Climate Action and Reporting developed ‘carbonn Cities Climate Registry’ (cCCR) as a result of "the Mexico City Pact" agreed upon at the World Mayors Summit on Climate in 2010 (The Bonn Center for Local Climate Action and Reporting, 2012). The aim of this was to provide a registry and platform on which local governments could report and track progress.

ICLEI – International Local Government GHG Emissions Analysis Protocol

In 2009, ICLEI released the International Local Government GHG Emissions Analysis Protocol (IEAP) to bring standardisation to GHG inventories at the local government level. The Protocol was designed to assist not only with local government internal (that is, operational) emissions, but also to provided additional guidance on calculating the emissions from the wider community’s activities (ICLEI, 2009). Sectors to be included in the inventory comprise energy (stationary, transport and fugitive emissions), industrial processes, agriculture, land-use, land-use change and forestry, and waste both from local government and community owned operations such as landfill and waste incineration (ICLEI, 2009).

5.3.2 UNEP, UN Habitat, World Bank, WRI & WBCSD

As mentioned above, numerous climate change and GHG measurement tools, initiatives and programs have been developed and offered to cities and communities over the years by various key international bodies such as ICLEI, UNEP, UN Habitat, World Bank, WRI and WBCSD, as well as other joint initiatives such as The Clinton Climate Initiative and C40 cities. The abundance of initiatives and the significant overlap between them led to the amalgamation of several parties and programs, as well as agreement to collaborate on developing an overarching GHG framework for communities and cities, called the ‘Global Protocol for Community-Scale GHG Emissions’ (GPC).

5.3.3 Global Protocol for Community-Scale GHG Emissions

After recognising the need for and seeing the advantage in having a more harmonised approach to understanding cities emissions, several key organisations (C40 Cities Climate Leadership Group, ICLEI Local Governments for Sustainability, World Resources Institute, World Bank, UNEP, UN-Habitat, GHG Protocol and industry partners such as ARUP) joined together to develop a new standard for calculating emissions at the local level. Named the 'Global Protocol for Community-Scale GHG Emissions' (GPC), it helps to "improve policy coordination and dissemination of best practices between local governments facing comparable climate-related challenges, and facilitating climate-linked finance through a verifiable, common standard" (C40/ICLEI/WRI, 2012, p. 1). The standard will provide far greater comparability of emissions between cities and increase the integrity of local government claims. A pilot version was released in 2012 and is currently accessible online for cities and communities to trial.[68] After the pilot phase, this tool is expected to become the new international standard under the GHG Protocol for city-based GHG accounting (GHG Protocol, 2012).

5.4 Programs facilitating Emission Analysis and Reporting

5.4.1 C40 Cities and the Clinton Climate Initiative

C40 Cities was set up in 2005 by then Mayor of London, Ken Livingstone, to encourage the world's largest cities to begin to reduce their emissions and take action on climate change. The first meeting brought together key figures from 18 global megacities and concluded with an agreement by each city to actively work towards reducing their city's emissions and to create an environment that encourages participants to swap ideas and share experiences. A key focus is on accelerating the adoption of new low carbon technologies by encouraging partnerships between cities and industries, and to create joint procurement policies and alliance-structures for purchasing such technologies to increase general uptake in the marketplace (C40 Cities, 2013).

In 2006, The Clinton Foundation launched another international city-focused initiative called the Clinton Climate Initiative (CCI), which took a business-centred approach to engaging cities in the fight against climate change. CCI focused on employing practical, quantifiable and industry-focussed measures and actions at the city level. Seeing the clear link between the two initiatives, CCI soon joined forces with C40 Cities, with CCI acting as the delivery vehicle for C40 Cities. The actions, initiatives and measures being undertaken by participating cities[69] to address emissions under the joint initiative are documented in various reports produced by their industry partner Arup

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[68] See http://www.ghgprotocol.org/city-accounting

[69] In 2012, 59 cities are members of C40 Cities/CCI Initiative and have committed to acting on climate change.

(ARUP & C40 Cities Climate Leadership Group, 2011). The representative body that was created as a result of this initiative is called the C40 Cities Climate Leadership Group.

Also emerging out of this initiative was a new program called Carbon Positive Development Program (CPDP), which has identified 18 urban development projects from participating C40 cities that aim to go beyond net-zero to create carbon positive developments. The program provides a platform for the various representatives from the projects to share experiences and ideas, collaborate and work towards achieving this goal (C40 Cities Climate Leadership Group & Clinton Climate Initiative, 2012).

5.4.2 CDP Cities

In 2010, the Carbon Disclosure Project, which had previously focused on getting the 500 largest global companies to measure and report their carbon emissions, took on a new challenge and set about creating a similar platform for cities. The CDP Cities Project partnered with existing initiatives, including the C40 Cities Climate Leadership Group, to encourage currently participating cities to report using this platform, as well as promoting the concept to new cities. As of 2012, 73 cities are reporting their emissions, and 45 of these are participating under the C40's initiative (Carbon Disclosure Project, 2012).

Cities that join the project do so voluntarily and can choose what information they disclose, e.g., their current city GHG inventories, GHG reduction targets and reduction actions.[70] The project does not stipulate what cities should include in their inventories or which methodologies to use but simply provides a platform for cities to report and communicate on. The project, like C40's Cities Climate Leadership Group, allows cities to discuss issues, share learnings and be part of a collaborative, proactive demonstration group that is showing the rest of the world how cities can take the lead in acting on climate change.

The first CDP report, released in 2011, revealed a wide variety of emission reporting styles, demonstrating that there is currently no single, or preferred, GHG accounting methodology among cities. It states that "the data suggests that many cities recognise the value in international protocols but still find them lacking' (KPMG et al.,

[70] Only 70 per cent of the cities reported their emission inventories through the CDP Cities Project in 2012 (Carbon Disclosure Project, 2012).

2011, p. 14). Several cities are using existing methodologies such as ICLEI's local governments GHG reporting framework, or they have combined existing standards and/or frameworks (e.g., GHG protocol and IPCC) with proprietary tools to create new methodologies that use locally relevant information (Carbon Disclosure Project, 2012; KPMG et al., 2011).

The current variability in GHG methodologies utilised by participating cities means the emissions sources included in each city's inventory have the potential to vary significantly. Such inconsistency in reporting methods makes it difficult to compare cities' emission profiles. Nevertheless, it is the intent of the project, and believed by the organisers, that greater consistency in accounting methodologies and reporting methods will occur naturally over time.

The style of reporting also differs between cities. Excel spreadsheets currently appear to dominate as the basis for data collection, although there appears to be a shift towards more sophisticated, analytical software tools and systems (CDP, 2011). An example of this is Western Australia's "Local Government Emissions Reporting Platform" developed by local private industry, Greensense, in partnership with the Western Australian Local Government Association (WALGA).[71] This GHG accounting system is compliant with Australia's national reporting standards (National Greenhouse and Energy Reporting Act and Guidelines) and the National Carbon Offset Standard - the standard against which carbon neutrality is certified in Australia - to ensure that the tool is as practical and useful as possible for the local context.

Verification is another interesting component of the reporting of city emissions, and it is starting to play a larger role in the CDP Cities Project. Around 37 per cent of participating CDP cities currently have their GHG inventories verified by a third party organisation, demonstrating that it "is becoming fundamental for establishing credibility of data with stakeholders" (KPMG et al., 2011, p. 35)

5.5 Academic Discourse on GHG City Methodologies and Attribution

While cities are identified as being major contributors to climate change, they are also recognised as being a powerful force in global GHG mitigation (Bartholomew & Ewing, 2008; Dhakal, 2010; Dhakal & Strestha, 2010; Dodman, 2009; Hoornweg et al., 2011; Newman et al., 2009; Sattherwaite, 2008; Roseland, 2012). Much academic

[71] See http://www.walgaclimatechange.com.au/walga-reporting-platform.htm

literature has been concerned with identifying the activities and resulting emissions attributable to cities, in order to better manage and reduce city-based emissions. While the discussion continues around the specific emission sources and activities (Dhakal, 2010; Dodman, 2009; Satterthwaite, 2008), this literature has helped to inform public debate and contributed significantly to the development of the various city GHG accounting methodologies and inventories currently being used by several of the initiatives outlined above.

Some of the key challenges to calculating and managing carbon emissions in cities, as noted by Dhakal & Shrestha (2010), include:

> …data and information gaps, developing long-term scenarios, establishing a consistent urban carbon accounting framework, understanding of the urban system dynamics, and interaction of urban activities related to carbon emissions across the multiple system boundaries, formulating appropriate policies, and operationalizing the policy instruments. (p. 4753)

Fortunately, many of the issues outlined above are being addressed by recent initiatives including the collaborative development of the Global Protocol for Community-Scale GHG Emissions (GPC) mentioned above. As commonly noted in the literature, adopting a standardised GHG accounting approach, such as the GPC, will help to increase the reliability of placed-based comparisons, particularly between international cities, as well as generating a more accurate understanding of the true GHG attribution for cities globally (Dhakal, 2010).

One of the most common topics emerging out of the literature on GHG accounting for cities has been around GHG attribution and system boundaries (Dhakal, 2010; Dhakal & Shrestha, 2010; Dodman, 2009; Hoornweg et al., 2011; Matthews et al., 2008; Satterthwaite, 2008). Most research identifies the important effect consumption has on a city's emissions profile. This is largely because traditional city GHG accounting has taken a production-based approach that considers the emissions produced physically onsite or within a city's geographic/legislative boundary (Dodman, 2009). When adopting this production-based approach, larger cities often come out having smaller per capita footprints. This is demonstrated in an analysis by Dodman (2009), who compared several UK cities and showed that inhabitants of larger cities indeed often had lower per capita emissions than average UK citizens and significantly lower footprints than citizens of smaller rural cities that are likely to have more industry located in their boundaries but fewer people.

The production-based approach fails to acknowledge the fact that a significant proportion of the emissions generated from the production of commodities in one geographical area (often smaller industrial towns) are generally created primarily to satisfy the demand for those commodities in other areas – typically larger cities. Ramaswami et al (2008) highlight this fact, that 'producer cities' (i.e., those that produce materials such as cement, steel, food and other key urban materials) often get penalised in the production-based approach, while other 'consumer' cities get rewarded for their recycling.

Nevertheless, significant urban research suggests numerous other reasons exist for the lower GHG emissions associated with larger, denser cities. Factors such as dwelling size, transport mode, infrastructure options and consumption habits can contribute significantly to larger cities having lower per capita carbon footprints compared to their suburban and rural counterparts (Beattie & Newman, 2011; Dhakal, 2010; Dodman, 2009; Ewing et al., 2008; Glaeser, 2011; Glaeser & Kahn, 2008; Newman et al., 2009; Newman & Kenworthy, 1999; Newton, 2008; Rauland & Newman, 2011; Roseland, 2012).

Although the consumption-based approach for GHG accounting provides a more holistic and arguably more accurate representation of a city's emissions profile, research into this area is currently limited and there remains no accepted framework for apportioning these consumption-based emissions at a city-wide scale (Dhakal & Shrestha, 2010).

In their article 'Rigorous classification and carbon accounting principles for low and Zero Carbon Cities', Kennedy and Sgouridis (2010) attempt to include the emissions from both production and consumption within cities and thus provide a useful and comprehensive analysis of city-wide emissions. A summary of their proposed scopes and boundaries for the urban scale is provided below in Figure 5.1.

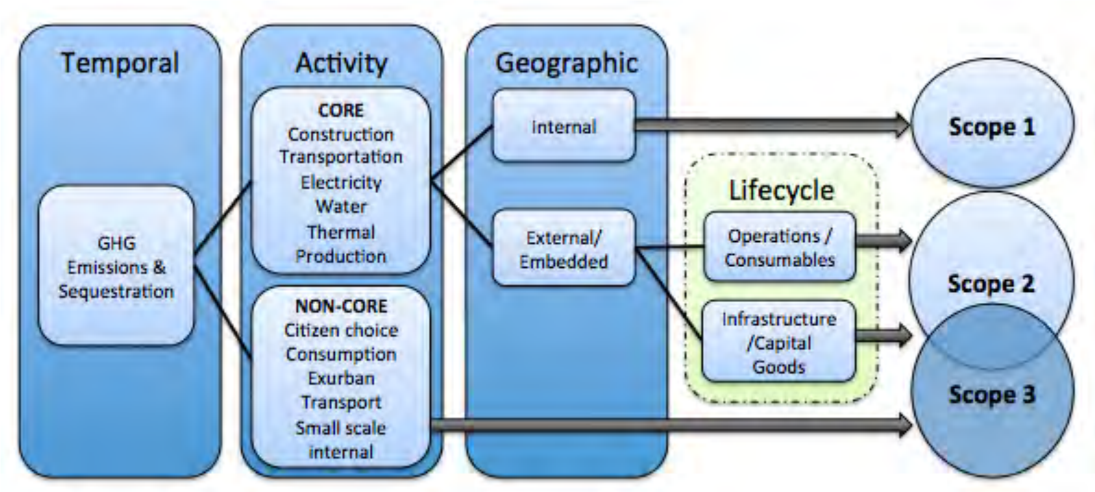

Figure 5.1. Urban GHG Emissions: Scoping and Boundaries. Source: Adapted from Kennedy & Sgouridis (2011).

As can be seen from their illustrations, the urban-scale climate change and sustainability assessment tools of Kennedy & Sgouridis (2011) are a relatively complex analysis of urban emissions that take into account all three Scopes of emissions. They argue that the broad and relatively simplistic carbon footprint definitions and principles that are often applied to products and organisations are not necessarily appropriate when applied to cities and precinct developments, as these larger areas need to take into account and include multiple stakeholders, a variety of urban scales and numerous emission sources (Kennedy & Sgouridis, 2011). However, they also point out that using a definition that is too narrow such as the one proposed by Wiedmann and Minx (2008), can end up "underestimating the value of urban efforts for system-wide mitigation" (Kennedy & Sgouridis, 2011, p. 5262) such as those discussed in Chapter 2.

The GHG accounting proposed by Kennedy and Sgouridis (2011) helps to bring a more thorough understanding of the total carbon associated with cities and urban areas and demonstrates how interrelated and complex cities are, and hence how complicated such GHG accounting can be. However, when applied to the precinct scale, this analysis arguably goes beyond what a developer could legitimately be held responsible for, even in conjunction with other key stakeholders such as utilities. It also runs the risk of being too complicated and time-intensive to get developers willing to participate in calculating and managing such a broad range of emission sources.[72]

Nevertheless, having a comprehensive GHG analysis can be very helpful in developing appropriate carbon policies and mitigation strategies for both developers and local councils, such as sourcing commodities with lower carbon footprints and requiring lower carbon transport infrastructure (Dhakal & Shrestha, 2010). It could also help to provide a basis and framework for knowledge sharing, because, as Sovacool & Brown (2009) note, "the lack of comparative analysis between metropolitan areas makes it difficult to confirm or refute best practices and policies" (p. 4857).

5.6 Precinct-Scale Accounting Schemes

Cities are predominantly designed and constructed around precincts and neighbourhoods (Sharifi & Murayama, 2013). While the importance of this smaller scale (compared to the wider city level) in achieving sustainability outcomes has long been recognised (Brugmann, 2010; Choghill, 2008; Haapio, 2012; Roseland, 2005), it is only in recent years that assessment tools have been developed to specifically focus on this level (Sharifi & Murayama, 2013).

Prior to this neighbourhood focus, assessment tools had predominantly targeted individual buildings as a way to assess the built environment (Retzlaff, 2008), evidenced by the many building assessment tools currently in existence worldwide. Abundant research has described, evaluated and compared the vast range of such tools and analysed their role in promoting better performance (e.g., Burnett, 2007; Cole, 1999; Cole, 2005; Cole, 2006; Ding, 2008; Dixit et al., 2012; Forsberg & Malmborg, 2004; Haapio & Viitaniemi, 2008; Lutzkendorf & Lorenz, 2006; Ng et al., 2012; Retzlaff, 2008).

Despite energy efficiency and GHG emissions being a popular focus of these tools over the years (ARUP Sustainability, 2004), Ng et al (2012) found that few in reality are able to quantitatively measure emissions. Varying considerably in their design and method, these tools have adopted different 'typologies' for their assessment (Lutzkendorf & Lorenz, 2006). Such typologies include checklists, Life Cycle Assessment (LCA), rating tools, assessment frameworks, labelling and certification

[72] It is important to note that calculations of different sources of emissions are necessary for different purposes, e.g., for developers, for behavior change programs for consumers, for town planners or transport planners.

schemes (Haapio, 2012). As neighbourhood and precinct assessment tools have largely evolved from building-scale performance tools, these new tools also vary greatly in design and measurement.

While some argue that the availability of precinct assessment tools is still rather limited (Kyrkoua & Karthausa, 2011), others suggest that the market has already become beset by tools proliferating in this space (AILA, 2010; Blundell, 2010). The lack of coordination and integration between the existing tools has also been recognised, adding to confusion within the industry (AILA, 2010; Burke & Brown, 2006).

Several studies have identified and compared the growing number of neighbourhood and precinct tools and schemes (see AILA, 2010; Beattie et al., 2012; Haapio, 2012; Kyrkoua & Karthausa, 2011; Sharifi & Murayama, 2013). However, as Haapio (2012) rightly notes, comprehensive scientific and/or academic analyses at the precinct scale are still somewhat limited due to the relative infancy of the precinct-scale tools.

The tools and schemes identified use a variety of terms to describe this level including neighbourhood, community, settlement, local area and precinct. These terms are therefore, used interchangeably within this section. Table 9 lists around 60 Australian and international sustainability and climate change-related precinct-scale assessment tools that have been identified in these studies.

	Name of Tool	Developer and location
	Australian Tools - Existing & Under Development	
	AGIC Sustainability Rating Tool for Infrastructure	Australian Green Infrastructure Council
	East Lake Planning Tool – Integrated Sustainability Assessment Platform	CSIRO & ACT Planning & Land Authority, ACT
	Ecological Footprint Model	South Australian Land Management Corporation
	EnviroDevelopment	Urban Development Institute of Australia, QLD.
	EPRA Sustainability Assessment Tool	East Perth Redevelopment Authority & GHD, WA
	GBCA Green Star Communities Framework tool	Green Building Council of Australia & VicURBAN, VIC
	HIA Greensmart	Housing Industry Association
	Integrated Model for Urban Sustainability	University of South Australia
	LESS Local Area Envisioning & Sustainability Scoring system	HASSELL
	Liveable Neighbourhoods	Department of Planning & Infrastructure, WA
	Local Government Climate Change Adaptation Toolkit	ICLEI Oceania
	PRECINX	Landcom, NSW
	Smart Growth Assessment Tool	City of Waneroo, WA

	STEPS Sustainable Tools for Environmental Performance Strategy	Moreland City Council, VIC
	Sustainability Management System	Department of Planning & Infrastructure WA
	Sustainability Modelling Framework SMF	South Australian Land Management Corporation
	Sustainable Community Rating Tools	VicURBAN
	Urban IT model	City Futures Research Centre
International Tools – Existing & Under Development		
	Adaptation Wizard	UK Climate Impacts Programme
	ASPIRE	Arup International & Engineers against Poverty
	BCA Green Mark for Parks	Singapore Building & Construction Authority
	BioCity Health Index	McGregor Coxall, NSW
	BREEAM	BRE Global UK
	BREEAM Communities	BRE Global UK
	Bristol Development Framework	Bristol City Council
	CASBEE UD	Japan Sustainable Building Council
	CASBEE UD+	Japan Sustainable Building Council
	CRISP Framework	EC Thematic Network
	DPSIR	United Nations Environment Program
	Ecocity	EU Research Project
	EcoDistrict Performance and Assessment Toolkit	Portland Sustainability Institute (POSI), USA
	European Urban Audit	EU Initiative
	Green Mark for Districts	Singapore Building and Construction Authority (BCA)
	Green Neighborhood Index	Malaysian Institute of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM)
	Green Plan	City of Guelph
	GreenPrint	BRE, UK
	IRM Integrated Resources Management tool	ARUP International
	LEED ND	Green Building Council, USA
	Local Climate Change Visioning Project	Centre for Advanced Landscape Planning, Vancouver, Canada
	LUSH Programme Landscaping for Urban Projects & High Schools	Singapore Building & Construction Authority
	Manchester Guide to Development	Manchester City Council, UK
	Neighbourhood Sustainability Framework	Beacon Pathway, NZ
	One Planet Living (OPL)	BioRegional Development Group and WWF International, UK
	PLACE3S	California, Oregon & Washington State Energy Commissions, USA
	PlanSmart NJ	New Jersey, USA
	PPDS Precinct Planning & Design Standard	Green Globe, Earthcheck
	QATAR Sustainability Assessment System (QSAS) Neighborhoods	Gulf organization for Research and Development, Qatar
	SEAT Subdivision Energy Analysis Tool	California Energy Commission PIER Programme
	Singapore Index on Cities' Biodiversity CBI	Singapore National Parks Board
	SPARTACUS System for Planning in Towns & Cities for Urban Sustainability	European Commission consortium
	SPeAR Sustainable Project Appraisal Routine	ARUP International
	SSIM Sustainable Systems Integrated Model	EDAW AECOM
	STAR Community Index	ICLEI-Local Governments for Sustainability USA, U.S. Green Building Council & the Centre for American Progress
	SUE-MoT	Dundee, Glasgow, Caledonian, Loughborough & St. Andrews Universities consortium

	Sustainability Planning Toolkit	ICLEI USA
	Sustainable City Program of Vancouver	City of Vancouver, Canada
	Sustainable Sites Initiative	Green Building Council & Partners, USA
	Sustainable Urban Landscapes – Site Design Manual for BC Communities	University of British Columbia
	TUSC Tools for Urban Sustainability Code of Practice	Synergine & Waitakere City Council, NZ
	UNEP Yearbook	United Nations Environment Programme

Table 9. Precinct-Scale Climate Change and Sustainability Assessment Tools.

Despite the increasing prevalence of precinct-scale assessment tools, it has also been found that very few provide adequate or comprehensive methodologies or frameworks for calculating the GHG emissions at this level (AILA, 2010; Beattie et al., 2012).

This lack of quantitative GHG measurement at both the building and precinct level is most likely due to the fact that the majority of the tools have focussed on the design stage and have overwhelmingly consisted of checklists embedded into point-based systems to create a sustainability rating. AILA (2010) identified this absence of quantifiable performance-based numbers within their analysis report '*Climate Adaptation Tools for Sustainable Settlements*', noting that "the general lack of robust indices for measuring urban environmental quality or 'green infrastructure' performance" (p. 8) was a key concern.

From the literature available at the time of writing, only two tools appear to be able to provide adequate quantitative carbon measurement: PRECINX and eTool. However, even these do not provide a comprehensive analysis of all the key areas identified in Chapter 2 as being critical in reducing carbon at the precinct level. Nevertheless, these two tools were chosen for comparison along with six other precinct-scale tools identified as being leaders in the area of precinct-scale sustainability assessment.

All schemes discussed in this section are voluntary schemes. The nine tools chosen for analysis are briefly introduced below, which is followed by a discussion, which identifies their strengths, weaknesses and their ability to undertake a comprehensive GHG analysis for precincts. A table comparing the nine tools is provided in Appendix A.

5.6.1 International Tools

BREEAM Communities

BREEAM (*Building Research Establishment Environmental Assessment Method*) was developed in the UK in 1990 by BRE Global. It was the first commercially available environmental assessment tool for buildings and remains one of the most widely used tools for this purpose globally (Haapio & Viitaniemi, 2008; Sharifi & Murayama, 2013). In 2008, BRE Global created the BREEAM Communities tool to assess the wider impacts of our built environment.

The Communities tool broadly follows the same methodology and point-based system as its buildings rating scheme, assessing environmental, social and economic impacts of developments. It awards between 1 – 3 credits per criteria, depending on performance. There are 51 criteria split between eight categories (Haapio, 2012). Although all criteria are given equal points (i.e., up to 3 credits), not all the categories and credits are mandatory under the BREEAM tool; they are determined based on various factors such as size, type and whether projects are regional or national (Kyrkou & Karthaus, 2011). Thus, the overall score for BREEAM Communities is given as a percentage, which is translated into six ratings such as 'Pass' ($\geq$25%), 'Good' ($\geq$40%), 'Excellent' ($\geq$70%) and so on (Haapio, 2012).

LEED Neighborhood Development (ND)

Leadership in Energy and Environmental Design (LEED) was developed by the US Green Building Council and he Natural Resources Defence Council in 1994, taking inspiration from the UK BREEAM rating scheme. While LEED predominantly targets the US market, it is also used informally around the world. Together, LEED and BREEAM are the two globally dominant building environmental assessment tools (Kyrkoua & Karthaus, 2011).

LEED for Neighbourhood Development (LEED-ND) was initially developed and piloted in 2007 (Sharifi & Murayama, 2013), but the official rating system was only released in 2010 (Haapio, 2012). Like BREEAM Communities, LEED-ND uses a points-based system to determine the overall rating, but the number of credits per category is different in the two tools. There are 53 criteria in the LEED-ND tool, spread over three primary categories and two additional ones. Unlike BREEAM, the number of credits per criteria varies under LEED (e.g., some criteria are awarded 10 credits) and all criteria are mandatory (Haapio, 2012; Kyrkoua & Karthaus, 2011).

Since LEED-ND was developed in conjunction with the Congress for New Urbanism, LEED-ND tends to place greater emphasis on rewarding principles of new urbanism such as those relating to land use and transport, than the broader environmental concerns and impacts that BREEAM focuses on (Kyrkoua & Karthaus, 2011). There are also critiques of New Urbanism that show the outcomes of their principles are insufficient if location, transit provision and density are not more seriously considered in designs (Falconer et al., 2010). As the final scores are just points, it is easy to miss significant parameters that can change real carbon outcomes much more than would a list of 'worthwhile' measures. The overall score for LEED-ND is provided in points and given one of four ratings: Certified, Silver, Gold or Platinum.

CASBEE Urban Development

Developed in 2004, Japan's Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was a joint initiative of the government, industry and academia (Haapio, 2012). Two years later, in 2006, CASBEE for Urban Development (UD) was created and was thus the first of the major precinct-wide sustainability assessment schemes available. It also uses a points-system to evaluate developments based on categories with specific criteria.

CASBEE-UD has 80 criteria that, similar to BREEAM, are all equal. Each criterion is awarded between 1-5 points or credits, depending on performance; though in some cases the full range of points is not applicable (Sharifi & Murayama, 2013). Unlike BREEAM and LEED, the way in which CASBEE calculates its overall score is based on qualitative and quantitative measurement and ratios, and thus may be considered quite complicated in comparison to the above tools.

The final score or rating in CASBEE-UD is based on a points system in which <0.5 = 'Poor', 0.5-1.0 = 'Fairly Poor', up to 1.5-3.0 = 'Very good' and $\geq$ 3.0 'Excellent' (Happio, 2012).

One Planet Communities

One Planet Communities is an international design and sustainability-branding tool for community-scale development. It was created in 2004 by BioRegional, a not-for-profit organisation based in the UK, and now has offices in eight countries around the world.

One Planet Communities differs from other rating schemes in that it does not provide a sliding scale for achievements (e.g., 4, 5 or 6 stars); a developer either meets the requirements or they do not. BioRegional also does not provide certification as such, but will 'endorse' communities that demonstrate their commitment to achieving the One Planet Living principles. The concept of One Planet Living is based on the ecological footprint model (Rees & Wackernagle, 1996), which demonstrated that we are currently living beyond what the planet can provide in one year.

The tool identifies 10 Common International Targets (CITs) or themes that aim to improve quality of life of citizens and reduce per capita consumption and pollution at the community scale to a level that allows us all to live within our planetary limits. Stringent targets are set for carbon, waste, transport, materials and water and include measurable reductions such as 'zero carbon' (e.g., for the operation of buildings) and 95 per cent reduction in waste, though if and how GHG reductions are measured is not clear.

To receive endorsement, communities must demonstrate they have set an action plan, are delivering on the action plan and are willing to undertake an annual review process.

5.6.2 Australian Tools

Green Star Communities

Australia's Green Star Communities tool is the nation's leading precinct-scale sustainability assessment tool, developed by the Green Building Council of Australia (GBCA). The GBCA was first established in 2003 and is a member of the World Green Building Council (Mitchell, 2009). Although initial development of the Communities rating tool began in 2009, the first pilot version was only released in 2012, and is therefore the newest of these larger, well-known schemes.

While being influenced by BREEAM Communities and LEED-ND, Green Star Communities undertook extensive consultation with various stakeholders from industry, academia, government, planning, utilities and social service organisations in order to create a unique Australian tool (Blundell, 2010). Similar to the aforementioned tools, Green Star Communities uses a point system to rate a development's overall sustainability performance. The tool has 38 criteria or credits spread over six main categories. A varying number of points are available under each credit (i.e., from 0.5 to 10) and together equal a total score of 110 (GBCA 2013). While there are some mandatory requirements within the tool (e.g., yes/no checklists) in addition to the points allocated, it is uncertain whether all categories are mandatory. The overall rating is given in points (45-59, 60-74, 75+) and stars (4-6) and expressed in terms of comparative practice e.g., 'Best Practice', 'Australian Excellence or World Leader (see Table 9).

EnviroDevelopment

EnviroDevelopment is another well-known and well-utilised Australian neighbourhood assessment tool, particularly popular with smaller players within the development industry. It was created by the Urban Development Institute of Australia (UDIA) in 2006 and, while it has the ability to assess various types of developments including commercial, residential and industrial, it has predominantly focused on low-density residential development (EnviroDevelopment, 2011a).

The tool has six categories or 'elements', which are represented by leaves in its rating system. Unlike the previous tools, it does not use a points-based system to rate design, but has specific requirements that need to be met under each criteria. Some elements (e.g., energy) also set performance targets such as a percentage reduction in GHGs on a state's average for energy generation. Supporting evidence needs to be provided (UDIA, n.d.), though it can be as basic as documented evidence from a technology supplier that their technology has lower emissions than prevailing technologies. Thus, it eliminates the need for comprehensive carbon accounting.

Despite the quite prescriptive and detailed nature of the technical standards, which outline how to achieve the criteria under each element the elements themselves are not mandatory (AILA, 2010a). Developers can therefore, choose one or more elements to have certified (i.e., a leaf). However, if fewer than six elements are sought, eight additional (non quantitative) criteria must also be met (UDIA, n.d.).

PRECINX

PRECINX is an Australian neighbourhood sustainability assessment tool, developed by Kinesis for the New South Wales State Land Development Agency, Landcom. Launched in 2009, it was one of the first of a new generation of precinct-scale assessment tools that uses a more quantitative approach for assessing sustainability. Rather than using points to rate a design, it helps to inform the design by modelling various options around onsite energy, embodied CO_2 in materials, potable water, stormwater, transport and housing diversity.

As the tool is able to quantify the differences in tonnes of CO_2, litres of water, vehicle kilometres travelled and housing affordability using various modelling scenarios and options, it helps developers make better urban planning decisions based on real numbers (Perinotto, 2009). As suggested in the previous chapter, assessment should incorporate both life cycle and operational aspects of an urban development. PRECINX is able to combine these (Matan et al., 2013).

The tool has been increasingly adopted by major developers across Australia (such as Australand, LendLease and Stockland) and is being used in all states by the government land development agencies under a licence. Western Australia's State Land development Agency, Landcorp, has begun to use it on some projects (Perinotto, 2011). The tool was developed for the same NSW government agency that developed the building scale assessment tool BASIX. The BASIX tool has become an acceptable part of planning but PRECINX, although planned to be used in regulatory approval processes, has not yet been accepted for that purpose. If the tool continues to grow, it is likely to be used as a design and assessment tool. Other tools that are more transparent and publically available may also be developed for this purpose as the need to quantify design outcomes for decarbonising cities becomes more and more pressing.

eTool

eTool emerged around the same time as PRECINX, in 2009, and began as a life cycle carbon assessment-modelling tool to help industry understand the importance of embodied carbon in the construction of individual buildings. The aim was to provide a user-friendly online platform that could assist architects, designers and developers to make informed decisions about how best to reduce carbon within buildings from a life cycle perspective.

While individual buildings were the initial focus of the tool, it now has the capacity to assess various types of built forms, from small residential and/or commercial development to infrastructure projects to larger scale urban redevelopment projects. Being a life cycle tool, it models the carbon associated with the design, construction and operational energy of developments. However, it currently does not measure the carbon associated with the transport of residents or the emissions associated with the operation of precinct-scale infrastructure (e.g., water and waste management).

Unlike the other international precinct assessment tools, which focus on a variety of environmental and sustainability issues, eTool focuses primarily on carbon. This tool and PRECINX are the only two that apply rigorous carbon accounting.

5.7 Issues for Precinct-Scale Tools

The importance of assessment and rating tools for the built environment has long been identified and discussed (Burke & Brown, 2006; Cole, 1999; Cole, 2005; Cole, 2006; Ding, 2008; Forsberg & Malmborg, 2004). They provide a structured way of collating, presenting and disseminating information on the environmental performance of buildings, and have thus played a critical role in helping to shift behaviour while also providing the ability to measure and track our progress towards sustainability (Ding, 2008). Burke and Brown (2006) note the importance of rating schemes in providing benchmarking as a way to stimulate environmental performance. For these and other reasons, rating and assessment tools have been identified as 'one of the most potent and effective means to both improve the performance…and to promote higher expectations and demand' within the building industry (Cole, 2006, p. 357).

5.7.1 Measurement Methods

The brief analysis of the eight precinct tools provided above has demonstrated how greatly assessment tools can vary in terms of design and methodology, and thus, their overall output and function as a tool. Cole (2005) makes the distinction between assessment and rating tools, suggesting that assessment tools are more quantitative and often based around life cycle assessment (LCA), while rating tools provide the 'extended outputs from an assessment process' (p. 456) as a way to compare and brand achievements. The outputs generated from the assessment processes in rating schemes often use diverse criteria, both qualitative and quantitative in nature, commonly comprising of checklists and multi-criteria analyses (Retzlaff, 2008). They therefore often need to be embedded into point-based frameworks to provide a common metric to calculate the overall rating. Forsberg and Malmborg (2004) also acknowledge a broad division of tools, classifying them either as quantitative (e.g., LCA focussed) or qualitative (based on mixed criteria) tools.

Sharifi and Murayama (2013), who reviewed seven precinct sustainability assessment tools, note the use of layers of measurement within the tools, such as themes, criterion and indicators. It is common that a series of indicators will be used to measure specific criteria (or credits), which when combined, make up a broad theme as illustrated in Figure 5.2.

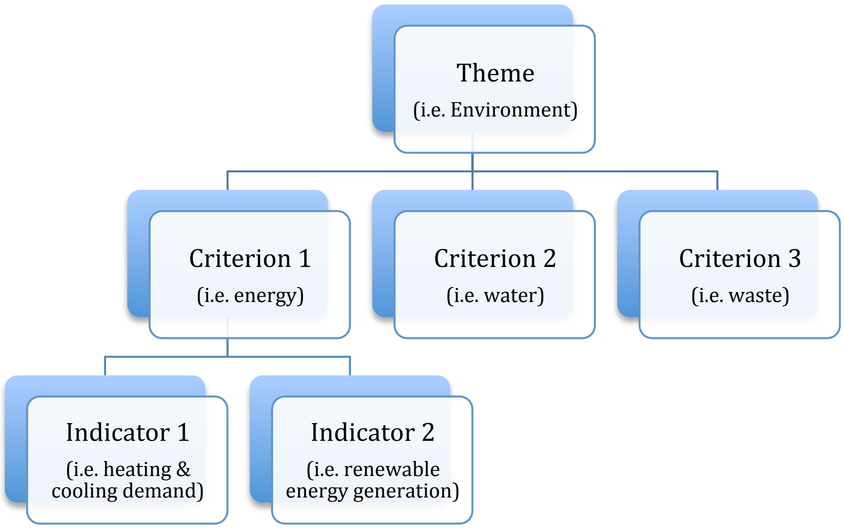

Figure 5.2. Example of Layers of Measurements within Assessment Tools.

The overall score achieved is then usually displayed as a designation or rating such as 'Good', 'Excellent' or 'Silver', 'Gold', (Cole, 2005) or in stars, such as the Green Star Communities tool, or other, often abstract graphical representations such as leaves as in the case of EnviroDevelopment.

Point Score	Green Star Rating	Outcome
45 – 59	4 Star	Best Practice
60 – 74	5 Star	Australian Excellence
75+	6 Star	World Leader

Table 10. Rating Framework adopted by the Green Building Council of Australia.

5.7.2 Point-Based Systems and Use of Weightings

The majority of precinct assessment tools and schemes discussed in the section above adopt a point-based system for measurement. While several of the tools reviewed within this analysis, as well as tools reviewed in previous studies, have similar themes or criteria, the number of points or credits given to each area often varies considerably between tools (Kyrkoua & Karthausa, 2011). The idea of allocating varying amounts of points to certain areas is also known as 'weighting'. Weighting involves assigning different values to different criteria in order to reflect their perceived importance.

As Ding (2008) recognises, however, there is often "no clear logical or common basis for the way in which the maximum number of points is awarded to each criterion" (p. 458), as tools rarely provide the reason or justification for their allocation. Sharifi & Murayama (2013) contend, "weighting is one of the most theoretically controversial aspects within SA [sustainability assessment]" (p. 80), noting that the process of selecting criteria and assigning the weights is usually highly subjective. Weightings are usually established using stakeholder surveys to determine the overall importance of various environmental issues (Burnett, 2007). This suggests that the developers of tools and their advisory teams can preference, by giving greater weight to, an area that is desirable to them.

AILA (2010) also identifies the notion of 'vested interests' as a concern in the development of tools. Blundell (2010) further highlights the risk associated with tools developed by certain industries such as the property industry, suggesting they can potentially push specific agendas such as promoting urban growth. Regardless of the reasons behind the choice of weightings, their adoption can effectively distort numbers, leading to very different rating scores between different tools measuring essentially the same areas. This makes comparisons between tools, and consequently the developments they are rating, difficult.

Adding further confusion to the overall output of numbers is the decision to allow voluntary or optional credits for assessment. For example, despite the numerous similarities between the BREEAM and LEED tools, all criteria within LEED ND are mandatory, whereas there are several optional criteria under the BREEAM Communities tool (Kyrkoua & Karthausa, 2011). The EnviroDevelopment tool also allows developers to choose any number of 'leaves' for certification, meaning developers are not required to meet specific environmental standards in all areas.

5.7.3 Complexity

The major appeal of point-based systems is their simplicity. Any developer can go through the motions of an assessment and claim the points at a certain level of performance. This may make people in the development industry, in communities or in government feel better, and indeed may lead to innovations that would not have happened under BAU. However, they also may just be misleading as the assessed outcomes are not necessarily quantified. The urban systems being built may indeed be much more complex than the list of isolated parameters can ever suggest.

Another aspect of the point-based assessment tools is that they themselves are growing into quite complicated structures in order to try and accommodate the complexities of urban systems. Kyrkoua and Karthausa (2011) suggest that neighbourhood sustainability assessment schemes are becoming increasingly complex and detailed, particularly regarding the allocation of weightings, which they suggest decrease functionability, comparability and adaptability of tools and add to the ambiguity of results. This was also found to be the case in the review of the eight tools above. Kyrkoua and Karthausa (2011) thus recommend that future frameworks would benefit from less complexity and a more "transparent and auditable structure" (p. 210) in order to ensure greater understanding, and wider adoption of tools. This supports the notion and need for a common, universally adopted framework for classifying precinct-scale emissions and simple quantifiable models that can be used in assessment.

5.7.4 Phase of Adoption of the Tool

One of the major limitations or shortcomings of assessment rating tools is that they are often adopted too late in the design process, meaning the decisions that can potentially maximise the overall sustainability and environmental gains are not built in from the start (AILA, 2010). Burke and Brown (2006) contend that rating tools are often developed as appraisal tools, which necessarily need to be applied at the end of the building phase, meaning that many of the "opportunities to improve performance are often lost long before the rating tool is even applied" (p. 5-6).

As a result, sustainability measures are in many cases 'bolted on' at the end of the design process as developers seek to gain credits from tick-box items, which can result in perverse outcomes. There are numerous examples of this occurring within industry. In Australia, tri-generation systems appear to be one of the common 'bolt-on' options for buildings attempting to attain additional Green Star points. However, due to speedy installation processes and a lack of communication between building designers and engineers, many systems are incorrectly sized in relation to a building's heating, cooling and energy requirements and are thus never turned on or utilised (Kelly 2012). This causes many to doubt the usefulness and efficiency of the systems.

This 'point-grabbing' phenomenon fostered by some rating tools can therefore have a detrimental effect on the overall sustainability agenda, as it can lead to some promising technologies such as tri-generation being perceived negatively by industry and the public.

5.7.5 Performance and Evaluation

The lack of follow-up or performance-based monitoring or assessment within current rating tools is also seen to be a limitation of existing tools. AILA (2010) identifies this, observing that current precinct-scale tools appear to concentrate either on predictive performance (i.e. design-based) or on operational performance, and noting that few are able to measure both in a comprehensive manner. This is true for the majority of the tools discussed in this section, with the exception of eTool and EnviroDevelopment. eTool has a performance measure built into the tool, while EnviroDevelopment has an option for annual certification based on performance targets. Some of the larger, national tools such as Australia's Green Star certification system have only recently designed performance tools for buildings. It is unclear as to whether their new Green Star Community tool will have a performance component to it.

Providing an evaluation component to tools to encourage the measuring and assessment of performance will help to address and minimise the perverse outcomes associated with some of the 'bolt-on' actions mentioned above. It can also help to identify when problems occur as in the case of the BedZED development discussed in Chapter 3, where the malfunctioning of the biomass plant meant that the development failed to maintain its intended goal of being supplied by 100% renewable energy.

Jones and Patterson (2007) warn of the danger of this occurring if using tools without performance elements, highlighting that "thinking is constrained to what is only in the tool and to the time period in which the tool is applied" (p. 257).

5.7.6 Functionality of Tools: Decision-Making Versus Assessment and Rating

A further area of discussion relates to the ability of rating tools to actually help inform the decision-making process or pre-design-process, as opposed to simply rating developments at the end based on arbitrary checklists. The ability to weigh up various options based on real numbers and quantifiable benefits to help planners, architects and urban designers choose the best options for meeting their prescribed goals is something largely lacking within the existing rating and assessment tools targeting the built environment (AILA, 2010; Retzlaff, 2008).

From the tools analysed, eTool and PRECINX are the only two able to provide this sort of 'options-modelling' or decision-support, i.e., they are design tools. Retzlaff

(2008) discusses the need for these types of tools, particularly in respect to greenhouse gas emissions. Nevertheless, neither tool currently considers all the areas of a development identified in Chapter 2. Enabling developers to choose the most appropriate option at the design phase allows important decisions to be made about various materials, technologies and urban planning options based on quantifiable factors such as GHG emissions, water use and cost.

In understanding the differences between tools, e.g., decision-making capacity versus assessment or rating, it becomes clear that each type of tool provides important but quite distinct functions. Although many tools try to combine the functions[73], they may in fact prove to be more useful when used for the purpose they were primarily designed to perform. For example, a decision-making tool may be best used in the initial pre-design phase in order to help guide and inform the design, while an assessment tool can help to determine a development's overall success (usually in a specific area) and thus their impact based on actual performance. This information can then feed into a rating or certification scheme, which provides the overall branding and comparability function.

Sustainability tools for the built environment have thus been identified as falling under three distinct categories: Decision-support tools, Assessment tools and Rating and Certification tools, as illustrated in Figure 5.3.

Figure 5.3.Type of Tool and Ideal Order for Use

Regardless of the order tools are used in, or which tools are ultimately chosen, it is important for both the developers of tools and their users to recognise and acknowledge the limitations of each type of tool. For example, a rating tool applied at

[73] For example, eTool was initially designed as a decision-making tool to help inform the design process, though due to customer demand, they also created a rating system. The rating system is obviously limited to the specific outputs of the tool, measuring predominantly GHG emissions, though it does rate sustainability in a broad sense.

the end of a project's design phase is unlikely to produce the most optimal outcome in terms of environmental performance, while current decision-making or assessment tools, which generally focus on relatively narrow areas (e.g., GHG's emissions) are unable to cover the full spectrum of criteria needed to rate the overall sustainability of a precinct (AILA, 2010).

5.7.7 The Need for a Sustainability Framework

Many studies have acknowledged the rapid increase of tools and schemes that measure and rate various aspects of our built environment. Noting the general 'lack of knowledge and skills relating to what tools to use and how to use them' (Patterson & Jones, 2007, p. 256), the proliferation of tools appears to be causing more confusion amongst users than providing assistance (Blundell, 2010). Indeed, according to a study Burke and Brown (2006) conducted, participants insisted that when "new innovative ways to measure urban sustainability" are created, opportunities should be sought "to embed their work into existing tools, if possible" (p. 7).

Recognising the abundance of, and variability in, functionality between tools currently available at the precinct level, AILA (2010) argue for a more integrated and coordinated overall approach to progressing the sustainability agenda for the built environment in Australia. One of the main recommendations that arose from the AILA (2010) report was the development of a national sustainability assessment framework as a way of addressing the inconsistencies associated with having such a vast number and range of tools targeting precinct-scale urban development. They assert:

> Until such a mechanism is in place, climate adaptation and sustainability assessment tools will continue to be designed to serve arbitrarily defined goals, responding to uncoordinated sectoral interests, and without reference to any consistent implementation pathway for broader national objectives. (AILA, 2010, p. 5)

The GHG framework proposed in this thesis thus forms one essential element of what could be considered within the broader sustainability framework for the built environment proposed by AILA (2010). Given the current lack of consistent quantitative GHG measurement within existing tools (see Appendix A for a comparison of the tools discussed), and the acknowledgement of the importance of GHG emissions in our future low carbon economy, the creation and adoption of this universal framework is critical. The framework should be considered at and inform each of the three stages identified above (i.e., during decision-making, assessment and rating), as the areas identified in the framework have a direct impact on each stage.

It should be noted that it is not the intention of this thesis to create a tool that can calculate the GHG emissions of a development or provide decision-making support. The overarching GHG framework proposed in this thesis is designed to provide guidance on the emissions that ought be calculated within urban development at the precinct level. Many decision-support and/or GHG measurement tools may be developed using this framework. These tools don't necessarily need to provide any certification or rating themselves, but can be used in conjunction with existing rating schemes such as BREEAM, LEED, Green Star and EnviroDevelopment to demonstrate that the GHG component has been met.

5.8 Conclusion

Although we are yet to see a universally accepted definition and GHG accounting framework for cities or precincts, there is clearly significant research being undertaken in this field and considerable effort being put into developing better, more consistent GHG accounting practices and rating tools for cities, precincts and urban developments.

Currently, most city GHG accounting frameworks focus on production-based, operational emissions, which include emissions arising from business and industry activities occurring within a city's geographic and legislative boundaries. Much of the recent academic discourse, however, suggests that this focus is misplaced as it fails to recognise and address the emissions associated with a city's overall consumption of resources and subsequent emissions, thereby creating misleading per capita carbon footprints of cities.

Directing greater attention towards the precinct-scale for GHG management may help to bridge the gap as it allows more demand-side emissions to be considered, for example, those arising from household transport patterns, energy and water consumption, as well as embodied emissions such as those in construction materials. As has been shown in previous chapters, considerable emission abatement can be achieved from improving urban design and building and resource management within cities.

However, in order to include these sorts of emissions, a different carbon accounting framework and scheme is needed to those currently targeting the city level. A precinct-scale GHG framework will require more of a life-cycle approach to calculating emissions (which includes the embodied and operational emissions of buildings as well as transport by residents), rather than the city-scale inventory approach, which includes only the operational/industrial activities occurring within cities. These activity-based emissions from industries that occur are less relevant to developers, who are generally not responsible for business activities occurring within their precinct developments. However, developers do need to ensure that they make well-informed design decisions around location, density and land-use mix, as these will also impact severely on operational energy use.

Despite the growing abundance in recent years of sustainability assessment and rating tools targeting the built environment and urban development, very few have focussed specifically on GHG emissions or provide a comprehensive framework for their measurement. A key challenge, therefore, is to determine how best to translate and integrate the knowledge and insight gained from the development of the GHG measurement processes at the city level into a carbon accounting framework at the precinct level, a framework that fosters carbon reduction through improved urban planning and precinct design.

Focusing on this level will help to promote better interaction between key urban stakeholders such as developers, builders, architects, urban planners, utilities, local governments and the community, thereby helping to create tangible change at the ground level using a bottom-up approach to carbon reduction.

However, there is currently no established governance framework that can help to facilitate a process involving such a myriad of stakeholders at this level or to set out the requirements of a model and assessment framework. Thus, determining a robust governance structure to deal with precincts as they attempt to decarbonise represents a major challenge.

While cities and local governments already have institutional frameworks in place to be able, at a democratic level, to sign on to the initiatives outlined in this chapter, it is far more difficult to get buy-in and collaboration from developers and other key stakeholders who are not subject to, and bound by, the same institutional requirements. It is argued, therefore, that a framework and process for calculating and addressing emissions at the precinct scale would benefit from linking into frameworks, schemes and initiatives already established at the local government level. This may further benefit local governments by allowing them to develop a greater understanding of their community's emissions, as well as to discuss future policies and initiatives to address them. These ideas will be pursued in the next chapter.

Chapter 6 – Carbon Neutral Certification Schemes for the Built Environment

6 Carbon Neutral Certification Schemes for the Built Environment

6.1 Introduction

The number of businesses and organisations making environmental claims and promoting green credentials in order to differentiate themselves has increased significantly in recent years. This has correlated with consumers' willingness to pay a premium on 'green' goods and services in an increasingly carbon-constrained and environmentally-conscious marketplace (Brecard et al., 2009; OECD, 2002).

For many organisations, the notion of moving 'beyond compliance' to achieve higher environmental standards is appealing, particularly if it warrants a higher price on their products or services or can help to differentiate them from their competitors. However, communicating environmental attributes to consumers is often hard as environmental actions or processes are not always observable or tangible (Brecard et al., 2009; Hamilton & Zilberman, 2006). Eco-labeling and/or certification has thus emerged as a way of validating environmental claims to drive more sustainable consumption practices (Jamalpuria, 2012).

Since this eco-movement emerged largely in the voluntary space, it has lacked the stringent rules and regulations that generally underpin compliance or mandatory practices, industries and markets. Consequently, the rapid rate at which this unregulated, voluntary 'green industry' has developed has seen growing concern over the credibility and legitimacy of some of the environmental and in particular, carbon claims being made. Consumers began to become wary of 'green' claims, particularly when carbon offsets, or the term 'carbon neutrality' were used, as sufficient information was rarely provided to substantiate or explain the claims.

This chapter examines some of the reasons why certification for carbon-related achievements is necessary, highlighting issues pertaining to the regulatory system using as a case study the Australian Competition and Consumer Commission (ACCC). An overview of the organisational structures and key documents underpinning the industry is then provided, followed by a brief summary of several well-known existing Australian and international carbon certification schemes. Australia's National Carbon Offset Standard Carbon Neutral Program (NCOS-CNP) is identified as one of the leading independent certification schemes worldwide, and it is thus discussed in greater depth towards the end of this chapter. The chapter concludes by acknowledging and discussing several issues relating to the certification of urban development under this program.

6.2 The ACCC and Trade Practices Act

In response to the growing issue of the credibility of carbon claims in Australia, the Australian Competition and Consumer Commission (ACCC) began publicly investigating a number of businesses for false claims. One notable case involving General Motors was taken to court in 2008 by the ACCC.[74] General Motors was found guilty of breaching the *Trade Practices Act 1974* with its carbon claim being declared false and misleading by the court. The case, which was given significant press coverage, was used to demonstrate to other organisations and businesses that false and misleading claims that breach the Act will be actively pursued by the ACCC.

Several further investigations followed[75], before the ACCC in 2008 released a document titled *Carbon Claims and the Trade Practices Act*. The purpose of this document was to inform and provide guidance to businesses and organisations on how to avoid making false claims. The document warns that those making claims found to be breaching the Act, i.e., those considered to be misleading consumers (intentionally or not) and thereby engaging in deceptive conduct, are liable for fines up to $1.1 million (Australia Competition and Consumer Commission, 2008).

The ACCC urges organisations to clearly explain all claims, noting that the absence of universal carbon definitions can lead to significant variation in consumers' understanding of the terms. They assert that "Vague, unsubstantiated, confusing or misleading information will reduce consumer confidence in carbon claims thereby disadvantaging ethical traders" (Australia Competition and Consumer Commission, 2008) and ultimately damaging the emerging green economy.

In 2011, the above guidelines were revised and new information added about the introduction of the National Carbon Offset Standard (NCOS), the Carbon Neutral Program and the establishment of the Australian Carbon Trust (now Low Carbon

[74] See "Saab 'Grrrrrreen' claims declared misleading by Federal Court" (available at: http://www.accc.gov.au/content/index.phtml/itemId/843395)
[75] See "When green wash won't wash: Avoiding misleading environmental claims" (available at: http://www.edo.org.au/conference/2010/2010michael_terceiro.pdf)

Australia). This guide will continue to play an important role, particularly with the recent introduction of the Federal Government's Carbon Price Legislation in July 2012, which aims to drive greater investment in low carbon technologies and greener practices, thereby increasing demand for eco-labeling, certification and the marketing of green credentials.

Ensuring that carbon claims are clear and transparent is critical to avoiding the legal risks and liabilities associated with false claims under the Trade Practices Act. It can also help to bring greater credibility and integrity to carbon claims. However, having carbon claims recognised or certified by a third party provides even greater assurance to consumers and the ACCC, providing that the third party is a reputable and, ideally, accredited body. Such certification should ensure that carbon audits/footprints are undertaken using internationally accepted best practice carbon/GHG accounting standards and are verified by an independent third party. This, together with assurance that purchased offsets (if certification is for carbon neutrality) are legitimate and trustworthy, can add considerable validity to claims.

6.3 What is Certification and Who Conducts It?

Any organisation or body can certify a product/service or business as being carbon neutral in the same way anyone can make a carbon claim. However, the degree of reliability and trustworthiness of a certification scheme, just like any claim, can vary greatly. As Murray and Dey (2008) pointed out in their study of eleven online carbon calculators, little similarity existed between each calculator, creating confusion and doubt around the correct methodology, the reliability and the integrity of offsets being sold and, thus, the overall legitimacy of certification being offered.

There are an increasing number of organisations and schemes emerging, however, whose certification is based on international standards and methodologies guaranteeing rigour and robustness in calculations, and stringency in terms of verification. Such organisations can also seek accreditation themselves in order to be recognised and acknowledged as providing reputable certification to clients.

Although the terms accreditation and certification are frequently used interchangeably, they have quite different roles, functions and meanings when discussed in terms of providers. The International Organisation for Standardisation (ISO), an independent body that develops and publishes international standards used by governments and private industries worldwide[76], has provided a distinction between the two terms. They identify 'accreditation' as that given to bodies or organisations who are recognised as being reputable providers of conformity assessments and certification (ISO, 2013). These bodies then award certification to final consumers, businesses and products that have met specific standards. Further clarification of the terms and the role of the ISO, is provided below.

6.3.1 The ISO: Definitions of Accreditation & Certification of GHG Assertions

The International Organisation for Standardisation (ISO) was established in 1947 "to facilitate the international coordination and unification of industrial standards" (International Organisation for Standardisation [ISO], 2013).[77] Over the past 65 years it has developed over 19,000 standards spanning a range of fields and industries, bringing greater consistency and credibility to business practices worldwide.

In relation to carbon and GHG accounting, ISO has developed a range of standards, including the ISO 14064 series that provides guidance on calculating GHG emissions, as well as on the verification of GHG claims and assertions. Another more general standard relevant to the carbon industry relates to conformity assessment. The standard, known as ISO/IEC 17000:2004 Conformity Assessment - Vocabulary and General Principles (ISO, 2004), helps to identify credible bodies that carry out GHG audits and providing certification. These bodies ensure stringent adherence to the guidelines and methods outlined in the ISO 14064 series. They are referred to as 'Conformity Assessment Bodies' or CABs and their accreditation has been described as "third party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks" (ISO, 2004). These organisations or CABs are accredited based on the international standard ISO 14065:2007 *Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition*.

6.3.2 Conformity Assessment Bodies

JAS-ANZ (Joint Accreditation System of Australia and New Zealand) is an example of an organisation that provides accreditation to CABs to formally recognise

[76] See http://www.iso.org/iso/about.htm
[77] http://www.iso.org/iso/about/the_iso_story/iso_story_founding.htm

their expertise and aptitude in undertaking and awarding certification. Certification by CABs can then be offered to a large number of organisations, products and services based on the accepted international protocols and standards. ISO refers to certification as "third party attestation related to products, processes, systems or persons" (ISO, 2004). Figure 6.1 below illustrates this process.

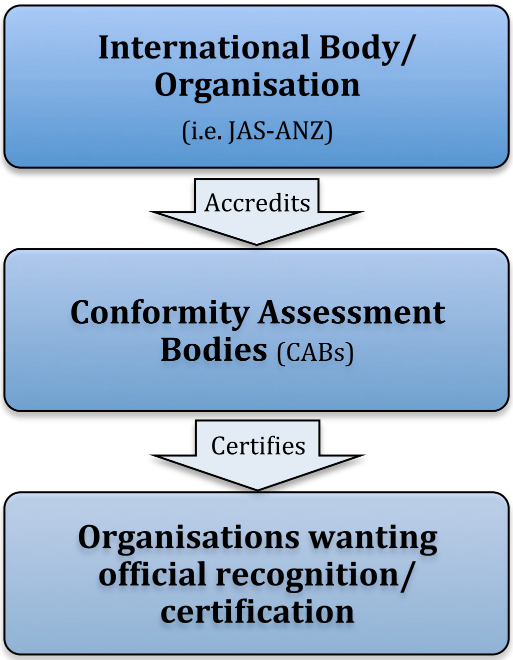

Figure 6.1. Overview of the Accreditation and Certification Processes.

JAS-ANZ was set up in 1991 by the Australian and New Zealand governments to establish a consistent system of accreditation between the countries. JAS-ANZ is a member of the International Accreditation Forum (IAF), a global program for conformity assessment, ensuring that accredited bodies from around the world can be relied upon to provide the same standard of certification.[78] JAS-ANZ defines accreditation as "an endorsement of a conformity assessment body's (CAB's) competence, credibility, independence and integrity in carrying out its conformity assessment activities" (JAS-ANZ, 2013).

JAS-ANZ provides accreditation for a number of different programs including Management Systems, Inspection Bodies, Personal Certification, Product Certification and GHG Validation and Verification. There are five organisations currently accredited

[78] See http://www.iaf.nu/

by JAS-ANZ under the GHG Validation and Verification program.[79] These organisations must verify carbon assertions and claims made by companies or individuals based on the ISO 14064 Greenhouse Gas series.

6.3.3 ISO 14064 Greenhouse Gas series & The GHG Protocol

The ISO 14064 Greenhouse Gas series consists of three documents. They include:

1. ISO 14064-1:2006. Greenhouse gases - Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals;
2. ISO 14064-2:2006. Greenhouse gases - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emissions reductions or removal enhancement; and
3. ISO 14064-3:2006. Greenhouse gases - Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions.

The ISO series of standards are based predominantly on the Greenhouse Gas Protocol documents, which were produced as part of the Greenhouse Gas Protocol Initiative. The initiative convened in 1998 and was a collaboration between the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). Three primary documents were produced as part of the initiative and include:

1. The Greenhouse Gas Protocol - A Corporate Accounting and Reporting Standard;
2. The Greenhouse Gas Protocol - The GHG Protocol for Project Accounting; and
3. GHG Protocol – Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2011).

The three documents were developed in 2001, 2004 and 2011 respectively. They provide detailed guidance on GHG accounting and reporting for projects and

[79] See http://www.jas-anz.org/index.php?option=com_content&task=blogcategory&id=44&Itemid=1

organisations and form the basis for most GHG accounting schemes worldwide. The ISO 14064 series was produced through a partnership between WBCSD, WRI and ISO.

In addition to the ISO, Australia has its own organisation for standardisation called Standards Australia. This organisation originated as an association in 1922, before the creation of the ISO. However, it became a founding member of the ISO in 1947 to ensure that the standards developed would be internationally aligned.[80] As such, these internationally aligned standards are labelled 'AS ISO' standards. The Australian version of the abovementioned standards is thus 'AS ISO 14064:2006 Greenhouse Gases' series.

6.4 Certification Schemes

As mentioned above, certification is "third party attestation related to products, processes, systems or persons" (ISO, 2004). While numerous carbon neutral certification schemes are likely to exist around the world, the following section outlines some of the more well-known international, national and private schemes offering carbon neutral certification, with a focus on Australia. Interestingly, few schemes or organisations currently pursue accreditation from an official accreditation body such as those outlined above, despite the credibility it can bring to the company providing the certification process. This may have to do with the fact that there are relatively few carbon neutral certification schemes compared to the rapidly increasing number of organisations claiming carbon neutrality, thereby placing less importance on the need for certification companies to differentiate themselves. Nevertheless, most certification bodies and organisations do base their certification and GHG measurement process on the international GHG accounting standards mentioned above.

A summary of seven of the most well-known Australian and international carbon certification schemes are discussed below and a comparison is provided in Appendix B.

6.4.1 CarboNZero

Formed in 2001 by New Zealand's Government owned institute *Landcare Research New Zealand Ltd*, CarboNZero was one of the first organisations to offer carbon neutral certification worldwide. It was also the first company accredited through JAS-ANZ under ISO 14065. Based in Zealand but operating internationally, carboNZero

[80] See http://www.standards.org.au

has certified over 200 companies, products, events and services under its program. Countless more have been certified under another scheme (CEMARS), which does not require offsetting (i.e., to become carbon neutral) but ensures that a company is taking action to manage and mitigate its emissions (carboNZero, 2012).

CarboNZero's record is testimony that certification can provide an effective tool in promoting and ensuring carbon mitigation within the voluntary sector. This was acknowledged by the Director of Communications from the United Nations Environment Program, who stated:

CarboNZero is an important example of how a nationally driven greenhouse gas emissions management and certification scheme can advance the global transition to low carbon economies and societies by encouraging companies big and small organisations and even individuals to do something about their carbon footprint. Satinder Bindra (carboNZero, 2012)

CarboNZero is very transparent on its website[81] in outlining its methodologies and certification process. It clearly asserts that certification is based on international GHG standards and protocols, and it provides a comprehensive list of eligible offsets under its program as well as offset registries where offsets can be retired. This transparency undoubtedly adds credibility to the organisation.

6.4.2 Certified Carbon Neutral Global Standard - The CarbonNeutral® Company

Founded in the UK in 1997, originally under the name 'Future Forests', CarbonNeutral® is now one of the largest, private international organisations offering Carbon Neutral certification for companies and businesses worldwide. CarbonNeutral® has worked with around 400 companies in over 40 different countries to deliver carbon neutral certification as well as many other carbon reduction solutions.

CarbonNeutral® certification is based on The Carbon Neutral Protocol (The Carbon Neutral Company, 2012), a document, launched in 2002, which provides guidance on how to reach carbon neutrality. The protocol uses international best practice for GHG accounting methods (i.e., WBCSD/WRI's GHG Protocol and Britain's PAS2060 guidance on carbon neutrality). The certification requires third party

81 For more information, see http://www.carbonzero.co.nz

verification to substantiate carbon inventories, footprints and offsetting. It also provides guidance on how it complies with Australia's National Carbon Offset Standard.

6.4.3 PAS 2060:2010 - Specification for the Demonstration of Carbon Neutrality

A PAS is a *Publicly Available Specification* endorsed by the British Standards Institution (BSI). PAS 2060 was created in 2010 to provide guidance on "the demonstration of carbon neutrality". A PAS differs from a formal British Standard in that it is developed relatively quickly by key stakeholders after identifying a lack of information or guidance in an area that is rapidly developing, such as in the case of carbon management and carbon neutrality. The guide is fast-tracked to create a specification under the BSI and after two years in existence, along with sufficient feedback and revision, a PAS document can become a formal standard under the BSI.[82]

While PAS 2060 provides comprehensive and strict guidance to organisations wishing to achieve Carbon Neutrality, PAS 2060 and the BSI do not officially certify for carbon neutrality. Compliance is based on self-certification, meaning it is up to organisations to provide enough information to meet the standard. BSI undertakes no official review process. As a result, PAS 2060 demands a high amount of rigour to back up claims. Having developed specific rules around the monitoring of reductions, the purchase and retirement of carbon credits/offsets and the communication of the achievement ensure that it complies with BS EN ISO/IEC 17050-1 standard (British Standards Institution [BSI], 2004).

6.4.4 Carbon Neutral

Carbon Neutral[83] is an Australian not for profit organisation providing carbon consultancy, offsets and certification for carbon neutrality. The company was formed by Men of the Trees in 2001, but became its own entity in 2007. Carbon Neutral operates nationally and has become a market leader in providing carbon offsets through bio-diverse tree plantings and revegetation.

Carbon Neutral does not officially offer certification under its own logo but can help companies achieve carbon neutrality without any official certification or branding, ensuring that companies do not breach Australia's ACCC Trade Act. Carbon Neutral

[82] See http://shop.bsigroup.com/Navigate-by/PAS/

[83] The Australian Carbon Neutral company has no affiliation with the UK's CarbonNeutral® Company.

also provides assistance to companies, products and services wanting to achieve carbon neutral certification under the federal governments NCOS carbon neutral program.

Currently, any company that donates over 20 tonnes of CO_2 abatement (i.e., 120 trees) can use its logo.

6.4.5 Climate Friendly

Climate Friendly (CF) is an Australian Offset company dealing primarily with the international offset market. As CF's main business is providing offsets, its focus is on ensuring that a high level of rigour and integrity is maintained around this. The carbon footprinting and certification process for businesses wanting to become carbon neutral (or Climate Friendly as its certification states) appears to be secondary to this. Consequently, the carbon footprinting process appears to be less rigorous than other schemes mentioned in this section. Clients wanting to use CF's logo simply enter their emission details into an online carbon calculator, which informs them how many offsets they need to purchase. This lacks transparency in terms of the methodology underpinning the calculations and the process does not require third party verification.

Similar to carboNZero, Climate Friendly offers two types of certification: one that essentially makes clients carbon neutral (*'Climate Friendly Business'*) and another for clients that may only wish to offset part of their total emissions *('Taking Action With Climate Friendly'*) (Climate Friendly, 2013).

6.4.6 NoCO2 – The Carbon Reduction Institute

The Carbon Reduction Institute was formed in 2006 and offers a variety of carbon management services including carbon neutral certification within Australia. The company offers several types of carbon certification including NoCO2, LowCO2 and Carbon Neutral. Its methodology is based on recognised international frameworks and protocols but has been adapted, suggesting it is not necessarily comparable or as rigorous as other certification schemes. The certification for carbon neutrality does not specify inclusions/exclusions but the website states that the "greenhouse gas impacts produced by, and embodied within all products and services consumed" must be accounted for (Climate Reduction Institute, 2012).

There is no mention of third party verification, which is a key component of the international GHG protocols, frameworks and standards, as it provides robustness, rigour and credibility to audits and carbon claims. Without this third party attestation, this type of certification may prove harder to sell to consumers in the future as people become more critical and demand greater transparency and substantiation to defend the credibility of carbon claims.

6.4.7 Carbon Neutral - ICLEI

As mentioned in Chapter 5, ICLEI has, over several years, been involved in creating various frameworks and protocols to advise cities, local governments and councils on how to measure and manage their carbon emissions and how to achieve carbon neutrality. While councils can claim that they have achieved carbon neutrality under the ICLEI framework, there is no certification process, annual fee or evaluation of documents by ICLEI or another body. However, the guides do encourage participants to seek third party verification.

6.5 NCOS Carbon Neutral Program – Low Carbon Australia

In 2010, the Australian Federal Government introduced an official, government endorsed Carbon Neutral certification scheme for use in Australia. Research suggests it is the second of only two government initiated schemes worldwide. It is based on the National Carbon Offset Standard, which has brought credibility and integrity to the Australian voluntary offset market. The NCOS carbon neutral program is the most rigorous, independent and locally relevant scheme for certifying carbon neutral products and businesses in Australia. It is for this reason that greater focus has been given to understanding this scheme in more depth and to analysing it in terms of it applicability to land development. Further information about the Government NCOS Carbon Neutral Program is provided in section 6.6 below.

6.5.1 Discussion

Despite the somewhat limited information available regarding the current state of carbon neutral certification schemes being offered worldwide[84], the various carbon neutral protocols, frameworks and certification schemes mentioned above suggests this is a growing field. The brief analysis above highlights some of the more well-known schemes that currently offer certification for carbon neutrality, both domestically in Australia, and internationally. The schemes vary in their GHG methodologies, amount

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[84] No academic studies were found on this specific topic. Research was limited to information available in English.

of rigour (i.e., requirements for third party verification), eligible offsets and period of certification. Thus, when it comes to choosing reliable, robust, ongoing carbon neutral labelling or certification from a reputable (i.e., government endorsed) or internationally recognised organisation, options appear to be limited and issues become apparent.

Vested Interests

One of the primary concerns regarding carbon neutral certification is the issue of vested interests, particularly in relation to carbon offsetting. A potential conflict of interest can occur when companies who offer carbon footprinting or carbon neutral certification also supply the offsets. Prospective clients have a right to be dubious of or question the carbon footprinting method applied to their organisation, once they understand that it is in the offsetting/certification company's intention to sell them the offsets. It would be in the interest of the offsetting company to make the boundaries of the footprint/inventory large if that meant they could sell additional offsets. Similarly, such an organisation has less incentive to encourage rigorous in-house reductions by companies if it decreases their own potential to sell more offsets.

Interestingly, the majority of the abovementioned certification schemes, despite clear variations in their transparency and rigour, sell offsets as an additional (if not primary) service. Thus, this can be seen as compromising the integrity or questioning the ultimate motivation of the company providing certification.

Only three organisations do not sell offsets: ICLEI, the BSI (PAS, 2060) and Low Carbon Australia. However, the BSI and ICLEI provide only frameworks and standards for achieving carbon neutrality as opposed to actual certification, leaving Low Carbon Australia as the only independent organisation offering purely certification.

Government Endorsement

The 2011 State of the Voluntary Carbon Market Report (Peters-Stanley, 2011) lists Australia's NCOS Carbon Neutral Program as one of only five certification schemes and the only Government endorsed program offering carbon neutral certification. However, the previous section reveals the New Zealand based 'carboNZero' program, established in 2001, was the first official Government led carbon neutral certification scheme to be implemented globally.

The UK PAS 2060 Standard is also Government endorsed, and this provides guidance on reaching Carbon Neutrality but does not offer independent certification. Compliance with PAS 2060 is based on self-certification and organisations making carbon neutral claims under this standard must provide sufficient documentation to support their claim.

From research conducted thus far[85], the Australian and New Zealand carbon neutral programs remain the only government initiated programs worldwide offering rigorous, third party verified carbon neutral certification. However, as discussed above, the carboNZero program also sells offsets as part of its core business.

A Global Leader

The Australian Government endorsed NCOS Carbon Neutral program, with its rigorous GHG accounting methodology, backed up by third party verification and linked to a national carbon offset standard (though separated from the actual selling of offsets), is a very robust, reliable and trustworthy scheme and puts Australia in a unique global leadership position.

It is expected that this Federal Government Carbon Neutral Program will become the accepted standard for carbon neutrality within Australia into the future, and perhaps will be seen as global best practice. For this reason, it has been chosen as the primary carbon neutral certification system to analyse and assess in this thesis. A more detailed overview of the program is provided below, followed by an analysis of the scheme's applicability and viability in certifying land development.

6.6 The Australian Carbon Neutral Standard

The move towards national carbon pricing in Australia in recent years has led to a re-evaluation of the existing voluntary carbon offset market and what it means to become carbon neutral in the Australian context. These policy developments led to the establishment of a new National Carbon Offset Standard (NCOS), which ensured that offsets bought and sold - thus, inherently connected to carbon neutrality - remain additional to those carbon reductions expected to occur under a regulated carbon price.

Alongside this overarching national standard for carbon offsetting, the government introduced a rigorous, government-endorsed process for certifying carbon neutral products, services and organisations - the NCOS Carbon Neutral Program. This program has helped to provide clarity and credibility to a rapidly growing field and industry in Australia.

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85 This area is rapidly evolving with new players entering this space frequently. This information was accurate at the time of writing to the best of my knowledge.

Shortly after the release of the NCOS Carbon Neutral Program (CNP), the Australian Federal Government created an independent body called Low Carbon Australia Limited (LCAL), to be responsible for administering the certification process. The certification process carried out by LCAL is an independent, stand-alone service, i.e., GHG audits, third party verification and the purchase of carbon offsets each remain a separate exercise, providing LCAL with greater impartiality and credibility.

The section below begins with an overview of the National Carbon Offset Standard, as it plays a pivotal role in the certification process. A brief history of Low Carbon Australia is then provided, before examining the specific process for achieving carbon neutrality under the NCOS CNP. Finally, some issues arising around the certification of land development are identified.

6.6.1 The National Carbon Offset Standard

In 2009, the Australian Federal Government developed the National Carbon Offset Standard (NCOS) to increase the credibility of, and consumer confidence in, carbon offset claims in Australia. It was also designed to bring both consistency and reliability to the Australian voluntary carbon offset market in light of the proposed new carbon price mechanism (CPM). By ensuring that offsets were additional to Australia's national targets and the then planned CPM[86], businesses and organisations could be assured that their voluntary actions and commitments demonstrated a genuine contribution to Australia's national emissions reduction effort (Climate Group, 2009).

Pre-NCOS

Prior to NCOS, offsets were generated from a variety of different sources both internationally and domestically. International offsets were largely dominated by CDM projects and those certified under voluntary carbon standards discussed in Chapter 4. Domestic offsets produced in Australia were generated from a variety of projects from various sectors of the economy. If elected, they could have been certified under the former 'Greenhouse Friendly™' program, which was established in 2001 and provided government certified abatement credits or offsets from Australian projects. These certified credits could then be used to certify Greenhouse Friendly™ carbon neutral products and organisations.

[86] The Carbon Price Mechanism came into force in July 2012.

However, the eligibility of many these offset projects came into question in 2007, after the new Australian Government officially ratified the Kyoto Protocol.87 This effectively changed the rules surrounding the generation of domestic carbon offsets due to new national GHG emissions reduction commitments and new reporting requirements. The National Greenhouse and Energy Reporting Act was passed in 2007 and reporting by organisations commenced in July 2008. The reasons behind this Act are illustrated in Box 2.

Box 2. The National Greenhouse and Energy Reporting Act

Section 3 of the National Greenhouse and Energy Reporting Act defines the object of the Act:

The object of this Act is to introduce a single national reporting framework for the reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy consumption and energy production of corporations to:

- underpin the introduction of an emissions trading scheme in the future;
- inform government policy formulation and the Australian public;
- meet Australia's international reporting obligations;
- assist Commonwealth, State and Territory government programs and activities; and
- avoid the duplication of similar reporting requirements in the States and Territories.

(DCCEE, 2008, p. 3)

Box 2. The National Greenhouse and Energy Reporting Act.

Two supporting documents, The National Greenhouse and Energy Reporting Guidelines (DCCEE, 2008) and Technical Guidelines (DCCEE, 2012c) provide additional guidance on how to report and identify the thresholds for determining liable entities under the reporting scheme. This scheme formed the basis for determining the sectors and entities to be covered under future carbon pricing legislation.

[87] The ALP Government replaced the Coalition Government in July 2007 and within their first few days of office had ratified Kyoto.

Post 2007

As a result of the abovementioned policy changes, sectors that were previously able to generate and sell government approved (i.e. Greenhouse Friendly™) offsets suddenly became ineligible, as they were identified as falling under 'covered sectors' (e.g., waste)[88] under the proposed carbon price mechanism.[89] In order to maintain an offset's additionality criteria[90], offsets can only be generated from sectors and projects that fall outside covered sectors. As such, many Greenhouse Friendly™ credits/offsets were no longer accepted under the government's program. They were, however, still eligible for use in other non-governmental certified carbon claims.

The National Carbon Offset Standard (NCOS) was developed to rectify this issue and thus, replaced the Greenhouse Friendly™ scheme. As mentioned, the NCOS was released in 2009 and officially commenced in July 2010. Greenhouse Friendly™ credits were not accepted under the initial version of the NCOS. However, in 2012, after a review of the program and guidelines, which included significant public consultation, it was decided that the remaining Greenhouse Friendly credits would be eligible for use under the NCOS Carbon Neutral program until July 2013 (of Australia, 2012).

Eligible Offsets under the NCOS

There are various types of offsets currently accepted under the NCOS, including both domestic and international offsets. International offsets consist of either Kyoto units or Voluntary units from a range of different schemes discussed in Chapter 4 and outlined in Table 11 below.

There are three sources of domestic offset units eligible under the NCOS: Australian Carbon Credit Units (ACCUs), which are developed through the Federal Governments new Carbon Farming Initiative (CFI); Carbon Units, which are issued

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88 It was initially unclear where the waste sector would sit in relation to the CPM and CFI, when both schemes were initially introduced. It now appears that activities related to landfill are considered to be within the "Land" sector and thus included under the CFI and able to generate offset units. Other emission intensive forms of waste management are covered under 'Waste sector' and thus, are captured under the CPM.

89 Certain carbon abatement projects in the waste sector have since become eligible under the CFI, however.

90 The "requirement that a project or activity provide abatement that is additional to any that would occur in the absence of the project or activity, and that is additional to abatement that would occur anyway to meet Australia's International Target" (Commonwealth of Australia 2012: iii).

through Australia's new CPM; and the remaining/leftover Greenhouse Friendly™ credits[91] (DCCEE, 2012a,b).

The CFI is the only scheme currently generating offset credits from projects within Australia. These offsets must come from sectors outside those covered by the CPM (e.g., agriculture). All projects applying for carbon credits through the CFI must have their methodologies approved by The Domestic Offsets Integrity Committee (DOIC). The DOIC is an independent committee set up by the previous Department of Climate Change and Energy Efficiency (now DIICCSRTE) to provide expert advice and to assess the abatement methodologies of offset projects submitted to the government. Currently, 13 methodologies have been approved[92] and they include projects related to manure generated from piggeries and dairy farms, vegetation projects (e.g., environmental plantings, savannah burning, afforestation and reforestation), and from landfill and alternative waste treatment projects (e.g., landfill methane capture and combustion, and landfill diversion). Several other methodologies are currently under development.

Table 11 below summaries the offsets eligible under the NCOS.

	Type of Offset	Name of unit	Program
Domestic Offsets	Australian Government Units	Australian Carbon Credit Units (ACCUs)	Carbon Farming Initiative (CFI)
		Greenhouse Friendly credits	Greenhouse Friendly Program (until July 2013)
		Carbon Units	Issued under Australia's Carbon Price Mechanism
International Offsets	Kyoto Units	Certified Emissions reductions (CERs)	Clean Development Mechanism (CDM)
		Emissions reduction Units (ERUs)	Joint Implementation (JI)
		Removal Units (RMUs)	Land use, land-use change and forestry (LULUCF) activities
	Voluntary Units	Verified Carbon Units (VCUs)	Verified Carbon Standard
		Voluntary Emissions reductions (VERs)	Gold Standard

Table 11. Eligible Offsets under the NCOS.

[91] These can be used until the end of July 2013 (DCCEE, 2012b).
[92] As of 25th April 2013. See http://www.climatechange.gov.au/en/government/initiatives/carbon-farming-initiative/methodology-development/determinations.aspx

To become carbon neutral certified under the NCOS Carbon Neutral Program, only offsets recognised under this Standard are able be used. It is important to note that offsets can still be generated from a range of other activities and schemes that are not recognised by the NCOS. While these offsets cannot be used under the Federal government's NCOS Carbon Neutral Program, they can be used to make carbon neutral claims outside of the program, so long as the claim (including information about the type of offset) is clearly explained to satisfy the requirements of the ACCC.

6.6.2 Low Carbon Australia Ltd

The launch of the NCOS in 2009 coincided with the launch of the Federal Government's Australian Carbon Trust Limited (LCAL), a new body that would be responsible for driving voluntary energy efficiency and emissions reductions within the built environment. It was established as an independent, public company with its own board of directors, though it is funded entirely by the Federal Government. It was largely modelled on the United Kingdom's (UK's) Carbon Trust, and its name was chosen to reflect this partnership. It began official operations in 2010 and quickly established itself as reputable body, headed up by prominent leaders in the field.

As the Scope and role of the company rapidly evolved, diverging from its UK counterpart as it dealt with unique Australian conditions and politics, the company decided, in 2011, to change its name to Low Carbon Australia Limited (LCAL) to demonstrate this independence and to better reflect its own aims and ambitions.

LCAL currently manages the Government's Energy Efficiency Program, which actively promotes energy efficiency and clean technologies to commercial businesses, local governments and community organisations and their facilities by offering a range of services including expert advice, collaborative partnerships and innovative financing mechanisms for energy and GHG related retrofits. LCAL was also responsible for administering the Federal Government's NCOS Carbon Neutral Program on behalf of the government Department of Climate Change and Energy Efficiency, thereby providing official, government-endorsed certification of Carbon Neutral products, services and organisations.[93]

[93] On the 1st of June 2013, the NCOS Carbon Neutral Program moved to the Department of Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education and is no longer being administered by LCAL.

In early 2013, LCAL merged with the Federal Government's Clean Energy Finance Corporation (CEFC), a $10 billion fund to activate investment in renewable energy, low emissions technology and energy efficiency. LCAL runs on a cost recovery basis with its primary objective to help drive voluntary GHG reductions to assist Australia in the transformation towards a low carbon economy.

While LCAL is not currently accredited under any international scheme mentioned in the previous section, the scheme does follow stringent international guidelines and protocols, requires third party verification of the GHG audit and process and only accepts NCOS recognised carbon offsets. Nevertheless, it is proposed that accrediting LCAL through JAS-ANZ or some other formal Accreditation body could provide additional credibility to LCAL in the future.

6.6.3 NCOS Carbon Neutral Program and Certification Process

The National Carbon Offset Standard Carbon Neutral Program commenced in 2010, marked by the release of the first version of the NCOS Carbon Neutral Program Guidelines. The NCOS CNP is underpinned by the NCOS and based largely on the GHG Protocol developed by the World Resources Institute and World Business Council for Sustainable Development (WRI & WBCSD, 2004) and Australia's National Greenhouse and Energy Reporting Systems (NGERS) (DCCEE, 2008), and is consistent with the ISO documents (ISO 14064 series) outlined above. Certification follows the broad three-step process outlined in Chapter 4, which involves first calculating the carbon footprint of the product or organisation, then reducing emissions where possible or financially viable, and finally purchasing eligible carbon offset credits to offset the remaining unavoidable emissions.

The NCOS Carbon Neutral certification runs over a five year period and requires:

- annual reporting of emissions and updating of the emissions management plan;
- bi-annual third-party verification of the audit;
- annual purchasing of offsets; and
- payment of an annual certification fee.

The general process for achieving carbon neutrality is highlighted in Figure 6.2 below.

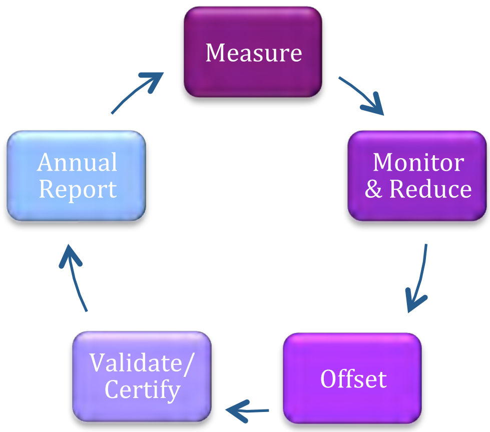

Figure 6.2. Overview of the Carbon Neutral Process Required by LCAL.

The license fee structure is determined by the size of the footprint being assessed.

There are four key documents that must be submitted annually as part of the certification process. These are:

4. The Greenhouse Gas Inventory/Carbon Footprint;
5. The Emissions Management Plan;
6. The Public Disclosure Summary; and
7. The Annual Report

These documents are briefly described in the section below.

The Greenhouse Gas Inventory/Carbon Footprint

The NCOS and Carbon Neutral Program Guidelines (CNPG) allow participants to choose between the two types of carbon footprint calculation methodologies outlined in Chapter 4. These include either the inventory approach (targeting organisations) or a Life Cycle Analysis approach (recommended for products and services). However, after a period of public consultation[94], the revised CNPG also permits and suggests using a hybrid approach for calculating the carbon footprint of certain projects such as construction works, which may not fall specifically within either category.

[94] I wrote a submission for this consultation (see Appendix C), together with a colleague at my Institute (Samantha Hall), which may have influenced the decision to encourage the hybrid approach for construction.

The applicant then determines the boundaries of the organisation, deciding for example if the entire operation is to become carbon neutral or only a section (i.e., a department or aspect of the business).[95] Emission sources and Scopes are affected by the methodology and boundaries chosen above. Nevertheless, the guidelines require that all Scope 1 and 2 emission sources be included and recommend where feasible, and that all Scope 3 sources also be incorporated. This is far greater than what is required under the NGERS reporting, particularly for small organisations, where Scope 3 emissions often represent a far greater proportion[96] of total emissions (Downie & Stubbs, 2011).

Scope 3 Emissions

Recognising the magnitude of, and complexity associated with Scope 3 emission sources, the GHG Protocol released a new standard in 2011 called *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (WRI & WBCSD, 2011). Table 12 provides a summary of the framework for identifying the various Scope 3 emissions proposed by this new Protocol. The sources are identified as either 'upstream' Scope 3 emissions (points 1-8) or 'downstream' (points 9-15) Scope 3 emissions (WRI & WBCSD, 2011).

Potential Scope 3 emissions

'Upstream Emissions'	Purchased goods and services Capital goods Fuel- and energy-related activities (not included in Scope 1 or Scope 2) Upstream transportation and distribution Waste generated in operations Business travel Employee commuting Upstream leased assets
'Downstream Emissions'	Downstream transportation and distribution Processing of sold products Use of sold products End-of-life treatment of sold products Downstream leased assets Franchises Investments

Table 12. Scope 3 Emissions. Adapted from WRI & BBCSD (2011).

[95] It is generally too complicated to separate a product's boundaries, particularly when marketing, hence the requirement for an LCA methodology.
[96] Downie and Stubbs (2011) suggest it can be up to 75 per cent of a company's total emissions.

While the CNPG recommend including as many Scope 3 emission sources as possible, they require at a very minimum that the Scope 3 emissions for paper, waste and business travel be accounted for in the carbon footprint (The Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013). The latest version of the NCOS CNP guidelines, however, acknowledge that these stipulations are not necessarily relevant for all carbon neutral applications (i.e. construction and land development),[97] and thus advocate an individual appraisal and identification of the most relevant and feasible sources of Scope 3 emissions.

Renewable Energy

The purchase or use of renewable energy (or GreenPower™) in relation to carbon claims can be interpreted in many ways. In order to avoid confusion, the NCOS Carbon Neutral Program developed specific rules relating to the use of GreenPower™. As such, where government-approved GreenPower™ has been purchased from an electricity retailer, the emissions associated with this electricity consumption (i.e., an organisation or product's Scope 2 emissions) will equal zero. A similar situation exists if a company produces its own renewable electricity onsite, that is, the emissions from this electricity will simply equal zero. However, it must provide evidence to LCAL that the Renewable Energy Certificates (RECs) associated with the renewable electricity generation have been retained by the owner and cancelled and not sold on.[98] Generated or purchased electricity from renewable energy sources cannot be used to offset other internal emissions associated with an organisation or product's carbon footprint under the NCOS Carbon Neutral Program. This poses a problem for land developers, which will be discussed later.

The Emissions Management Plan

The Emission Management Plan (EMP) underpins and documents the entire carbon neutral process under the NCOS Carbon Neutral Program. The EMP is defined within the CPNG as an outline of "the management framework, systems and processes … in place to effectively manage your carbon neutral commitment from start to end"

97 This is the only mention of the construction sector in this revised proposal. As yet, no construction company or developer has sought certification.

98 If RECs are sold, the electricity produced is no longer considered carbon-free as the certificates are going towards assisting a liable entity to meet their quota under the Federal Government's 20 per cent Renewable Energy Target (RET). If RECs are retained by the producer of the electricity (e.g., from rooftop PVs), this ensures Australia goes above and beyond what the RET mandates.

(DCCEE, 2011b). The EMP must provide information on the greenhouse gas audit, data collection and record keeping, quality control practices, the emissions reduction strategy (which highlights all emission abatement activities and initiatives including justification of all reduction estimates), the carbon offset purchasing process, and verification and identification of uncertainty within the audit.

The Public Disclosure Summary

The Public Disclosure Summary (PDS) extracts the main points from the EMP (often a lengthy document) to create a short, one to two page summary, highlighting the key areas of the applicant's process to demonstrate to the public how the applicant achieved carbon neutrality. The purpose of this document is to promote transparency and credibility of the certification process, thereby strengthening the carbon claim.

Annual Report

As mentioned, the documents must be updated and submitted annually to provide evidence to LCAL that the applicant is on track in meeting its NCOS obligations under the carbon neutral certification program. Every second year the audit and process must be reviewed by independent, third party, NGERS qualified GHG verifiers.

The annual report must be submitted within four months of the end of the reporting period (DIICCSRTE, 2011). This has significant implications for urban development, and is thus discussed below.

6.7 Precinct Level Urban development and the NCOS CNP

Vast amounts of literature over several decades have highlighted the impact the construction industry has on the environment and greenhouse gas emissions (ASBEC, 2008; Cole, 1992; Dixit et al., 2012; Zuo et al., 2012). Developers are increasingly becoming aware of their environmental impact and many are taking proactive measures to reduce it. Several are striving to become leaders in their field and differentiating themselves in the market based on their green credentials.[99]

Carbon Neutral certification provides one way of demonstrating this environmental commitment to the public. Striving for carbon neutrality also provides numerous other benefits, as mentioned in Chapter 2, such as the reduced long-term

[99] See the Pixel Building by Grocon http://www.grocon.com

operating costs of living and working in low carbon precinct developments (e.g., reduced energy, water, waste and transport costs), increased health benefits, and increased productivity, amenity and liveability.

The Australian Federal Government's NCOS Carbon Neutral Certification Program has provided a world-class platform for acknowledging the carbon reduction achievements of organisations in Australia. Being underpinned by robust, international standards for carbon accounting and overseen by leaders in the field, this program is pioneering its way through a complex and unique set of conditions in relation to Australia's carbon market, which is set within a capricious political landscape.

With these complex circumstances in mind, and the fact that the NCOS CNP is still in its infancy, it is not surprising that many issues are still being identified and worked through. Several issues quickly become evident when applying the certification process to precinct-scale urban development.

To begin with, the generic guidelines mean that many decisions, such as those about boundaries or ways of dealing with various types of developments (e.g., new development versus redevelopment), are relatively open to interpretation, making comparisons less robust and effective. There is currently little guidance in the carbon neutral certification process around how to manage the multiple stakeholders that are inevitably part of larger, precinct-scale developments. Ongoing certification poses another problem for developers who often hand over responsibility once a development or parts of it are sold.

Offsets are yet another challenge for developers wishing to attain carbon neutral certification through the NCOS CNP, as many of the onsite emissions reduction opportunities within urban development are not considered eligible offsets under this scheme. How to deal with behaviour change in the long term, and how to ensure that the calculation process and transaction costs associated with certification do not become too onerous or prohibitive, are additional areas that need to be considered. These areas are discussed in more depth below.

6.7.1 Generic Guidelines

The Carbon Neutral Program guidelines are intentionally generic in order to be relevant to the largest possible number of participants. However, having generic guidelines may lead to inconsistent GHG methodologies being adopted within certain subsectors such as precinct-scale development. For example, the current guidelines, which primarily target organisations and/or their products, recommend either the inventory approach or a life cycle analysis for calculating emissions. However, as the construction of urban precinct development is more consistent with an ongoing project than an organisation or a typical product, it tends to fall between the two proposed methodologies. The revised guidelines (DCCEE, 2011b) recommend that in circumstances where there is no clear methodology, such as for construction, a hybrid approach can be adopted. However, this could be seen as further exacerbating the problem of inconsistency and incomparability in terms of reporting.

The hybrid approach may well be the best option for calculating the footprint of a precinct-scale development, but a consistent definition relating specifically to the boundaries of the development needs to be in place. Identifying and defining these boundaries remains the biggest challenge in achieving consistency of reporting. Kennedy and Sgouridis (2011) in their article 'Rigorous classification and carbon accounting principles for low and Zero Carbon Cities' acknowledge the difficulty in defining these boundaries, pointing out that the city with its precincts is a:

> dynamic and complex system, defined in part by its geographic boundaries, but also by its interconnections with a much broader region through exchanges of materials, energy and information. This interconnectedness complicates the task of determining which emissions should be included. (p. 5261)

With this in mind, it is argued that sector-specific guidelines are needed to bring greater consistency to the reporting of emissions of developments at the precinct level to ensure that, at a minimum, certain key emissions sources such as the six highlighted in this thesis[100] are included in the emissions calculation, regardless of the chosen methodology.

6.7.2 Catering for Different Types of Development

Another factor that is likely to have a significant effect on the overall footprint of a development is the type and location of the development. There are three broad

[100] I.e., the embodied emissions in the materials of buildings, roads and infrastructure, and the up- and downstream emissions associated with the energy, water and waste cycles and transport

classifications of urban development. These are ‘greenfield’ developments (sites where no previous development has taken place), ‘greyfield’ developments (previously light industrial/commercial or older residential sites) and ‘brownfield’ developments (previously heavy industrial sites, often requiring land remediation). The titles broadly establish whether a development is using reclaimed land (a greyfield or brownfield redevelopment site) or is a brand new development, often situated at fringe of the city (a greenfield site) – see Newton et al (2012).

The potential variation in footprints is likely to be significant when factors such as occupant transport and the embodied emissions associated with construction are considered. For example, if a project reuses materials already onsite from a previous development, or if aspects of an existing development are retained and reconstructed, the embodied emissions are considerably less (e.g., if there is retention of foundations, the building’s core, or water and gas pipes). In this case, it should be stipulated in the carbon accounting methodology or guidelines that only the embodied carbon that is new to the site be included in the carbon footprint.

Kennedy (2011) suggests that the embodied emissions included in a carbon footprint of a redevelopment be based on the starting year of a carbon claim, thereby allowing emissions already locked up in existing buildings and infrastructure be excluded from the audit.

The carbon footprint of a development is ultimately defined by its location and connection to low carbon transport infrastructure. Although greyfield or brownfield sites can still vary greatly in respect to their accessibility to public transport, these sites typically have fewer transport emissions than greenfield sites[101], as they are located in more established areas, often with amenities in a closer proximity.

These considerations should be taken into account when designing guidelines to properly acknowledge and reward genuine low and carbon neutral developments. It stands to reason that a development, no matter how energy efficient it is or how many sustainability features or technologies it has incorporated, cannot be truly carbon neutral if the residents and businesses are forced to use emission intensive car-based transport to commute long distances to and from the development.

[101] With the exception being if a new greenfield development is being built as a Transit Oriented Development.

6.7.3 Dealing with Multiple Stakeholders

Another pertinent issue for developers aspiring to gain carbon neutral certification involves managing multiple stakeholders. There are countless stakeholders associated with precinct-scale development, including developers, architects, urban planners, local councils, state government agencies, energy, water and waste utilities, construction workers and tradesmen, and existing and potential residents and businesses. Each stakeholder has an ability to affect, either positively or detrimentally, the outcome of the development and attainment of carbon neutral status. Blundell (2012) specifically highlights the importance of the utility sector as key stakeholders within precinct-scale development, suggesting that without their commitment, collaboration and support, sustainability outcomes will fail.

In order to be successful in achieving ambitious sustainability goals, a developer needs the commitment and on-going support from all stakeholders. Stakeholders, therefore, need to be engaged in the process from the beginning and the aspirations for the development (i.e. carbon neutrality) need to be made clear from the outset of the project. Participation and support are likely if there is a perceived benefit to all parties (Thabrew et al., 2009).

Thus, establishing a clear understanding of the costs and benefits associated with the project on each of the stakeholders is critical. The notion of 'split incentives'[102] is likely to be an issue for urban development striving for carbon neutrality. Split incentives involves a situation where a set of conditions (i.e. cost and risks) prevents certain parties (e.g., owners) from investing in improvements or upgrades in a building if the benefits accrue to a different set of stakeholders, (e.g., tenants) (ASBEC, 2008; DCCEE, 2010; WBCSD, 2009). If left unresolved, this can lead to inertia and stagnation and prevent the attainment of goals.

In terms of carbon neutral development, the question will be: who ultimately benefits from the carbon neutral development, in particular, from certification, and who pays the cost of achieving and maintaining it? To ensure all stakeholders share in the benefits, as well as the associated costs and risks, these factors will need to be identified and worked through at the beginning of the process.

[102] Also known as 'Principal-Agent problem' (DCCEE, 2010) and 'Landlord-Tenant problem' (ASBEC, 2008).

There are some examples where good stakeholder participation has led to exceptional results. The successful design and development of Vauban eco-community is one such project. Having encouraged strong community and stakeholder participation from the outset, the ideas, aspirations and goals generated throughout the process were essentially owned by all (Williams, 2012). Thabew et al (2009) also acknowledges the importance of community, suggesting that they should be at the centre of the process to ensure that they, along with other key stakeholders, feel "empowered to influence and share control over development initiatives, decisions, and the resources affecting them" (p. 67, 68).

Examples such as Vauban suggest that an integrative, participatory sustainability planning approach involving multiple stakeholders is likely to increase the likelihood of success in achieving ambitious or complex goals within urban development, yet despite this, formal methodologies for managing the process still appear limited (Thabrew et al., 2009). A recent review suggested there is currently no universally accepted structured approach for engaging and managing stakeholders within the construction industry (Yang et al., 2011), though several methodologies and approaches do exist for managing and facilitating stakeholder engagement processes in general (Reid, 2008; Thabrew et al., 2009).

6.7.4 Issues with Ongoing Certification

While the need for ongoing certification of carbon neutrality has previously been identified as a key requirement to ensure carbon claims remain valid and accurate, there are likely to be several issues associated with maintaining this in relation to urban development. The primary issue concerns ownership of the development. Developers rarely maintain control or ownership over urban development projects once construction is complete. Thus, the question that arises is: who will be responsible for ensuring that ongoing measurement, monitoring, emissions reductions and purchasing and retiring of offsets will be carried out in line with the requirements under the NCOS CNP?

Once land development is sold off to individual landholders (both commercial and residential), it will become increasingly challenging to obtain agreement amongst all new owners to maintain certification.[103] However, if by chance, the decision to pursue and maintain certification *is* agreed upon by the various stakeholders, the question still remains: who will be responsible for undertaking the process (i.e. conducting the annual carbon footprinting and writing up emissions management plans etc) and who will be responsible for implementing measures and ensuring that targets are being met/enforced?

The solution to this is that land developments may only seek certification in their design phase. Finding further emissions reduction opportunities within an urban development that has been designed well will also prove challenging as the majority of emissions reduction measures will have been implemented in the design phase. Nevertheless, new technologies are continuously emerging and becoming available, providing new emissions reduction opportunities into the future, so the possibilities of an operational certification scheme should not be abandoned.

6.7.5 Offsets

Currently, there is no specified limit on the number of credits or offsets that can be purchased or used within a development when claiming carbon neutrality under the NCOS CNP. The only requirement is that applicants demonstrate that onsite carbon reductions are also being pursued. The main rules, requirements and guidelines around offsets focus on the *types* of offsets allowable under the standard.

As mentioned in Chapter 4, surplus carbon-free renewable energy generated onsite within a development and fed into the grid is commonly seen as a form of offsetting. When applied to buildings, this concept is referred to as 'net-zero energy', whereby the buildings feeds as much energy generated onsite into the grid as the building has taken from the grid over a year period (Hernandez & Kenny, 2009).[104] While this process has traditionally not taken into account the embodied emissions associated with buildings or infrastructure, Hernandez and Kenny (2009) argue that it should, and propose a new definition of zero energy from a life cycle perspective, as follows:

103 This issue also impacts on the commercial building rating schemes that have proliferated around the world. While these tools are primarily design tools, attempts are being made to create operational ratings. Nevertheless, the mix of owners and users in large buildings usually make it difficult to seek any ongoing certification or rating.

104 Kennedy and Sgouridis (2011) refer to this as 'balancing'.

> …the primary energy used in the building in operation plus the energy embodied within its constituent materials and systems, including energy generating ones, over the lifetime of the building is equal to or less than the energy produced by its renewable energy systems within the building over its lifetime. (p. 817)

Williams (2012) suggests that developments that claim to be net-zero carbon on an annual basis can do so by using this process.

However, this concept and method of balancing or neutralising emissions is not accepted under the Australian Federal Government's NCOS Carbon Neutral Program, which is based on internationally recognised protocols for offsetting (DCCEE, 2011b). One of the key eligibility requirements for offsets under these protocols is that they meet the additionality criteria mentioned previously—that is, that offsets are additional forms of abatement relative to those which would occur under a BAU scenario (WRI & WBCSD, 2003).

Since energy generation is a covered sector under the Australian Federal Government's new national carbon pricing legislation, developers are already paying the equivalent of a carbon tax on their energy related emissions, either directly or as a cost passed on from energy utilities. Therefore, as developers are already fiscally encouraged to reduce carbon, any action to further cut emissions from energy production or use onsite is argued to have occurred as a result of the legislation. As a result, energy-related offsets are not deemed additional voluntary forms of abatement under the NCOS. The only eligible domestic offsets under this legislation come from the Carbon Farming Initiative (CFI) and remaining Greenhouse Friendly offsets (DCCEE, 2011a,b, 2012a,b). International offsets are also eligible.

Interestingly, the only fully articulated guidelines and certification scheme in Australia that could potentially recognise a precinct-scale development's carbon reduction contains a rule that prevents onsite carbon reduction from energy being recognised as an offset. It is believed that this issue will make it particularly difficult for developers to achieve carbon neutrality using current eligible offsetting methods.

Thus, urban developers are being pushed away from using on-site renewables and towards using offsets that are often not seen to be part of the development, but just an accounting process. Developers and prospective buyers or renters are therefore not being encouraged to create the kind of eco-city developments that are currently becoming global best practice in green urban development. Integrated renewables-based urban development is being pushed by many (e.g., Droege, 2006) and is emerging as a major part of the urban landscape in Australia (Newton & Newman, 2013). There is therefore a major flaw in the certification system that needs to be addressed in the urban decarbonisation policy process.

6.7.6 Behaviour Change

A big issue with any new green building development or new technology relates to operational behaviour. Assessment of the BedZED development showed that people who came into the development without prior knowledge were able to save carbon about half the national carbon footprint (due to physical design elements) but those educated and committed to reducing their carbon footprint were able to save considerably more (Newman & Jennings, 2007). If residents or workers within a low carbon environment aren't educated about how to live or work sustainably, then the goals and targets are unlikely to be fully reached. Nevertheless, this does not discount the fact that design can still achieve worthwhile carbon benefits.

6.7.7 Transaction Costs

Transaction costs are another factor that needs to be considered when deciding whether to seek carbon neutral certification. There are several different fees associated with gaining certification through the NCOS program. These include fees for the administration of the certification, which are paid to Low Carbon Australia Limited, fees to an independent third party verifier, and the costs associated with purchasing offsets. In addition, developers with no prior experience in conducting a carbon footprint are likely to need to hire a consultant to undertake this initial work (which is then verified by a third party consultant).

Currently LCAL has three tiers of certification fees based on level of emissions the applicant is responsible for. The 2013 fees are provided in Table 13.

Tier	Level of emissions	Price
1	<2,000tCO_2-e	$3,230
2	2,000 – 10,000 tCO_2-e	$9,631
3	>2,000tCO_2-e	$22,773

Table 13: Low Carbon Australia 2012/13 Fee Structure.
Source: P Watt (Personal Communication 13, May, 2013)

The costs associated with undertaking the initial carbon footprint and third party verification can vary considerably depending on the organisation carrying it out. While it is difficult to estimate the cost for these services, as this depends on the size of the development, it is expected to be higher than a typical organisational footprint. Furthermore, as large industry, including the mining and energy sector, currently dominates the demand for carbon accounting, costs for these services are relatively high and unrealistic for smaller organisations. This will most likely change as demand for carbon accounting and green jobs grows.

Although offsets are likely to be the smallest cost associated with the carbon neutral certification process[105] at present, it is expected that the costs of offsets will rise in the future in line with a rising global carbon price.

The transaction costs associated with obtaining certification are not insignificant and may deter some applicants from pursuing this as an option.

6.8 Conclusion

This chapter highlighted various issues associated with carbon claims, which arose from the rapid and less regulated development of the voluntary carbon market and associated carbon industries. These issues led to mounting credibility and validity issues around the quality of services being offered and the claims being made. This in turn, led to a crack down on false carbon claims in Australia, with the ACCC fining companies for inaccurate and misleading claims.

Certification schemes for carbon neutrality emerged as a way to increase the integrity of carbon claims and thus increase consumer confidence in them. This chapter

[105] Based on the current availability of cheap international offsets.

outlined some of the well-known Australian and international carbon certification schemes and focused on Australia's National Carbon Offset Standard Carbon Neutral Program (NCOS-CNP). Although the NCOS CNP is identified as one of the leading independent certification schemes worldwide, a deeper analysis revealed several issues when applying the certification scheme to urban development. These included: generic guidelines which fail to provide sufficient guidance to developers, how developers deal with a variety of stakeholders at the precinct level, and how they deal with ongoing certification, the types of eligible offsets that discourage on-site renewables, behaviour change issues (as ongoing certification for urban development is predominantly about the people living and working there) and the costs associated with certification. Further investigation is needed into how to deal with the various issues identified, which may require changes to the NCOS CNP guidelines. These are dealt with further in Chapter 7 and 8.

Chapter 7 – Certifying Carbon Neutral Urban Development: Framework and Core Elements

7 Certifying Carbon Neutral Urban Development: Framework and Core Elements

7.1 Introduction

From the issues outlined in previous chapters, it is clear that there are several obstacles currently facing the urban planning/development sector, which make gaining carbon neutral certification difficult. It is argued that new sector specific guidelines for urban development are required in order to provide greater clarity and direction for developers wishing to pursue certification. It will also help to bring greater credibility to the concept of carbon neutrality for the built environment and allow accurate and trustworthy comparisons to be made. The following section proposes a Framework for calculating the emissions associated with precinct-scale low carbon development, and it outlines some core elements that need to be considered when establishing a certification process for such development.

7.2 Proposed GHG Framework for Precinct-Scale Urban Development

The GHG framework for precinct-scale urban development espoused in this research involves the calculation of emissions associated with six key areas of development. Each area has its own literature about the benefits of adopting alternative technologies or approaches, although the process of bringing them together has not been undertaken, nor has it been applied in the Australian context. Thus the approach here is to develop a detailed understanding of the carbon associated with each of the six areas of an urban development project.

The areas have been chosen based on the literature review conducted in Chapter 2, which identified significant carbon abatement opportunities, as well as other savings, such as in potable water use, within each area if alternative practices are adopted.

Some of the areas identified are often neglected by developers, as they commonly fall outside the operational control, and therefore responsibility, of a developer (e.g., energy and transport infrastructure). However, they have been chosen and included in the analysis for the reason that they can be influenced by the developer, and because they are of significant interest to the planning agencies. Tools that include all of these characteristics can become important design tools for achieving planning approval.[106] Furthermore, developers are now acknowledging not only the carbon reduction possible from transit-oriented development (Newman & Kenworthy, 1999) but also the financial value in locating urban development around public transport systems (McIntosh et al., 2011).

New small-scale technologies and processes for supplying and managing resources such as energy, water and waste at the precinct level, are now being identified as key priorities for developers, and are increasingly targeted in the design of developments (Bartholomew & Ewing, 2009; Newman et al., 2009; Newman & Matan, 2013; Roseland, 2012).

The six main sources of emissions to be included in any carbon analysis of the built environment, as proposed by this research, include the emissions associated with the:

1. Site Preparation and Construction Process
2. Embodied Carbon in Materials
3. Energy Production and Management
4. Water Management
5. Waste Management
6. Transport

These sources are illustrated in Figure 7.1. Examples of low carbon options available within each area are provided below.

[106] This is discussed further in Chapter 8.

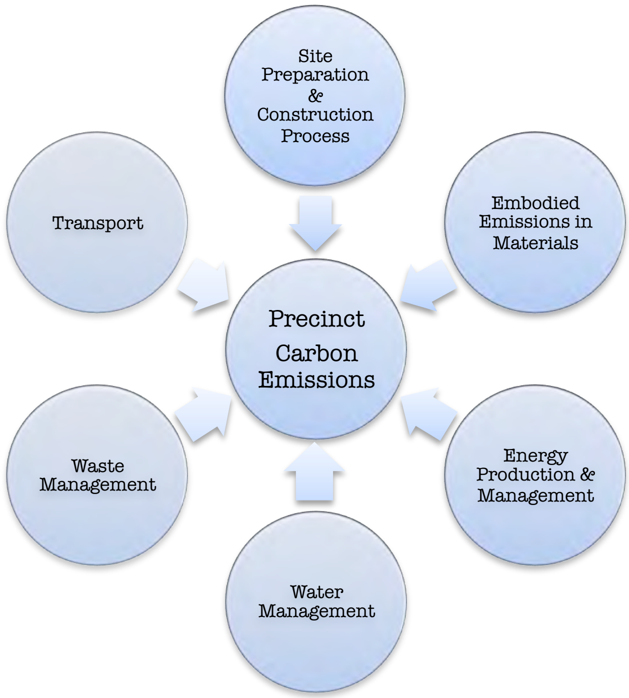

Figure 7.1. Key Emission Sources within Precinct Development

7.2.1 Site Preparation & Construction Process

The first step in the proposed framework for calculating the emissions associated with precinct-scale urban development involves site preparation and the construction process.

Site preparation involves the demolition, management and disposal of existing, onsite building, construction and infrastructure materials (i.e. if development is occurring on grey- and brownfield sites), along with other processes involved in preparing a site for development e.g., excavation, leveling and tree removal (Boake, 2008).[107] It is argued within this research that demolition is better dealt with in the beginning of the life cycle for urban development. These reasons are discussed shortly. The *construction process* involves the emissions associated with different methods for constructing buildings and infrastructure, for example, using prefabricated materials versus onsite construction. These two areas are discussed further below.

[107] Boake (2008) notes that significant emissions can also be locked up in the natural landscape (e.g., trees) before development, which he suggests should also be accounted for in carbon calculations.

Site Preparation

With the above issues in mind, it is argued that D&D emissions are best captured in the beginning of the development process under the banner of site preparation. This would help to ensure that the emissions captured are based on actual numbers, rather than assumed or predicted. It will also ensure that a developer takes part in managing onsite waste responsibly in order to minimise GHG emissions. In addition, it can help developers to become aware of the significant emissions already locked up in the existing materials (which they do not need to account for if re-used) compared to the emissions embodied in creating or using new materials (which will need to be accounted for). This may help to incentivise developers to think more holistically about the reuse of materials and maintenance of existing infrastructure onsite – i.e. seeing waste as a resource, as opposed to razing a development to begin from scratch. This is important, as research shows that "building reuse almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality" (Preservation Green Lab, 2011, p. vi).

There may, of course, be situations where it is unfeasible to maintain existing buildings or infrastructure, for instance, in the case where low-density urban form is being transformed into high-density development, or where the land-use of the site changes from industrial to residential. However, there may still be opportunities to re-use certain materials onsite or to retain the outer shells of buildings.[108] A study conducted by Thormark (2002) demonstrated a 45 per cent reduction in GHG emissions from using recycled materials.

Understanding that significant emissions are already locked in essential infrastructure such as power lines, water pipes and roads may also make infill development more attractive to developers, who will not have to account for these emissions, compared to greenfield development, where they would need to. Research undertaken by Trubka et al (2010a,b,c) demonstrates not only additional GHG emissions associated with fringe development, but also hidden costs associated with this infrastructure, costs which are usually borne by the tax payer.

Another consideration for Greenfield sites involves tress. If site preparation requires the removal of trees without adequate replacement, it is recommended that the carbon already sequestered and stored in them, as well as carbon that would be

108 Examples of this are include old warehouses being converted to residential dwellings.

sequestered in the future, be accounted for in the calculation process, as Boake (2008) suggests.

Understanding and accounting for all the emissions associated with site preparation can influence decisions made by developers and can dramatically affect the carbon emissions associated with a development.

Construction Process

Emissions are generated during the construction process of developments through onsite power and water use and the transport of materials to site, as well as from waste produced from unused materials (i.e. construction and demolition (C&D) waste). Currently, around 42 per cent of waste generated in Australia comes from C&D and around 50 per cent of this ends up in landfill (Productivity Commission, 2006). There are also emissions associated with transporting waste to landfill or a recycling facility.

However, the GHG emissions associated with these processes can vary considerably depending on the construction approach and techniques used. The use of prefabricated (pre-fab) materials[109], for example, has many environmental and GHG benefits, such as the reduction of waste produced onsite compared to traditional construction approaches, fewer embodied emissions in the materials due to greater potential for onsite re-use of materials during the manufacturing process, and a reduction in the time needed to construct a development, which in turn reduces the amount of onsite power (electricity) and transport fuel required (Aye et al., 2012; Lehmann, 2013). All this contributes to reducing not only onsite GHGs, but also costs, which can increase the affordability of buildings, and in particular of housing (Lehmann 2013).

It should be noted that there is significant overlap between site preparation, the construction process and the embodied emissions in materials, discussed in 7.2.2.

Dealing with Demolition and Disposal

While there appears to be limited academic analysis of site preparation as an isolated activity for GHG analysis within the development industry, much research has identified the importance of including the GHG's associated with building construction,

[109] This is a process whereby materials or components of a building or structure are assembled in a factory and then delivered as larger components or as complete assemblies to the construction site.

demolition, and disposal of waste in analyses, particularly if taking a life cycle approach to emission calculation (Crawford, 2009; Dixit et al., 2012; Nassen et al., 2007; Thormark, 2002). However, calculating the demolition and disposal (D&D) emissions from individual buildings is far easier than calculating them from precinct-scale infrastructure at the end of its life (i.e. at some unknown time period in the future), which proves rather complicated and impractical for several reasons highlighted below.

- *Differing Life Cycles of Infrastructure:* To begin with, precinct-scale development involves the construction of different types of infrastructure, such as pipes, roads, houses, buildings and energy infrastructure, all which have differing life expectancies and will thus need to be upgraded at different times. This makes traditional life cycle analysis of GHG complicated for a precinct-wide development.
- *Uncertainty Around Demolition and Disposal Processes:* It is also difficult to predict what processes will be employed when demolishing parts of a precinct development at some future point in time, and how the waste will be disposed of (i.e., if it will be sent to landfill, incinerated or recycled). The calculation of these emissions will be based on significant assumptions, which may or may not ultimately hold true.
- *Double Counting:* Any processes or activities undertaken by developers in preparing their land for construction, such as demolishing existing infrastructure and disposing of the waste, logically become their responsibility and should be taken into account in their GHG analysis. However, if D&D emissions have been included in an LCA of the previous developer, it would mean these emissions do not need to be accounted for by the current one, despite them undertaking the actual process. If this is the case, not only would there be little incentive to dispose of waste responsibly (if it means additional cost or effort), but this situation could also lead to issues of double counting, i.e., if emissions are calculated by a developer at the beginning and by another developer at the end.
- *Redundancy:* Factoring in the D&D emissions from the start could arguably be seen as building in redundancy, rather than assuming that materials and infrastructure will last or be adapted or re-used.

7.2.2 Embodied Carbon in Materials

As mentioned in Chapter 2, embodied energy (EE) typically refers to the emissions associated with the production and transportation of materials used to construct buildings (Cabeza et al., 2013). While the emissions associated with onsite construction, demolition and disposal are also often captured under the banner of EE from a life cycle perspective, the definition proposed in this research confines it just to the emissions associated with the extraction of raw materials, processing, manufacturing and transport, also known as 'cradle to gate' emissions (Dixit et al., 2010). The emissions associated with the construction process, including how materials are transported to and moved around on the site, as well as emissions from demolition, are captured separately in this analysis (i.e., in the Construction Process mentioned above).

New research is showing that embodied energy is responsible for a greater proportion of a building's life cycle emissions than previously thought, and can be as high as 62 per cent, largely because increasing energy efficiency within buildings reduces operational emissions by comparison (Cabeza et al., 2013; Crawford, 2012; Sturgis & Roberts, 2010; Thormark, 2006).

Embodied energy is thus included as a key component in the carbon analysis of precinct-scale development, due not only to the substantial amount of emissions associated with EE, but also because of the significant emissions reductions possible, depending on the materials used. For example, choosing to re-use materials that are already onsite or purchasing recycled materials generally produces far fewer emissions than using new materials (Preservation Green Lab, 2011; Thormark, 2002), depending on the type of material and its production process.

Many new low carbon materials are also being developed, materials that use either low carbon supplements such as fly ash, or cleaner production processes such as the use of renewable energy (Cabeza et al., 2013). Some studies have shown that the amount of embodied water in materials could be just as significant as the amount of energy (Crawford & Treloar, 2005), which can also have a significant impact on emissions, particularly if the water used is sourced from energy intensive processes such as desalination.

The use of pre-fab materials, as mentioned above, can also dramatically reduce the amount of embodied energy (Aye et al., 2012; Lehmann, 2013). Finally, EE can also vary considerably depending on where materials are sourced, i.e., locally, regionally or internationally, and how they were transported to site.[110]

7.2.3 Energy Production and Management

Energy is a particularly important component of the carbon framework, as the majority of life cycle emissions from the built environment generally come from energy related activities (Newton & Tucker, 2010). However, the emissions associated with energy production and consumption within a development can vary depending on a variety of factors such as the design and type of buildings, thermal efficiency, appliance efficiency, occupant behaviour and renewable energy generation (Newton & Meyer, 2012; Newton & Tucker, 2010).

Different building types have been examined in terms of their energy efficiency, with studies showing that denser urban form[111] is generally more thermally efficient than single detached housing (Glaeser & Kahn, 2008). The design of buildings can also dramatically affect the amount of energy required to run them. Well-known building techniques such as solar passive design have been extensively studied and are shown to significantly reduce the amount of artificial heating and cooling required in buildings (Morrissey et al., 2011; Stevanović, 2013). There are also a variety of energy efficiency measures such as improved insulation (Jelle, 2011) and alternative heating and cooling technologies that can significantly reduce energy requirements (Finney et al., 2012).

Significant variations in emissions can also occur depending on the source of the electricity supplied to buildings within a development. Conventional grid electricity sourced predominantly from coal is the most emission intensive form of electricity production and the primary cause of climate change (IPCC, 2007). Electricity sourced from natural gas produces fewer emissions, and is particularly efficient when used in a way that supplies power and heating (co-generation) or power, heating and cooling (tri-generation). The notion of small-scale, decentralised energy production (both from fossil fuel and renewable sources) is becoming increasingly popular as a low carbon source of power and is well suited to the precinct scale (Rauland & Newman, 2011).

[110] When undertaking carbon accounting at the precinct level, it is important to clarify where emissions have been captured (e.g., emissions from the transport of materials used in construction could be captured under either embodied emissions or the construction process. This is important to clarify in order to avoid double counting, or not counting at all.
[111] For example, townhouses and apartments.

Other decentralised low carbon or carbon free sources of energy include PV panels, solar hot water heating, small-scale geothermal heat pumps and small-scale wind.

Purchasing 'green power'[112] is another option, which in this case eliminates the emissions associated with electricity consumption onsite.

7.2.4 Water Management

The supply and treatment of water is another critical element to include in the GHG analysis of new developments. Water management is becoming increasingly connected to energy and carbon emissions as more cities, particularly in Australia, begin to rely on energy intensive forms of water supply and treatment such as desalination. The connection between energy and water, and thus emissions, has been extensively examined in the literature (see Griffiths-Sattenspiel & Wilson, 2009; Hall et al., 2009; Kenway et al., 2008; Medeazza & Moreau, 2007; PMSEIC, 2010; Rothhausen & Conway, 2011; Siddiqi & Anandon, 2011).

While GHG emissions can vary considerably depending on the technology used to produce water, for example, through desalination, treating recycled water or using dam water catchments, emissions occur over the water entire cycle, including through the distribution of water (i.e., pumping of water around cities), the consumption of water and the treatment of wastewater (Wang, 2009). While some studies have examined the environmental savings associated with decentralised water management (Sharma et al., 2010) and warn of the danger of locking into new energy intensive centralised systems such as desalination (Chanan et al., 2009), opinions still vary as to which is the most efficient or emission intensive form small scale versus large scale (Fagana et al., 2009).

Regardless of the scale debates, research is showing that water has become one of the biggest energy users in cities (Kenway et al., 2008), and this is thus a critical area to tackle in urban development. Knights et al (2007) question whether utilising renewable energy could be a way to offset the GHG impact of the rising energy use, though they warn of the issues associated with making offset claims.

The amount of water needed within a development will also vary depending on the urban design, which includes how gardens and public landscaping are managed.

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[112] GreenPower is a trade marked name in Australia and refers energy that comes from 100 per cent renewable or carbon free sources.

Water efficiency measures in buildings will affect the amount of water required as well (Kenway et al., 2008). Ensuring that water efficient appliances and grey water/third pipe systems are built into developments from the outset can optimise the water efficiency associated with the building infrastructure.

Development approaches that use water sensitive urban design (WSUD) require much less water for irrigation, and can provide opportunities for alternative storm water treatment, all of which can dramatically reduce GHG emissions (Sharma et al., 2008). Optimising local water sources and recycling have many environmental benefits (Hatt et al., 2006; Sharma et al., 2010) and can dramatically reduce emissions, though few precinct-scale initiatives have assessed this.

7.2.5 Waste Management

As mentioned in Chapter 2, the waste sector produces around 11 MT of GHG emissions annually (DSEWPC, 2010b). The GHG emissions associated with managing solid waste can vary considerably depending on the waste management technique adopted. Currently, around half of the waste produced in Australia ends up in landfill, which is a particularly inefficient and emission intensive form of waste management due to the production of methane emissions during the anaerobic digestion of organic materials (Lou & Nair, 2009).

The energy related GHG emissions associated with solid waste management and different treatment strategies have been reviewed in academic literature such as Hughes et al (2006) and Chen and Lin (2008). Waste management options that produce fewer emissions include waste to energy technologies through incineration and various forms of gasification (Mountouris et al., 2006).

However, the concept of resource recovery within waste management is the optimal way of dealing with waste, that is, viewing waste as a resource (Tillman, 2004), and this will no doubt play an essential role in decarbonising cities into the future. Resource recovery essentially involves re-using, recycling and composting as much of the waste as possible (Seadon, 2010). This not only has the potential to significantly reduce emissions, but also helps to create a more circular metabolism within our cities as espoused by Wolmann (1965) and Giradet (2004).

The very first step in any waste management process, however, should be to minimise or avoid the amount of waste generated in the first instance. Encouraging society to minimise waste is likely to be challenging and will probably involve local behaviour change programs. Increasing knowledge around recycling, and improving the process, can also be facilitated by ensuring sufficient infrastructure is in place to enable good behaviour (e.g., clearly marked recycling points). New waste collection techniques such as municipal vacuum waste, which sucks waste through an underground network of pipes to one or several collection points within a city, can also help to encourage better recycling. As well, it can dramatically reduce the transport emissions associated with waste collection, improve the efficiency of recycling, add amenity by reducing the number of garbage trucks on the road (City of Sydney, 2010). This system can also allow for more compact urban form by eliminating the need for roads large enough for garbage trucks to manoeuvre in.

7.2.6 Travel

Transport fuels used by residents will impact the GHG emissions associated with an urban development. Different modes of transport (e.g., trains, light rail, buses, traditional cars and electric vehicles) generate varying amounts of GHG emissions. Vast academic literature has analysed the differences in transport GHG emissions associated with different urban forms both internationally (Glaeser, 2011; Newman & Kenworthy, 1999), and in the Australian context (Mees, 2010; Newman, 2006; Trubka et al., 2010a,b,c), with a strong correlation being demonstrated between higher density and lower transport-related GHG emissions (Newman & Kenworthy, 1999).

Moreover, even between cities with the same mode of transport (e.g., trains), emissions can vary depending on the fuel source. For example, the emission intensity of an electricity grid will affect transport emissions associated with rail, if it is drawing electricity from the grid. Electric-based transport systems (i.e., trains, light rail or electric vehicles) that recharge using renewable energy can significantly reduce transport-related emissions (Newman et al., 2012).

Urban development that encourages low carbon and carbon free transport modes, such as walking, cycling and access to efficient public transport, can dramatically reduce the amount of GHG emissions associated with a development. It is therefore essential that these emissions be factored in when designing a development, and then regularly monitored.

7.2.7 Phases of Precinct Scale Emissions

Figure 7.2 illustrates the various stages of development and the proposed emissions that should be captured within carbon analysis.

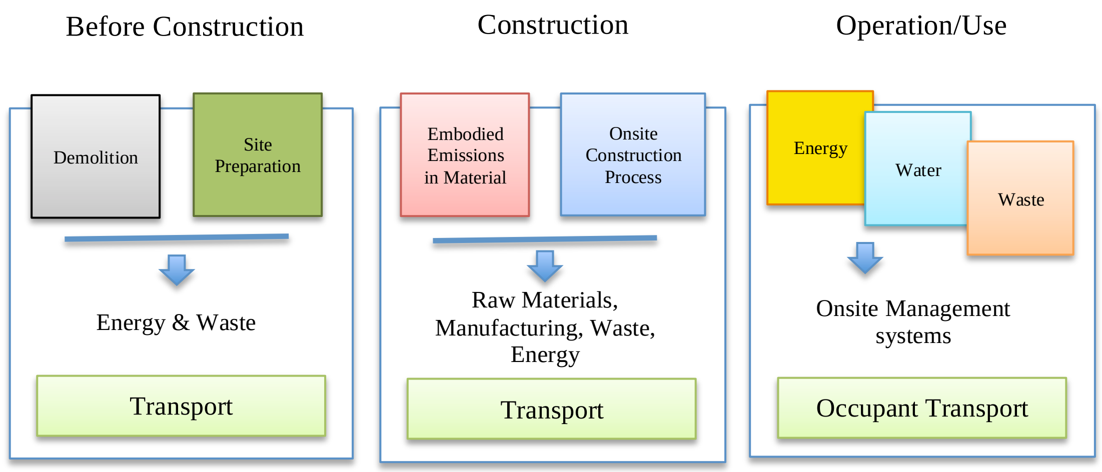

Figure 7.2. Phases of Precinct-Scale Urban Development Emissions.

7.3 Core Elements for Low Carbon/Carbon Neutral Certification within the Built Environment

7.3.1 A Carbon Accounting Framework for Urban Development

The previous section outlined the six key emissions sources that are proposed as the broad framework for calculating precinct-scale urban development emissions. The following section provides some insight into, and recommendations for undertaking the carbon footprint analysis at the precinct level.

A Hybrid Approach

The carbon measurement process and methodology for most applicants seeking carbon neutrality is relatively clear and straightforward: either they adopt a GHG inventory approach or a life cycle analysis approach. However the NCOS CNPG acknowledges that there are some areas, such as construction projects, that "may not obviously fit into these categories" (DCCEE, 2011b: 6). Suggesting that a hybrid methodology may be required in some cases, the guidelines recommend that such projects should follow up with an administrator at LCAL to determine the appropriate process for their specific circumstances (DCCEE, 2011b). This has significant implications in terms of the replicability of, and comparability between, development projects if no underlying policy or framework exists to guide LCAL administrators in the advice they provide applicants. Different administrators with varying levels of knowledge and expertise may provide applicants with very different advice, which would then produce very different carbon outcomes.

It is therefore suggested that the framework provided in this chapter be adopted as the basis for the carbon footprint for developers wishing to claim carbon neutrality. The general process required for calculating the emissions would still need to follow the standard carbon accounting rules outlined in the existing standards and protocols.

Dealing with Existing Development/Materials

To avoid double counting sites where infrastructure already exists, it is recommended that developers do not include the carbon associated with this, as these emissions have already been locked up, and it is assumed that the previous developer will have accounted for these emissions (e.g., in the future, when emissions reporting is more mainstream). This should make developing on existing land more desirable to developers, as fewer emissions would need to be accounted for, than developing on Greenfield sites.

7.3.2 Online Modeling Tools

New Tools to Assist with the Calculation Process

This carbon accounting process is likely to be seen as too complicated and time consuming for many developers attempting to undertake the analysis on their own, as the process requires in-depth knowledge of carbon accounting. It is therefore recommended that new carbon calculation tools be developed urgently to assist the development industry to undertake this analysis, which will also help to add consistency in the measurement process.

The development of such 21st century design tools that can be easily accessed by developers, the community and planning agencies is likely to become a major part of the urban development process over the next few years (Newton et al., 2012). They will be an important part of the decarbonisation process for urban development as well as the certification process.

Having access to new, easy-to-use and intuitive online carbon footprinting tools for development projects will make the process of calculating precinct emissions far easier and more cost effective for developers.

As mentioned above, eTool and Precinx are two examples of existing online tools that focus on carbon associated with the built environment and go some way in assessing these emissions, though they both will most likely require additional elements in order to incorporate the six areas identified in this chapter.

While eTool is currently free to use (though fees are required for consultancy assistance, and to verify and certify emissions), the costs associated with using the PRECINX tool are currently unknown, as the tool is only being used by developers and state government land development agencies and is not publicly available. The developer of this tool, Kinesis, also has another version of the tool (C^{CAP} Precinct), which developers can license for a fee based on the size of a project. Further development of a publicly available online tool for use in design and assessment is now underway as part of several research projects funded by the Federal Government.

For such tools to be used in a certification process, such as the NCOS CNP, a key requirement is transparency. As discussed in Chapter 6, all carbon audits need to be verified by a third party in order to gain certification. This would mean that a third party (and the certifying body) would need to be able to see and verify carbon calculations and assumptions sitting behind such tools. This is a currently an issue with existing tools, as their owners, for Intellectual Property (IP) and other confidentiality reasons, are justifiably unwilling to expose the calculations underpinning their software.

If a standard modelling tool can be developed for precinct-scale design and assessment it will break this nexus and is likely to become the standard tool required by all urban development at precinct scale. The other tools could still be used if they added value to what the standard model delivered. However, they would still need to be verified by a third party, and the certifying bodies would need to be able to view the calculations that sit behind the tools in order for them to become approved by the appropriate bodies (e.g., Low Carbon Australia). The commercially sensitive information sitting behind the tool could still remain confidential whilst ensuring that the basic carbon analysis was being acceptably conducted.

It is expected that as demand increases for such development-scale carbon measurement processes, new tools will become available, increasing market competitiveness and reducing the costs of using them. The move to design and assessment online will be sure to dramatically reduce the costs of all planning assessment, and carbon assessment will just become another part of that process.

Modeling the Cost of Abatement

Another advantage associated with emerging online measurement tools is their ability to measure not only the carbon abatement associated with alternative designs, technologies and efficiency measures, but also the differences in costs.

While there has long been a wealth of information available regarding various carbon mitigation and adaptation actions and measures, there has been little systematic way of analysing and comparing those options in order to determine which are the most beneficial, appropriate and financially viable options in a particular situation or for a particular site.

Research and practice has highlighted the previous lack of information and tools available to support the process of choosing the most appropriate set of actions to meet a specified carbon reduction goal. Carlisle and Bush (2009) refer to this as "the Planning Gap". Gore (2009) acknowledges that "cities and towns could benefit by developing computerised statistics on each of the major challenges they face and integrate them and display them visually for groups that include department heads and other stakeholders in a shared effort to discover what really works and what does not" (Our Choice, Al Gore, 2009).

By enabling users to instantaneously see the impact each abatement option has on the overall carbon and costs associated with a development, these tools can help inform decisions to enable the optimum choices to be made. Without these new and innovative, evidence-based tools such as eTool and PRECINX, decisions will continue to be limited to check lists, which have proliferated globally and dominate current decision-making.

Tools to Reduce Certification Costs

Transaction costs may pose a significant threat to developers wishing to pursue carbon neutral certification for their development. As is commonly the case with built environment certification schemes, such as the Green Building Council of Australia's Green Star certification program and Low Carbon Australia's NCOS Carbon Neutral Program, administration fees (including third party consulting fees) are a relatively large barrier and deterrent for many seeking certification.

However, as seen in Chapter 6 (Table 13), the certification fees paid to Low Carbon Australia for their role in administering the process are not overly inhibitive, particularly when compared to the entire budget associated with developing land. The largest cost is expected to be the work associated with the initial and ongoing calculation of a precinct development's life cycle emissions/carbon footprint, and this is likely to pose the greatest challenge in terms of time and cost burden on a developer and/or the body responsible for pursuing the ongoing carbon neutral status. However, the development of new online tools, as discussed above, can help to overcome this barrier.

7.3.3 Governance – Ongoing Management of Low Carbon Precincts

Management of Emissions and Annual Reporting

While the initial carbon footprint of a development can be managed by the developer (assuming they have the appropriate in-house knowledge, tools and/or assistance from a carbon accounting specialist), the ongoing, annual reporting of emissions and the development of Emission Management Plans (EMPs) are two significant issues for developers who wish to maintain their development's carbon neutral status beyond their own involvement in the construction. As mentioned in Chapter 6, developers usually walk away from any responsibility for a development once it is complete and has been sold. The primary issue, therefore, is that of who will have the ongoing responsibility for measuring the annual GHG emissions associated with developments and maintaining certification. This is discussed under governance in the section below.

Developing an Emission Management Plan

Writing up an annual Emission Management Plan (EMP), which identifies continual abatement measures for a precinct-scale development, will be quite different to traditional EMPs as the development is likely be designed as highly carbon efficient from the beginning. For example, compared to organisations and businesses that often benefit from having abundant retrofit and energy efficiency opportunities to pursue, well-designed precinct-scale development should have few carbon abatement opportunities. Nevertheless, there will always be chances to upgrade elements of developments when new technologies become available.

Governance Structures

This research proposes that a governance structure needs to be established or a body identified or formed to undertake, manage and be held responsible for the process of measuring emissions and maintaining certification of ongoing operations. Strata companies and local governments are identified as being in the best position to take on this responsibility. Green leases are also identified as a mechanism to assist the ongoing management of the precinct. These are briefly discussed below.

Strata Schemes, Companies and Body Corporates

Strata schemes are group residential and/or commercial building arrangements, which allow individual ownership of a strata lot (a single premise within a group of premises) and community ownership and management over shared facilities such as gardens, lifts and swimming pools (Western Australian Land Information Authority, 2012). Due to the shared facilities, the cost of buying into a strata scheme is usually more affordable than buying freehold title properties. They can also reduce the costs associated with shared infrastructure services such as electricity, gas, sewerage and water and minimise the maintenance costs associated with buildings (e.g., painting).

All strata schemes have a Body Corporate or Strata Company that manages the day-to-day operations and maintenance of shared facilities, and makes the decisions, which affect all owners. Every owner on a Strata-Plan is automatically a member of the Strata Company.[113] This company, or elected Strata Council[114], also formulate bylaws[115] specific to their complex (Western Australian Land Information Authority, 2012).

A strata company could be an appropriate body to administer and maintain responsibility for a development's carbon neutrality status, as it already has a governance framework that would enable this sort of administration to be carried out. Having a history of administering levies and rates and being responsible for shared infrastructure, body corporates, through their strata companies, could set up a system for requiring certain fees to be paid annually (e.g., for consultant fees for carbon footprinting, purchase of offsets and payment of CN certification fees).

Strata companies can also create by-laws that require owners within the complex to give the body corporate access to their utility bills, which would be needed for the carbon footprint at the end of each year. However, sub-metering to the site (i.e., for electricity, gas and water) is likely to already be in place within a strata complex, which may make such a by-law unnecessary.

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[113] In the case of Western Australia.
[114] A Strata Council is created in situations where owners do not wish or don't have time to partake in everyday decision-making regarding their complex.
[115] A by-law is a rule by which strata owners must abide.

Further by-laws may require new owners and tenants to undertake a compulsory sustainability or low carbon training or induction session (discussed further below) and to agree to live by certain sustainability principles. It may also require residents to undertake a bi-annual survey of their transport modes and travel emissions (also required for the precincts carbon footprint measurement), as well as informing the body corporate of any individual infrastructure upgrades or renovations undertaken within their apartment/space, in order to capture all onsite embodied emissions. This may also already be required as a by-law for other reasons.

Compulsory Green Leases could be mandated and managed by strata companies or local councils to ensure properties comply. These are discussed after the following section.

Local Government

Local councils are another entity that would be suitably placed to manage the ongoing carbon measurement process and maintenance of certification for CN PSD. Many councils have already been measuring GHG emissions at the local government level as part of their commitment under ICLEI (see Chapter 5), and so have experience in dealing with GHG measurement. There are also online tools available for calculating and reporting operational emissions at the local government level in Australia.[116]

Local governments also have a history of administering and receiving rates and levies from landholders within their jurisdiction. A carbon neutral levy could thus be built into the existing rates system but applied specifically to low carbon / carbon neutral districts or neighbourhoods. This CN levy would capture the costs associated with undertaking the annual GHG measurement process (as specified under the NCOS CNPG) and EMP for the precinct and, if desired, the purchase of offsets and CN certification fees.

This levy could also potentially facilitate the implementation of low carbon infrastructure, such as precinct-scale tri-generation, by enabling the upfront costs associated with installing the system to be spread out over a longer time frame and repaid through local government rates. This would help to reduce a developer's upfront costs, which would be passed through to the buyer, thus increasing the affordability of buying into the area. While land rates may be higher than other areas, this will be offset

[116] See the WALGA Reporting Platform - http://www.walgaclimatechange.com.au/walga-reporting-platform.htm

by reduced operation costs (i.e., energy and water bills). The concept is discussed further in Chapter 8.

Local councils have a vested interest in ensuring that the optimal precinct-scale solutions are reached, as this will not only reduce the carbon associated with their local government area (LGA)[117], but also have the potential to increase the long term affordability of living and working there[118], and thus the attractiveness of locating there for business and residents.

Behaviour change is another issues that could also be addressed at the local government level. For example, local councils could provide free sustainable living courses to residents moving into the area[119], though it would be difficult for a council to mandate such a program. Behaviour change is discussed further in section 7.3.5 below.

Green Leases

A Green Lease is a contract between the tenant and the building owner that sets out rules and guidelines for optimising the environmental performance of buildings (e.g., for improving energy and water efficiency and waste management within the buildings). The lease is negotiated between the two parties to ensure that the measures, actions and responsibilities for each party are realistic, manageable and implementable. Traditionally, green leases have been applied to commercial properties as a mechanism to help overcome the problem of split incentives discussed in Chapter 6 (and discussed further in Chapter 8).

Green Leases allow for a more collaborative approach to dealing with upgrades and general operational performance of buildings, and can create a more amiable relationship between landlord and tenant (COAG, 2012). Green Leases often provide an opportunity to create an Environmental Management Committee (EMC), which, like other important stakeholders such as building and facility managers, enables landlords and tenants to meet regularly and to develop and review annual Environmental Management Plans (Christensen & Duncan, 2007).

It is recommended that Green Leases be used when subletting or leasing property within a carbon neutral development or precinct. Strata by-laws may already provide some mandatory environmental efficiency requirements for owners. Green

[117] Which is likely to increase in importance in coming years.
[118] For example, by reducing the utility costs associated with energy, water and waste management.
[119] Several councils in Western Australia already offer this through the Living Smart program.

leases could therefore provide a suitable mechanism to ensure that tenants moving into the area also accept responsibility for ensuring that the environmental standards and goals of the precinct are met.

7.3.4 Engagement and Behavior Change Programs for Operational GHG

Occupant behavior remains a key issue in achieving the sustainability and low carbon outcomes associated within precinct-scale development (Zuo et al., 2012). The design of low carbon precincts, incorporating various types of low carbon infrastructure, is essential in facilitating and enabling a low carbon lifestyle for residents and businesses living and working in the area. Fuller (2009) highlights the importance of designing spaces and environments 'to improve outcomes by influencing patterns of choice' (p. 15). Once the design has been certified, the next stage is to ensure that the owners and occupiers of the precinct are able to keep within the expectations of the certification, or to even go further.

Having the infrastructure is in place does not necessarily mean that people will adopt the behavior associated with a low carbon lifestyle, however. Much literature has documented the problems associated with basing behavior change strategies for sustainability on the assumption that humans behave rationally (Fuller, 2009; Jackson, 2005; Moloney et al., 2010).

BedZED, one of the case studies discussed in Chapter 3, provides an apt example of the effect behaviour can have on the performance of a development. Based on the infrastructure available and the expected behaviour of 'ideal' residents, the per capita ecological footprint of the development was predicted to be 1.9 hectares. However, after evaluating the actual behaviour of the residents, the average ecological footprint was shown to be 4.36 hectares (Newman & Jennings, 2008). It is important to note that this was not due to the infrastructure or development not performing properly, but more to do with people's attitudes and behaviour. For example, despite the availability of a car share scheme and local public transport, some people still decided to own and drive private vehicles.

In order to create the most effective strategies to help transition society towards low carbon communities, Moloney et al (2010) suggest basing them on a "socio-technical framework that considers both individual psychological factors as well as the systems, standards and norms under which individuals operate" (p. 7614).

Fuller (2009, p. 3) suggests policies need to be created that provide opportunities to create ‘choice contexts’ for encouraging optimal social outcomes. He highlights five tools that can influence the choices people make. These are:

1. Setting the default option in a set of choices to the favoured option;
2. Offering ‘self-contracting’ to support commitment;
3. Presenting and organising information in a user-friendly way;
4. Designing physical spaces to guide behavior; and
5. Supporting the development of social norms.

Many of these ‘tools’ can be applied to various aspects of a low carbon or CN precinct development. Two options that go some way to addressing these issues are behaviour change programs such as Living Smart and Travel Smart (Ashton-Graham & Newman, 2013) and the adoption of Green Leases, which were discussed above. This research suggests that these programs (or variations of them) should be considered as part of the requirements for moving into and living within a designated low carbon precinct.

Further research into other strategies and mechanisms for influencing behaviour within low carbon precincts is recommended, and is currently being pursued through a Cooperative Research Centre (CRC) on Low Carbon Living.

Living Smart and Travel Smart

The Living Smart program is a sustainability behavior change program developed in the port city of Fremantle, Western Australia. It was the outcome of a call to action by local residents keen to learn more about sustainability. The program was developed by Murdoch University, the Fremantle Council and The Meeting Place Community Centre. It is a hands-on, interactive program that runs over 6-8 weeks and discusses a variety of sustainability issues that can be tackled in the home. The course encourages participants to set their own sustainability goals and get involved in weekly activities. Living Smart is now an award winning program with courses being organised and run all over Australia.

TravelSmart is a similar sustainability-based program targeting travel behaviour. This program also originally began in Perth, Western Australia, and was so successful that it has now been adopted all over Australia and even internationally. Unlike the Living Smart program, TravelSmart is conducted mainly over the phone or may involve someone coming to a program participant's house to discuss travel options and provide information about local public transport services or other travel options (e.g., bike paths). The aim is to empower people to make better, more sustainable and healthier travel choices by giving them the right information. Evaluations show significant savings in GHG are achieved by these programs (Ashton-Graham & Newman, 2013).

These two courses addressing behaviour change could be built into a carbon neutral management plan for local residents and businesses within the precinct. Even if it is not compulsory or undertaken by all, if enough people undertake it and demonstrate the desired sustainable behaviour this can help to create a social norm, which can affect others' choices as people strive to conform (Fuller, 2009).

7.3.5 Regulations to Assist Certification

New regulations will be required by government planning agencies that are ultimately responsible for land use, in order to establish a certification process that recognises the carbon reduction from urban development using the proposed Framework and addressing the items identified as core elements. This body is likely to be the State Government within the Australian system. These regulations would also contain mechanisms for resolving the question of offsets and the role of on-site renewables. These are discussed further below.

Offsets

As identified in previous chapters, only activities from sectors not currently captured under the Australian Federal Government's Carbon Price Mechanism are eligible to generate offsets that can be used within the NCOS CNP. This makes energy related carbon abatement delivered onsite within precinct-scale developments in Australia ineligible to be used as an offset against other onsite emissions. As a result, it would be relatively costly and impractical for developers (and the development's ongoing managing agency, i.e., strata companies or local government) to pursue and retain carbon neutral status under this set of conditions, and this it reduces the incentive for developers to become net positive.

New Offsetting Rules Needed for Development Industry

While the integrity of offsets must be ensured and upheld, it is argued that different rules should apply to the construction and development industry, in order to spur innovation and acknowledge the significant carbon reductions available at this level. This would require the development of new guidelines and regulations specifically for offsets generated in this sector.

It is recommended that only activities that can generate carbon abatement above what is operationally required by a development, such as excess renewable energy generation, be considered as an eligible offset that could be used against other unavoidable emissions associated with developments, such as the embodied emissions in the materials used in construction.

There is also the potential for developments to pursue offset generating activities within the bioregion that meet the requirements set out under the CFI.

Carbon reduction achieved from energy efficiency measures should not be classified as offsets, though these emissions reduction measures will be essential to help a development reduce its total emissions and make carbon neutrality viable.

If a developer does not generate excess renewable energy onsite, or cannot produce offsets through other CFI certified activities, then traditional offsets will need to be purchased (e.g., from those specified under the NCOS CNP) in order to neutralise the development's life cycle emissions. This can be done in several ways as discussed below.

Lump Sum Offsetting by the Developer

How developers go about offsetting a development's overall emissions may vary. For instance, as soon as a developer has measured and determined the total emissions associated with their development (including site preparation, construction process and embodied energy), they may choose to purchase a lump sum of offsets sufficient to neutralise the entire embodied emissions so that only the operational emission need to be accounted for on an annual basis.[120] They could then integrate the costs of this purchase into the individual land sales of the development, which, it is anticipated, would benefit from increased marketability.

This option assumes that, even if excess renewable energy is generated onsite, it will not be used to offset the embodied emissions associated with the development. The excess renewable energy could however be used to offset other ongoing operational

[120] The embodied emissions associated with renovations and upgrades will still need to be accounted for as they occur.

emissions associated with the development, such as residents' transport emissions or emissions associated with the use of natural gas.

Offsetting Over an Extended Period

Alternatively, the amount of offsets required to neutralise the embodied emissions could be spread over the lifetime of the development[121] and thus paid on an annual basis, potentially through strata fees or council land rates as mentioned above.

7.4 Conclusion

This chapter has proposed a framework for calculating the emissions associated with precinct-scale urban development, as the research conducted in this thesis has revealed that no such framework currently exists. The framework has identified six key sources of emissions that should be included in any carbon analysis of urban development. These were based on the findings presented in Chapter 2 that revealed significant emissions reduction opportunities in each of the six areas, when alternative approaches were adopted.

While Chapter 6 revealed that Australia currently has one of the most well-designed and rigorous Government-led carbon neutral certification schemes worldwide, the generic guidelines highlighted many issues for developers pursuing certification. These issues were addressed in this chapter and presented as recommendations designed to assist certification schemes in developing sector specific guidelines for the urban land development industry. As this sector is very different from general businesses and organisations seeking carbon neutrality, it will no doubt require a different set of rules and guidelines. The proposed recommendations aim to provide greater clarity and direction for developers pursuing certification, and to allow more accurate and trustworthy comparisons of carbon emissions to be made.

The significance of the proposed framework lies not just in its provision of a basis for carbon neutral certification: this framework has the potential to set an international, and thus universal, standard in carbon accounting for urban development. It will need to be supported by other elements including:

[121] However, this may be more difficult to calculate, considering the varying life times of different types of infrastructure.

1. Ways of bringing multi-stakeholders together in organisations such as Strata Title Companies to ensure on-going operational GHGs are managed and improved continuously;
2. New regulations to allow on-site renewables to be used as offsets against other emissions to ensure this rapidly growing green urban development approach is facilitated;
3. Behaviour change programs as part of any green assessment process; and
4. Minimisation of costs of certification by ensuring that online design and assessment can be done using publicly-available models that contain all the above framework on carbon emissions as well as other planning outcomes.

Chapter 8 – Benefits, Barriers, Opportunities and Governance

8 Benefits, Barriers, Opportunities and Governance

8.1 Introduction

Various forms of low carbon and carbon neutral urban development are being demonstrated around the world. However, this form of development has not yet become mainstream despite the numerous benefits it offers. The previous chapter showed that it is possible to provide certification for such development, though it will need specific rules, guidelines and governance systems in place. Having a standard way of assessing and certifying this type of development will no doubt help to achieve more carbon neutral development. However, there are many additional factors that make it difficult to achieve low carbon precincts. This chapter attempts to identify and discuss the wider issues that need to be addressed to ensure the decarbonising of cities can be mainstreamed.

The chapter begins by highlighting some of the broad benefits of low carbon development for both developers and property owners, before examining what is preventing greater adoption of this form of development. Some key obstacles facing developers are identified, such as regulatory and financial barriers. Even without specific barriers, however, the simple "lack of drivers for change" (Zuo et al., 2012, p. 279), has been identified as a key reason why developers continue to adopt a business-as-usual approach. Roseland (1997) identifies the general lack of guidance in assisting with the practical application of low carbon development at the community level.

These issues make it clear that this sector currently requires greater assistance and support in order to facilitate increased uptake of low carbon design and construction within the development industry. Assistance may be in the form of financial incentives, as well as new governance approaches and "support mechanisms…to provide reliable guidance on how to incorporate sustainability into practice" (Jones & Patterson, 2007, p. 258). Several examples of these types of opportunities are highlighted, many of which may only be required in the short-term, until such developments begin to become more mainstream.

8.2 Benefits of Low Carbon Development

The benefits for people purchasing properties or renting within low carbon developments include a reduction in energy and water consumption and thus utility costs; reduced need for car-based travel and thus reduced fuel costs; reduced overall emissions and carbon footprint; and increased liveability from better access to amenities and shorter commuting times.

There are also many advantages for developers pursuing this form of development, which include the market advantage of improved product positioning that can help to differentiate from competitors; reduced risk associated with carbon pricing and GHG reporting, as well as from future legislation around energy efficiency and stricter building codes; reduced construction costs;[122] opportunities to promote corporate social responsibility; and the ability to demonstrate a company's commitment to the environment and addressing climate change.

Furthermore, benefits also accrue to the broader economy, as developers who pursue low carbon design and construction have the ability to influence their entire supply chain, thus creating a shift in thinking towards low carbon within a variety of industries. This shift towards low carbon products and services will help to drive the new green economy.

8.3 Barriers to Uptake of Low Carbon Development

The knowledge and technology required to decarbonise our built environment already exists. There are also a variety of policies and initiatives in place to promote the shift to these low carbon options. However, despite the opportunities and incentives, progress and uptake of low carbon urban development by developers appears to be relatively slow. The largely unconnected nature of the existing opportunities, policies and initiatives is argued to play a significant role in obstructing progress by creating confusion. Several other obstacles have also been identified in the literature as inhibiting greater adoption of low carbon and energy efficiency measures within the built environment, including the high capital cost of energy efficiency upgrades, split incentives and regulatory barriers.

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[122] For example, if developers use prefabricated materials which can be cheaper to produce and reduce the construction time, as discussed in Chapter 7.

8.3.1 Information Barriers

Information barriers affect numerous areas of the economy, distorting and often negatively affecting decisions made and thus leading to various market failures (Garnaut, 2008). Information barriers are often discussed in relation to energy efficiency and commonly refer to the situation where a lack of appropriate information prevents consumers from making optimal purchasing choices, thus preventing the market from operating most efficiently. However, the lack of information can affect more than just the final purchasing decision. It can affect decisions being made along the entire supply chain, thus affecting the overall outcome or development of a product or service.

In relation to low carbon urban development, information barriers exist at all levels of the development process, from the design and construction of developments and the marketing and selling of properties, to the operation of houses, buildings and appliances by owners and the lifestyle options adopted by residents and occupants.

Developers/Builders

Developers currently lack information about low carbon infrastructure options, including the carbon and costs associated with different options.[123] This prevents builders, designers, architects and planners from making optimal choices based on quantifiable numbers. It is unrealistic to commit any developer to go carbon neutral without knowing the costs and carbon implications for a project. Thus without easily accessible information in these two important areas, developers are likely to make arbitrary choices or continue to follow business-as-usual (BAU) approaches (Newman et al., 2011). The desire to maintain BAU has resulted in a significant lack of innovation within the mainstream construction industry, particularly around sustainability (Glass et al., 2008).

A recent study of the perceptions of construction industry professionals has also demonstrated the lack of understanding by those working in the field about what low carbon and carbon neutral actually mean in the context of the built environment, particularly given the lack of clear definitions available (Zuo et al., 2012).

Another information barrier relates to the lack of knowledge and information by tradespeople, engineers and sub-contractors about green design and technologies, which

[123] The issue of long-term versus short-term costs and benefits are discussed further in section 8.3.2 and 8.3.3.

hinders their ability to deliver the new low carbon green infrastructure required in new carbon neutral developments (Glass et al., 2008; Hwang & Ng, 2013; International Labour Office, 2011; Williams, 2012).

Marketing Low Carbon Developments

At the marketing level, adequate information is often lacking about the benefits of green or low carbon designs, technologies and construction, which leads to serious market failure. For example, if real estate agents or marketing agencies fail to identify or understand the benefits associated with key sustainability features (which often have additional costs associated with them), these features are unlikely to be priced into the properties, thereby reducing the economic viability of adding such features into development projects. Developers need to be able to pass on the costs of improved environmental performance to consumers in order to maintain their profit margin (Ball, 2002). Being able to identify, discuss and promote the sustainability features of developments and buildings is likely to require additional training and education within the real estate sector (Pacifici, 2011).

Consumers/Occupiers

Finally at the consumers end, people are often not provided with enough information about the benefits and limitations of various building designs or features, particularly in relation to long-term versus short-term benefits. The result is a reluctance of consumers to pay more for green features.

Another barrier for consumers in making appropriate sustainable purchasing decisions concerns their ability to understand complex information. The public does not always have an adequate background education to understand the specific features of environmental alternatives, especially if they involve complex technical or engineering-related information. In many cases, labeling and certification schemes are intended to fill this gap (e.g., Green Star certification, energy efficiency ratings on appliances and ISO standards for sustainable construction), though issues still abound regarding the credibility of some schemes (Ball, 2002).

Circle of Blame

A barrier to the construction of more sustainable buildings and urban development involves what has been termed the 'vicious circle of blame' (Sedlacek & Maier. 2012). This negative feedback loop is as follows. Building occupiers say they would purchase more sustainable buildings, but they are not offered to them by the market; builders claim they could easily build more sustainably but developers don't request them to do so; developers argue that investors don't require them; and investors claim there is no demand for them by the market. The situation therefore is a self-perpetuating cycle of blame.

Sinclair (2008) proposes that several low carbon demonstration projects are needed in order to break the cycle, noting that "widespread development of innovative carbon neutral projects of varying scales should not be expected until a precedent has been set, and a planning framework has been tailored to exploit the benefits of this in future development projects" (p. 61).

Having sufficient market demand for carbon neutral development projects was also the number one 'critical success factor' identified (see Figure 8.1).

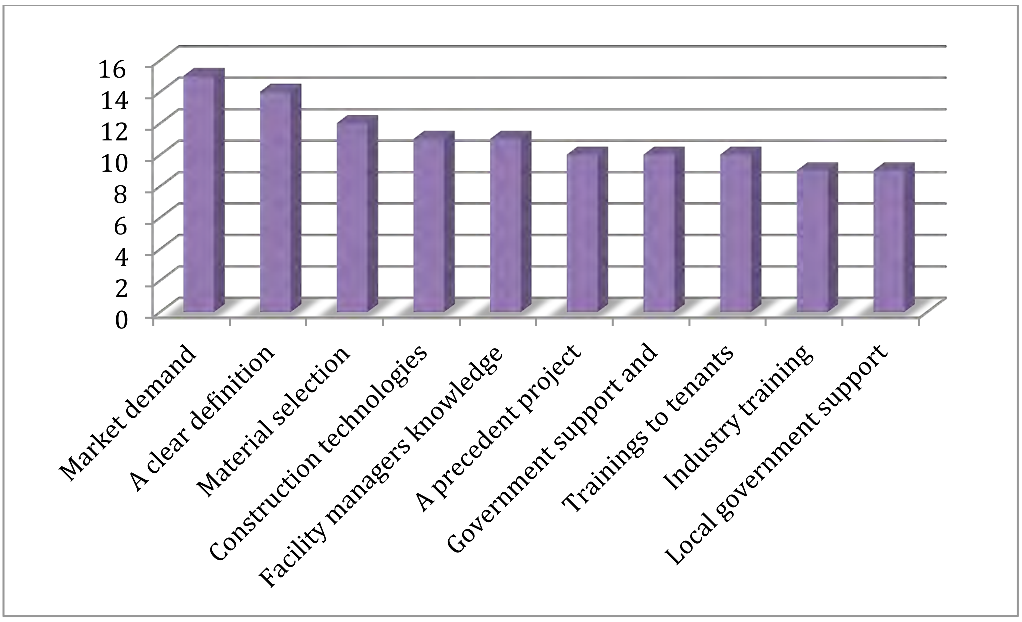

Figure 8.1. Critical success factors for carbon neutral commercial building developments.
Source: Adapted from Zuo et al (2012).

Addressing Information Barriers

Governments are also beginning to address some of the issues associated with information barriers. The Australian government's mandatory energy disclosure for commercial buildings has been a positive step forward in addressing a lack of information relating to energy efficiency in buildings. This sort of information can help to promote more energy efficient, low carbon buildings, and is discussed further in section 8.4.9.

Other options for overcoming information barriers that are being actively pursued by government relates to behaviour change. Even when a consumer has bought an environmentally friendly product (be it an appliance or a home), they will often need appropriate advice and information on how best to operate it. These sorts of issues are being addressed through behaviour change programs such as Living Smart and Travel Smart, discussed in Chapter 7.

Overcoming information barriers at all the levels discussed above is likely to require a range of new skills and knowledge by all participants, as the absence of these skills and knowledge significantly inhibits a low carbon agenda (DCCEE, 2010). Greater technical expertise and specialist knowledge in areas related to improved energy, water and waste efficiency are particularly important within the construction industry. The creation of this new knowledge and skills will require training, thereby creating a variety of new green jobs a vital component of the new green economy.

8.3.2 High Capital Costs

Low carbon developments generally have higher upfront costs associated with them[124], as they entail new and emerging technologies and greener materials that are more expensive (International Labour Office, 2011). Although the higher upfront costs are usually balanced out by long-term savings, the initial investment is still perceived to be risky and a barrier by the development industry, which worries that the costs associated with the long-term benefits may not be able to be passed on to the building owner. The problem posed by short-term costs and long-term benefits are further discussed below under Split Incentives. New technologies also carry greater financial risk due to the uncertainty associated with their performance (DCCEE, 2010).

However, it is expected that the costs associated with greener building products and technologies will decrease in time as increased demand creates economies of scale and brings new producers into the market - thus driving competition. Nevertheless, it is argued that, initially, new funding mechanisms and incentives are needed to assist the construction and development industry in pursuing these low carbon options. Some suggestions for this are proposed in section 8.4.8.

[124] It is acknowledged that this is not always the case. For example, studies of prefabricated wooden panels used in construction of low carbon buildings can reduce costs compared to BAU (Lehmann 2013).

8.3.3 Split Incentives

The notion of split incentives was discussed briefly in Chapter 6. It involves a situation where the costs of an action (e.g., an energy efficient upgrade) are borne by one party (such as the building owner), while the benefits accrue to another party (for example, the tenant) (WBCSD, 2009). In terms of low carbon urban development, the critical issue faced is that the higher upfront costs associated with green infrastructure are borne initially by the developer, while the residents receive the long-term benefit. This in itself is not a problem, if a developer can pass on the higher upfront costs associated with the green infrastructure. However, if the owner occupant is not provided with enough information to convince them of the financial and other benefits of green infrastructure, which is often the case, they will be reluctant to pay the higher upfront costs needed to cover the developer's additional upfront costs. This creates a lot of risk for developers trying to sell higher quality, low carbon developments, thus creating an incentive to simply provide cheaper developments that are more likely to be sold.

Another important issue is the *ability* of property buyers to afford the higher upfront costs. Purchasers may be well-aware of the long-term benefits but not have enough capital to meet the additional upfront costs associated with more efficient products (in this case a house) and are, therefore, forced to accept a more inefficient alternative. This has the potential to lead to the development of eco-enclaves, whereby only rich people can afford to live in more sustainable and ultimately more affordable developments.

Providing affordable housing within low-carbon urban developments is therefore a critical issue to address and an essential element in the provision of long-term sustainability in our cities.

8.3.4 Longer Approvals Process

Developments that demonstrate innovative low carbon technologies, new efficient green infrastructure and alternative designs are more likely to require longer periods for development approval (PIA, 2011), which ultimately represents additional costs to a developer.

8.3.5 First Mover Disadvantage

Also referred to as the free-rider problem, the first-mover disadvantage occurs when a person or business shoulders large initial costs associated with introducing a new technology or concept that subsequent businesses may benefit from (DCCEE, 2010; Garnaut, 2008). In terms of the development industry, an example could be a developer having to jump through a variety of regulatory hoops in order to get a new technology approved, and thus facing significant additional costs associated with the delayed approvals process. Subsequent developers, however, may benefit from the precedent set by the initial developer, thus shortening approval times and cutting costs.

8.3.6 Policy and Pricing Uncertainty

Every country finds carbon pricing difficult and the politics is often very combative, creating uncertainty in the market, including in the land development market. The introduction of a price on carbon in Australia in July 2012 was designed to bring certainty to business and industry and to encourage investment in low carbon options. However, the fact that it does not have bipartisan support, and that the opposition government continues to threaten to repeal it, has created an air of uncertainty for those ready and willing to invest in low carbon alternatives.[125] This is likely to affect developers' decisions on whether or not, or to what extent, they should pursue low carbon alternatives when designing urban developments.

8.3.7 Lock-In

Infrastructure lock-in is a serious issue and a significant barrier for retrofitting low carbon infrastructure in existing cities. Large infrastructure generally requires large capital investments and thus has relatively long lifetimes (often 50-100 years). Examples of infrastructure with long lifetimes include large-scale coal-fired power plants, freeways and in more recent times, desalination plants. Decisions to build low-density housing developments on the fringe of cities is also locking-in patterns of infrastructure that will be hard to retrofit into the future (HM Government, 2009). Indeed, all these

[125] At the time of completing the thesis there still had not been an election but the policies on carbon pricing remain diametrically opposed. A report after one year's operation of the carbon price showed it had been successful and that the economy had not been damaged in any way. The report titled "How's Australia's carbon price is working – one year on," released by Australia's Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, shows that the country has increased power generation from renewable sources by 28.5 per cent, is more energy efficient, and has reduced its carbon emissions. There was a drop in electricity generated from black coal and brown coal, 4.2 per cent and 13.3 per cent respectively, from the previous period.

infrastructure choices have shaped Australian cities for more than half a century (ARUP & C40 Cities Climate Leadership Group, 2011), and most have considerable emissions attributed to them, and are thus locking substantial emissions into cities for a significant time period. These sorts of decisions will have a significant effect on the ability to deliver low carbon urban development within our cities.

Another issue to consider is the vulnerability to the impacts of climate change that is essentially being locked-in from various infrastructural systems. Kennedy and Corfee-Morlot (2013), suggest that "it may be a cost-effective decision not to 'over-invest' to boost resilience in an infrastructure system" (p. 2). Small-scale distributed systems, which require lower capital investment, will be easier to retrofit in the future when newer, more efficient technologies become available.

8.3.8 Credibility of Carbon Claims

As noted throughout this thesis, credibility of low carbon and carbon neutral claims for development remains a key issue in relation to wider adoption. Even those working within the industry are dubious of the concept, with key stakeholders identifying "an initial lack of accreditation of the concept and workable measure for carbon reduction" as an impeding factor preventing greater adoption (Zuo et al., 2008, p. 282).

8.3.9 Multiple Stakeholders

As highlighted in Chapter 6, the design and construction of precinct-scale urban development has numerous stakeholders that, if not managed well, can act as a barrier to achieving low carbon or carbon neutral land development. Success requires significant collaboration between the various stakeholders. Blundell (2012) identifies utilities as an important stakeholder, arguing "there also should be more co-ordination between those in the property industry who are planning and developing more resilient communities, and the utilities sector" and noting that, without their support, low carbon developments will fail.

8.3.10 Regulatory Issues for Utilities

Utility regulatory barriers pose a significant problem for low carbon urban development. As highlighted in Chapter 2, new low carbon infrastructure is likely to increasingly be based around decentralised systems for resource management. However, given that cities are currently dominated by centralised infrastructural systems, most of the governing regulations are designed for this level of supply. Consequently, various regulatory issues currently prevent or make it difficult for small-scale energy generators to enter the market and access the electricity grid.[126] Bunning et al (2013) discuss some governance issues currently affecting decentralised, low carbon infrastructure and identify emerging governance models that deal with resources at a more local level.

Mobbs (2010) highlights a range of regulatory issues, which, although they may not necessarily block the installation or implementation of new low carbon infrastructure, can act as a disincentive preventing developers from pursuing low carbon development. An example he cites is the requirement for developers to pay for centralised services (e.g., connection to sewerage systems) even if they do not connect to the systems (Mobbs, 2010).

There are various other water-related regulations, particularly around health, that inhibit the uptake of small-scale, onsite wastewater recycling. Toze (2006) identifies that overly strict health regulations can result in "the requirement for overtreatment of recycled water, which can lead to potentially valuable water reuse projects becoming too costly and inefficient to be viable" (p. 41).

Dealing with these obstacles can be difficult and is likely to require new governance and participatory models specially designed for the development industry (Bunning et al., 2013).

8.4 Opportunities to Overcome Barriers

Existing examples of low carbon precinct-scale development around the world have generally required significant support in order to get off the ground, and thus are generally seen as 'demonstration projects', still situated in the early innovation stage within the innovation framework as illustrated in Figure 8.2.

[126] There are also technical issues that currently prevent distributed energy being fed into the grid. Such issues could be overcome with the introduction of a smart grid.

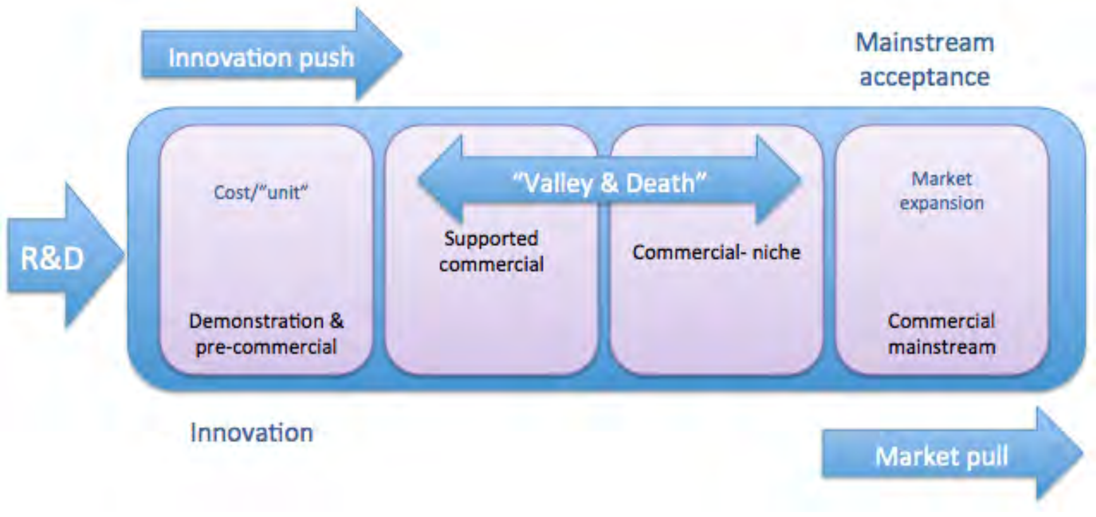

Figure 8.2. Innovation Framework. Source: Adapted from Moreland Energy Foundation (2012).

A recent study examining business models for enabling sustainable precincts (Moreland Energy Foundation et al., 2012) found that few low carbon developments were produced in a commercially viable way. It revealed that most developments are still far from being mainstream and require various forms of assistance, support and/or incentives in order to make them viable. This is due to the various barriers identified above.

Ensuring a successful transition to low carbon infrastructure within our precincts and cities will no doubt require a range of incentives, changes in regulations and information campaigns. The section below identifies some opportunities to support the development of low carbon and carbon neutral developments, from planning and regulatory assistance to various financial incentives.

8.4.1 Government Leadership and Facilitation

One of the key reasons why voluntary action is occurring, particularly at the local, precinct scale, is due to the lack of action taking place at higher levels of government. Nevertheless, studies are showing that government leadership and assistance is required to facilitate and enable low carbon and carbon neutral developments, particularly while they are still in the niche stage of the innovation cycle (Moreland Energy Foundation et al., 2011, Bunning et al., 2013).

The City of Sydney provides a good example of government leadership. In their drive to reduce local emissions by 70 per cent by 2030, they introduced a Tri-generation Master Plan, which they are now working towards implementing in multiple locations across the CBD. These systems will provide local precincts with low carbon and low cost energy, and carbon free heating and cooling. As many barriers stood in the way of implementing this small-scale technology, the City of Sydney has had to pioneer this space, negotiating with local energy companies and facilitating the changing of rules and regulations around energy supply networks and energy related services (i.e., heating and cooling) in Australian cities.[127] Having set the precedent, this will now help to enable other demonstrations to occur more easily, with less regulatory hurdles.

Places Victoria is another example of a government agency providing leadership. Places Victoria was the first state government agency to successfully implement tri-generation across multiple land titles, thus enabling Australia's first 'precinct-scale' tri-generation system to occur (Revitalising Central Dandenong, n.d.).

Other ways government can provide leadership is through adjusting planning regulations and legislation. An example of this was the City of Fremantle in Western Australia removing the requirements for developers in the city's CBD to provide car parking in new developments (Zaw, 2012).[128] This enables developers who wish to reduce the development's transport-related emissions to do so. The Mayor of Fremantle is currently entertaining the idea of creating a Fremantle Council led car share scheme in order to encourage more developers to pursue car parking-free developments (B Pettitt, *Pers comm*, 11 May, 2013).

8.4.2 Information Campaigns

Information campaigns and programs are intended to increase awareness about an issue in order for the public to make more educated decisions relating to that issue.[129] Many successful behavior change information campaigns and programs have been developed and run around the sustainability issues in recent years. These include the TravelSmart and Living Smart programs discussed in Chapter 7. Both programs have experienced broad success largely due to their tailored and interactive approach. Research has long questioned the effectiveness of broad, untailored media campaigns (Cone & Hayes, 1980).

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[127] Unlike other cities around the world, particularly Scandinavian ones, Australia has no precedent or experience in providing district heating as a service.

[128] Previous requirement were 1-2 car parks per dwelling.

[129] Smoking is an example of an information campaign that has been very successful in demonstrating the effects smoking can have on your health.

Information campaigns are often led by government, but can also be driven by community[130], businesses or industry, all of which may have some form of vested interest or benefit in some way. Indeed, 'information campaigns can be used to generate markets' (Williams, 2012, p. 164), which benefit businesses entering that market. While businesses can provide valuable marketing campaigns that raise consumers awareness about particular issues, it is also important to have unbiased source of information delivered to consumers and the public.

Garnaut (2008, p. 409) identifies three key points that should be considered when designing an information campaign. Such a campaign should:

- attempt to overcome biases by providing a simple comparison between current and future costs and current and future benefits;
- use familiar language (such as payback periods); and
- be located as close to the point of sale as possible.

A report of the Prime Minister's Task Group on Energy Efficiency (DCCEE, 2010) provides several other key ideas, recommendations and examples of information campaigns. Providing this sort of information to consumers or potential buyers of low carbon developments could significantly alter how people view properties.

8.4.3 Knowledge Sharing – Both Success and Failure

The lack of knowledge transfer around what has and has not worked within innovative, low carbon urban development projects can prevent greater learning amongst the development and property industry and thus reduce the ability to build on past experiences. While sharing success is vital and can help promote new technologies and designs, sharing the lessons learnt from what has not worked and why is just as important to ensure that mistakes are not replicated.

Jones and Patterson (2009) note that there is a tendency among green building projects to emphasised successes and hide failure to avoid backlash, thus 'greenwashing' projects. However, this can often lead to a sense of cynicism around sustainability if rumours of failure later emerge.

[130] LivingSmart was initially developed through collaboration between a local community, a university and council. The community continues to play a large role in the ongoing running of the program.

The Carbon Disclosure Project, which launched a city-based disclosure project in 2008, demonstrates the value in disclosing information particularly regarding strategies cities are putting in place to address emissions and sustainability (Accenture, n.d.). This public platform has provided a great opportunity for cities around the world to share knowledge on the performance and success of various strategies and measures, which has not only provided a way for them to communicate their value to stakeholders, but also offers other cities the opportunity to learn from them.

Providing a platform whereby developers, Energy Services companies (ESCo's), local governments and other stakeholders can openly share knowledge and experience around new technologies, planning guidelines and various precinct-scale innovations would go a long way in progressing the transition towards low carbon cities.[131]

8.4.4 Creating Baselines for Sector

Developers currently lack meaningful baselines by which to compare their developments at the precinct level. While several baselines and benchmarks exist for buildings, transport, waste and water, nobody really knows what the combined effect of these various sectoral emissions are at the precinct scale, despite the potential for developers to influence the outcomes of each element.

Thus, creating baselines for this sector would be very useful, not least because it would show the difference between current and best practice (in terms of GHG emissions). Furthermore, having well-established baselines can enable a variety of incentives and disincentives to be applied to developers. For example, a baseline and credit scheme specifically designed for urban development could encourage developers to be below (that is, better than) the baseline by allowing them to sell carbon credits as a result, while developers above the baseline must purchase credits to meet their liability. Creating different types of baselines for different urban typologies based on a mixture of features would provide valuable information for comparisons and general knowledge sharing.

[131] It is worth acknowledging that developers may also be reluctant to share some learnings or strategies, if these have given them a commercial edge or advantage. Strategies should be sought to overcome this issue.

8.4.5 Environmental Upgrade Agreements

Environmental Upgrade Agreements (EUAs) are a recent Australian adaptation of the Property Assessed Clean Energy (PACE) financing mechanism originally developed in the US (DCCEE, 2010). While the PACE mechanism initially targeted homeowners, EUAs focus on commercial buildings (Blundell, 2012). EUAs allow the cost of an energy efficient retrofit or upgrade of a building to be attached to the property rather than being borne solely by the building owner. The reason why building owners have been reluctant to pursue retrofits in the past was the concern that they would not be able to pass through the additional costs associated with the upgrade to the next buyer if/once they sold the building, or indeed, to the tenant who actually receives the benefit from the lower operation energy costs.

The EUA mechanism allows low cost loans to be taken out by the building owner and used to retrofit a building, with loans being repaid through an agreed special council rate attached to the building over a set period of time. This allows the cost associated with the retrofit of building to be passed on to future building owners (Blundell, 2012). This pioneering initiative has helped to overcome the split incentives problem facing existing commercial buildings.

While this issue is perhaps less relevant to developers who are usually building new developments (or redeveloping existing sites), as opposed to upgrading existing buildings, the idea of attaching the costs associated with a significant upgrade to a property rather than an individual owner/developer has merit and is worthy of further investigation. For example, if a developer agrees to install co- and tri-generation infrastructure within a development, though is not responsible for the implementation or operation of the actual system, this additional expenditure (which is far more cost effective to install during the development stage rather than retrofitting pipes at a later stage) could be a cost that is attached to the property and repaid through a fixed term, council loan. This idea is further discussed in the section below.

8.4.6 Business Development Districts for precinct development (GRIDs)

The Business Development District (BID) concept emerged first in Toronto, Canada, in the 1970s, and has grown considerably since, with estimates of up to 60,000 BID-like schemes now existing worldwide (Hoyt, 2004). A BID is essentially a body created and funded by local businesses and property owners within a defined district of a city, and it is responsible for managing the improvement of that district. A BID is most often funded by an increase in tax or a levy applied to businesses and property owners situated within the area of the BID. The stakeholders will have identified a need for revitalisation within their area and will generally be involved in the formation of it, and therefore are willing to pay the extra money in order to fund the process. Some BIDs also accept donations (Levy, 2001).

BIDs are often responsible for managing (but not necessarily delivering) services such as street cleaning, safety and security, as well as coordinated local marketing campaigns for businesses, in order to increase the attractiveness, and thus patronage, of local downtown business areas. Nevertheless, the roles and functions of BIDs vary considerably between different districts, cities and countries, depending on the needs of the local area (Levy, 2001). BIDs have also been adapted to fit various other districts within cities, such as suburban mixed-use centres[132], and residential and industrial areas.

BIDs use a very participatory process, whereby the people contributing to the fund play a part in deciding what the funds should be used for. BIDs are thus an alternative, privately funded, independent and participatory governance mechanism for improving specific precincts of cities. The possibility of using the concept of a BID to facilitate the implementation of Green Infrastructure is illustrated in Box 3. The concept requires further investigation and research, which is unfortunately outside the scope of this thesis, though initial analysis suggests it could be a promising and valuable mechanism for precinct-scale carbon reduction.

Box 3. Greening, Revitalisation & Improvement Districts (GRIDs)

The concept of a Business Improvement District (BID) can be adapted to provide an ideal mechanism for assisting urban development to adopt the new green infrastructure discussed in this thesis.

Revitalisation and improvement of urban areas can be greatly assisted by the implementation of new green infrastructure, which will not only help to improve the

[132] Brisbane council introduced a BID-like program (Hoyt 2004) in Australia in 1996, called SCIPs (Suburban Centre Improvement Projects). This program funded various infrastructure capital works within certain areas, which were paid off using a levy introduced to those areas over a 10-year period (Brisbane City Council 2013).

attractiveness of the area, but also help districts to become more resilient in the face of climate change impacts and rising energy and water prices.

A new term is given to this concept or mechanism – Greening, Revitalisation and Improvement District, or GRID, which aptly acknowledges that the new, emerging infrastructure is well suited at a smaller scale - a precinct-scale grid - rather than the traditional centralised grids for managing resources.

The issue of engaging multiple stakeholders, which has traditionally posed a problem for urban precinct development projects, is also well addressed through this mechanism, as stakeholder engagement and participation lies at the heart of the BID process.

GRIDs could, therefore, be the mechanism that helps deliver the basic green urban infrastructure needed at the local precinct level, including co- and tri-generation, community solar PVs and biophillic urban design (including local precinct-scale stormwater management). This mechanism removes the high upfront capital costs associated with the implementation of the infrastructure by spreading these costs over a longer time period (i.e. through a tax or levy on those situated within the area), thus increasing the affordability of buying into the areas, as well as reducing the ongoing operating costs associated with living and working in those precincts.

General revitalisation and improvement of areas including the provision of additional activities and amenities can also increase the attractiveness and desirability of living in these areas, thus potentially reducing personal transport-related emissions.

Box 3. Overview of the Greening, Revitalisation & Improvement Districts (GRIDs) concept.

8.4.7 ESCo's

An Energy Service Company, or ESCo as they are commonly referred to, is another mechanism that can help to overcome barriers associated with implementing energy efficiency upgrades and decentralised renewable or low carbon energy generation projects. ESCo's differ from standard utility companies by offering energy services (e.g., thermal comfort or improved lighting) as opposed to solely providing electricity. ESCo's are particularly useful in dealing with the high upfront capital costs associated with energy-related projects and removes the risk associated with the uncertain energy payback periods (Szatow et al., 2012).

An ESCo's business model generally involves the ESCo paying the initial purchase and installation costs associated with energy efficient equipment, appliances and/or systems, with this investment/loan being repaid through the energy savings resulting from the upgrades within the building over a set period of time. The repayment amount is determined by the ESCo, and while it usually equates to slightly more than the initial appliance purchase cost, the overall benefit it brings to the building owner by removing the upfront capital investment cost usually outweighs this additional cost spread over time. After the payback period, the building owner benefits from reduced ongoing utility bills.

The scope of services that ESCo's provide varies from lighting retrofits to installing and managing small- to medium-scale onsite energy generation, though ESCo's are often contracted to identify a range of energy efficiency solutions in a building (ASBEC, 2008). The ESCo usually manages and maintains the equipment during the entire payback period to ensure that the equipment is operating as efficiently as possible in order to maximise the energy savings.

In terms of precinct-scale developments, the ESCo model is particularly appealing as it functions predominantly at the small, decentralised level discussed throughout this research. It could also be used in combination with a variety of measures identified in this section, such as the GRID mechanism mentioned above.

8.4.8 Energy Market Reform

As mentioned in Chapter 2, the majority of cities worldwide are designed around large-scale centralised energy generation and distribution networks. Energy regulations and markets have, therefore, been designed to meet and best serve the operational requirements of this large-scale generation. As a result, the current regulatory framework has created many barriers preventing small-scale, distributed energy generators from easily entering the market (Garnaut, 2008). A report by CSIRO (2009), which analysed the value of distributed energy in Australia, identified numerous policy and regulatory barriers (amongst other types of barriers)[133] that are currently inhibiting uptake of distributed energy in Australia. Considering the substantial investment in the infrastructure associated with current energy networks, it is not surprising that there is

[133] These include financial costs (e;g., upfront equipment costs, access to market and energy prices), decision-making, energy market structure (e.g., utilities, service provides, distribution companies), information and technical barriers.

reluctance, particularly by those with vested interests, to make "broad regime change that threatens viability of incumbent assets" (Szatow et al., 2012, p. 2).

Nevertheless, energy market reforms are critical and will be essential in the long term to facilitate and encourage greater adoption of decentralised energy into the national energy market (Garnaut, 2008). Szatow et al (2012) also suggest, however, that it may be worthwhile investigating and pursuing alternative ways of addressing energy, such as through heating, cooling and energy efficiency services as opposed to electricity provision, by building those services into, and providing them as part of, the property development industry.

8.4.9 Mechanisms for Incentivising Precinct-Scale Carbon Reduction

Currently, few incentives exist to reward innovative, low carbon developments in Australia. Indeed, on the contrary and as demonstrated in this chapter, various obstacles inhibit such developments. The following section provides some examples of incentives that could be offered to low carbon developments, once they have credibly demonstrated (i.e., through certification) their carbon reductions.

Removal of Stamp Duty

The possibility of removing stamp duty[134] for developments that can demonstrate certifiable carbon reductions, could help to incentivise prospective properties owners to buy within low carbon/carbon neutral developments. Since such developments may be more expensive in the short term due to the adoption of new technologies, materials, innovative designs and lengthy approval processes, the reduction in cost due to the removal of this fee could help to offset the higher prices, therefore making purchasing into these developments more affordable and attractive. A study by Sayce et al (2007) demonstrated that stamp duty exemption was one of the options most favoured by industry stakeholders interviewed in the study.

Land Tax Exemptions

Taxes are an economic or market-based instrument designed to address an externality and rectify a market failure (Garnaut, 2008). The tax system could be used to incentivise low carbon development in various ways. Land tax exemptions are just one example of this. Land tax is an annual fee generally paid to state governments by owners of property (Government of Western Australia, 2012). The amount required to be paid

[134] Stamp duty is a fee levied on properties at the time of purchase or lease, which is paid to the State.

varies between states and various exemptions usually apply, e.g., for property owners who reside on the property.

Land tax exemptions could be applied to developments that demonstrate credible and quantifiable reductions in GHGs. While an Internet search on this topic did not reveal any cases where such a scheme is currently in place, various tax concessions, exemptions and incentives are presently being applied to green buildings (DCCEE, 2010; GBNYC, 2012).

Labeling and Certification Schemes

The concept and use of eco-labeling and certification has grown in recent years in line with consumers' willingness to pay extra for products that demonstrate environmental benefits (OECD, 2002). Labeling and certification provides a vehicle by which producers, or in the case of this research, developers, can share important information with the public about the environmental attributes and eco-qualities of their product, as these features and processes are often unseen (Brecard et al., 2009). Providing branding opportunities for innovative developers to promote their green credentials is important in helping developers differentiate themselves from their 'business as usual' competitors (Bratt et al., 2011). Branding is usually strengthened considerably if it is underpinned by a credible eco-label or certification that demonstrates that the product or development has undergone some form of independent assessment.

Fast Track Approval Process

Fast-tracking the approval process[135] for 'green' or low carbon development applications is another form of incentive that can help reward and encourage this type[136] of development. Traditionally, these sorts of development applications have been held up during the approvals stage as highlighted in section 2.5, which can add significant costs to a development's project budget (Partners in Project Green, n.d.). Therefore, creating a process that can expedite the process is a valuable incentive for developers.

The approvals agency can require specific criteria to be met for an application to be deemed 'green' and thus eligible for the fast track approval process. Alternatively, rating tools can be used to demonstrate that a specific standard has been met. The

[135] The term 'Green Door' has been applied to this concept in Australia.
[136] I.e,. developments that demonstrate key sustainability, low carbon or green features.

certification scheme proposed in this thesis is another example of mechanism that could be used to determine eligibility for this fast-tracking process.

This mechanism has been employed successfully in Vancouver, Canada, and in Queensland, Australia (Queensland Government, 2011).

Feed-In Tariffs

For reasons discussed in section 8.5, urban development is currently unable to generate carbon offsets (or carbon credits) from activities related to energy generation or performance that are already recognised under existing carbon trading schemes (both voluntary and mandatory). Developments can, however, generate Renewable Energy Certificates (RECs) from the renewable energy they produce onsite, which can be traded for cash. There are currently two forms of RECs; those that are generated through the Large-scale Renewable Energy Target (LRET), and those generated through the Small-scale Renewable Energy Scheme (SRES). The LRET and SRES are the mechanisms by which the Federal Government expects to meet its Renewable Energy Target (RET) of 20 per cent by 2020 (Climate Change Authority, 2012).

Energy Efficiency Standards & Mandatory Disclosure

As mentioned above, mandatory disclosure of energy use in commercial already exists, which will help to promote energy efficient buildings. Ideally this sort of public disclosure should be applied not just to commercial buildings over 2,000 m^2 but to buildings of all shapes and sizes, including residential buildings, for which this measure is now being considered (O'Leary, 2012)..

The simple act of providing information can help to reward developments that build more sustainable buildings by making their buildings more attractive to purchasers. Without adequate information about the environmental or cost saving benefits of certain features, particularly those related to energy efficiency, higher quality products will continue to be driven out of the market because of a lack of understanding of their benefits (O'Leary, 2012).

Green Mortgages

The concept of a 'Green Mortgage'[137] has been around for several years, and has been particularly popular in the United States. A Green Mortgage essentially allows a buyer to take out a larger house loan than they could normally afford if the house meets

[137] Also known as 'Energy Efficient Mortgage' (EEM) or an ' Energy Improvement Mortgage' (EIM).

higher energy efficiency standards or has a range of sustainability features that will result in reduced operational costs. Under this scheme, the money expected to be saved on utility bills from a more energy-efficient home is essentially added to a buyer's income, and thus, valued into the mortgage (Williams, 2012).

These types of mortgages can be used for the purchase of both newly constructed energy efficient houses and older houses that require retrofits. For new construction, the green mortgage enables buyers to purchase more expensive properties by taking into account the ongoing reduction in bills. For older houses, the cost associated with energy efficiency retrofits, such as insulation, can be added to the total cost of the mortgage, which again, can be higher based on the expected savings (Deneen, n.d.; Munoz, 2007).

Green mortgages could help ease concerns some developers may have that they might not be able to pass on the increased cost associated with greener developments to buyers, as buyers may not be able to afford the higher prices. Green Mortgages could potentially be used as a marketing tool by developers, to increase a buyer's confidence in purchases and increase overall awareness around the long-term benefits of low carbon design and construction.

White Certificate Schemes

Energy Efficiency Trading Schemes, also known as White Certificate Schemes, are another market-mechanism that could potentially target the development industry. Three state-based schemes targeting residential and commercial energy efficiency are currently in operation in Australia (an overview of these schemes are provided Appendix D), with a forth due to start in 2013 (Energy Action, 2013). There are also several schemes operating internationally. The three Australian schemes are similar in design and generally require energy retailers to produce or purchase, and then surrender, sufficient energy efficiency certificates to meet their liability or set target. One certificate usually represents one tonne of CO_2-e abated[138] and they are generated through approved energy efficiency activities. Certificates can be created from energy reduction activities in both residential and/or commercial buildings.

In 2008, in a submission to a public consultation brief in New South Wales, development company Lend Lease recommended the adoption of a national energy

[138] For more information, see https://www.veet.vic.gov.au/Public/Public.aspx?id=Overview

efficiency scheme (Lend Lease, 2008). Its proposal was significantly more comprehensive than the proposed state-based schemes as it also took into consideration the design and construction of buildings and the production of renewable energy onsite. It is believed that this proposed scheme could be adapted further to include the additional areas identified in Chapter 7 – the proposed framework for precinct-scale urban GHG emissions.

While the scheme proposed at the time took into account individual buildings and not entire developments, there would be potential to extend it to wider urban development if suitable baselines could be established. These baselines could be established through the proposed carbon certification scheme for urban development. It would therefore function similarly to the scheme proposed, in that developments that are below BAU or baseline GHG emissions generate credits while developers above that level would need to purchase credits. The currency could be tradable carbon efficiency or intensity certificates rather than purely energy efficiency certificates.

The generation and trading of these certificates could significantly enhance the economic viability and attractiveness of innovative low carbon and carbon neutral developments.

Carbon Trading for the Built Environment

Low carbon developments in Australia are currently unable to participate in the existing carbon trading scheme, firstly because they would generally not be large enough to be considered liable entities and thus captured under the scheme, and secondly, because they are unable to generate offsets for the reasons discussed in Chapter 6. Nevertheless, it is proposed that a carbon trading scheme could be developed specifically for the built environment, which would reward developers for each tonne of carbon they abate below a threshold, and require developments that emit over that threshold or baseline[139] to purchase carbon credits. This is broadly known as a baseline and credit scheme and is likely to be the most appropriate scheme for this sector. Further research is needed to determine the feasibility of such a scheme.

8.5 Conclusion

While there are numerous benefits of pursuing low carbon and carbon neutral urban development for both developer and resident, such as reduced ongoing costs

[139] Baselines could be set during two phases: over the construction period and during operation.

associated with living and working there, and marketing advantages for developers, there are also several barriers preventing or deterring developers from pursuing this form of development. This chapter reviewed some of the main barriers facing developers including high initial upfront costs, the notion of split incentives, and regulatory barriers.

Various opportunities were then presented that could help to overcome some of these barriers. Government leadership was identified as a key factor in driving innovation in low carbon development. In Australia, some governments were seen to be leading by example and demonstrating how to create low carbon precincts. The City of Sydney and the Victorian Government's land development agency (Places Victoria) were provided as examples of government leadership in this chapter. Governments also have the ability to change legislation and regulations, which, in the energy industry, will be essential to allow and encourage new types of energy generation for the market and allow for new economic models that can facilitate this.

Creating platforms to share knowledge was also identified as important to progress the speed of transition towards low carbon cities, as this allows developers to replicate successful measures and avoid less successful measures or failures. Platforms were also highlighted as a way to create baselines for the sector, allowing comparisons to be made between developments regardless of whether or not certification was sought. This could also provide the basis for a white certificate scheme for urban development.

Environmental Upgrade Agreements or EUAs at the precinct level were discussed as a mechanism that could assist developers dealing with the higher upfront costs associated with low carbon infrastructure, by allowing some of those costs to be passed on to the residents through land rates. This idea was discussed further through the concept of a Business Improvement District (BID), though one that targeted specifically green infrastructure. Thus a GRID (Greening, Revitalisation & Improvement District) was proposed as the mechanism to facilitate the transition to green infrastructure in existing areas.

Energy Service Companies (ESCos) were acknowledged as a critical part of the new low carbon economy that will likely play an important role in low carbon developments in the future.

Low carbon developments were identified in the literature as not yet being mainstream and therefore still requiring some form of assistance. As many of the barriers had financial implications, economic incentives were identified as a useful instrument to encourage greater uptake of the concept. Some of the incentives discussed, included the removal of stamp duty, land tax exemptions, a fast track approvals process, feed-in tariffs, green mortgages and various types of trading schemes (either carbon or energy efficiency) that could recognise and reward innovative developers and penalise poorly performing developments.

Finally, and as mentioned in Chapter 7, certification could be a suitable mechanism for determining eligibility for the abovementioned incentives.

Chapter 9 – Conclusions and Further Research

9 Conclusions & Further Research

9.1 Introduction

This thesis has examined the potential of cities and urban development to reduce global greenhouse gas emissions, and the question of whether the carbon reductions achieved can be recognised under any formal certification system. While the research has showed that considerable emission abatement is possible from this sector, there are several issues that need to be worked through in order to certify reductions, many of which relate to governance.

Historically, the process of tackling carbon has focused on the front-end of the economy and has adopted a top-down approach using measures such as emission trading schemes and carbon taxes. This has resulted in rigorous carbon accounting methodologies being developed for large industry. As this has generally been seen as sufficient in addressing emissions, few specific carbon measures and schemes have been developed at the other end of the economy, which includes urban development and the built environment. As a result, limited carbon accounting processes, methodologies and frameworks currently exist to measure emissions from this sector, and this prevents accurate reporting and subsequent recognition of reductions.

However, as awareness of the carbon reduction potential from the built environment has grown - a result of numerous low carbon and carbon neutral urban development demonstration projects around the world - the need for a consistent way to measure emissions and acknowledge the reduction has become evident.

New ways of promoting and incentivising low carbon and carbon neutral development in the short term was identified as a key requirement in order to help mainstream the concept, as uptake by developers is otherwise likely to be too slow.

The following sections address the four sub-questions posed at the beginning of this thesis.

9.1.1 What is the Carbon Reduction Potential of Urban Development?

The GHG contribution of cities and urban areas is considerable and is estimated to range between 40 and 80 per cent of global emissions, depending on definitions. The built environment is a large component of this and has long been recognised for its potential to reduce emissions. Buildings, which are large consumers of energy, have been the primary focus of emission reduction over the years. As a result a plethora of building assessment tools now exist, which has led to a thriving green building industry.

However, in recent years a shift in focus has occurred from the building to the wider precinct scale, as building designers, developers, local governments and urban planners have identified the greater benefits, efficiencies and synergies that can be achieved when measures such as energy generation are implemented at the precinct-scale. This scale is also particularly important for addressing transport GHGs.

Various demonstration projects around the world have trialled and tested different technologies and alternative ways of designing and constructing urban precinct development, which include new and innovative ways of managing resources locally and reducing car dependence. These have demonstrated significant carbon reductions. However, these developments remain 'demonstration' or 'niche' projects that require various forms of assistance. If these types of projects are not supported, encouraged and recognised for their carbon reduction achievement, this growing social movement is likely to collapse.

9.1.2 What does Carbon Certification involve and can it be applied to Urban Development?

Carbon certification is identified as a way of acknowledging and rewarding progressive urban developments that can demonstrate genuine carbon reductions. Carbon certification is now a global industry, underpinned by strict standards and regulations designed to prevent false claims being made and thus significantly helping to increase the credibility of claims.

The industry primarily targets end-users within the voluntary sector, i.e., those whose emissions are not captured under mandatory carbon reduction activities, and it has focused on businesses and organisations. The architecture of existing certification schemes has therefore been designed to deal with this relatively straightforward sector (i.e. businesses operational emissions). As a result, various issues arise when carbon certification is applied to precinct scale urban development and the built environment, as this sector has a different set of conditions and complexities associated with it.

The analysis undertaken within this research has shown that several key factors need to be considered when designing a certification scheme for such urban development. These are addressed below.

9.1.3 What are the Core Elements of Carbon Certification for Precinct-Scale Urban Development?

Creating a carbon certification scheme specifically for the development of urban precincts ideally needs to consider five core elements as follows: a standardised framework for calculating the carbon associated with six key areas of urban development; an online tool to help with the carbon calculation process in both the design phase and ongoing operations; the identification or creation of a local body responsible for managing the ongoing certification process post-construction; the adoption of engagement and behaviour change programs for people moving into the development to encourage the behaviours required to keep operational emissions low; and new regulations to establish this whole process in the planning system and to enable onsite emission reductions, such as those from onsite renewable energy generation, to be used as offsets against other unavoidable emissions. These core elements are illustrated in Figure 9.1 below.

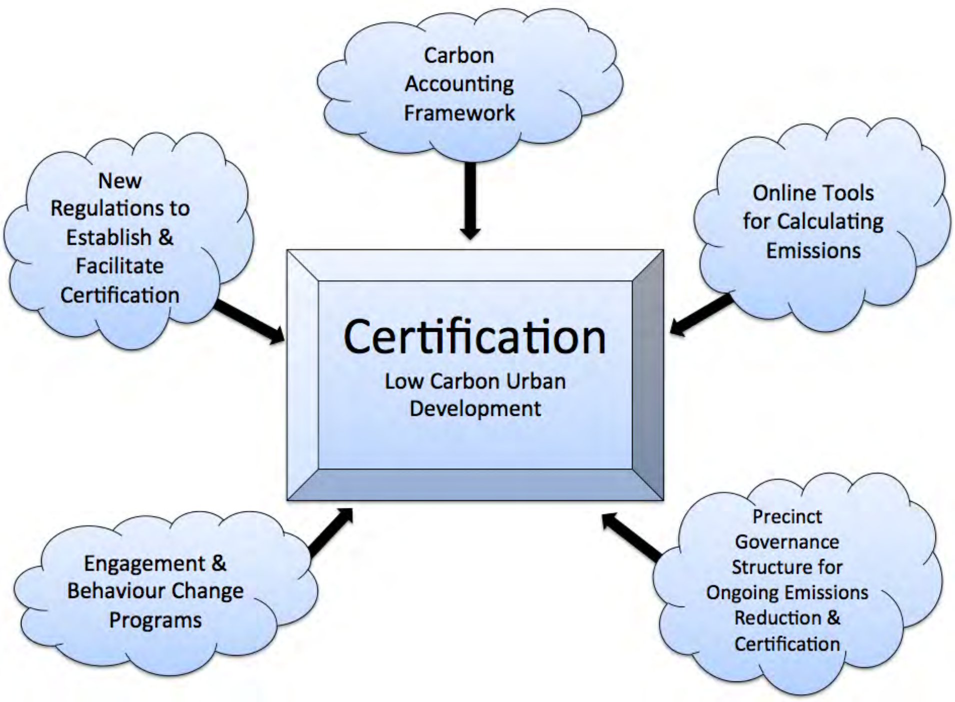

Figure 9.1. Core Elements for Low Carbon Certification for Urban Development

The carbon accounting framework proposed in this thesis is the first attempt to provide a comprehensive, standardised approach to calculating emissions at the precinct level in order to create a global GHG standard for the urban development sector.

9.1.4 What are the Barriers to Low Carbon Urban Development and What Opportunities Exist to Overcome Them and Promote Wider Adoption of the Concept?

Several barriers have been identified in this research that are preventing greater adoption of the concept of low carbon and carbon neutral urban development. These include higher upfront capital costs associated with newer technologies and designs, first mover disadvantage, the credibility of carbon claims, information barriers, split incentives, lock-in, policy and pricing uncertainty, and issues with utilities.

Various opportunities were also identified that could assist in overcoming many of the barriers, thus helping to facilitate a greater uptake of low carbon development. As many of the barriers resulted in additional development costs, economic incentives were seen as an important measure to encourage developers to pursue this form of development. Carbon certification was identified as a useful way of determining the eligibility of developments for receiving the financial incentives. Table 13 highlights the various barriers and opportunities and demonstrates the interconnections between them and how the barriers can be addressed.

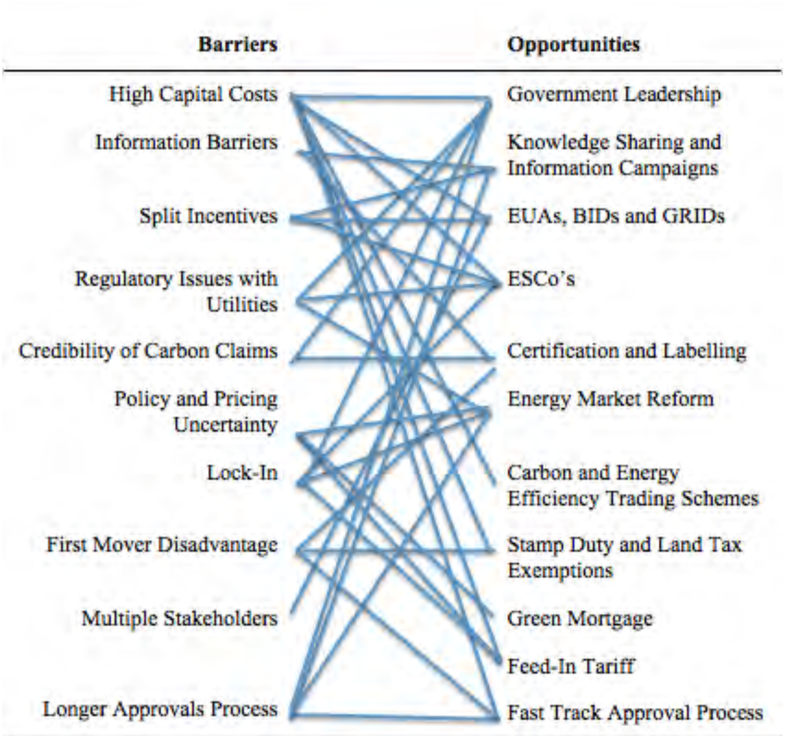

Table 14. Barriers and Opportunities for Low Carbon Development

The core elements for certification identified in this research, combined with the opportunities presented above could provide a powerful way of mainstreaming the decarbonisation process in cities. This is demonstrated in Figure 9.2 below.

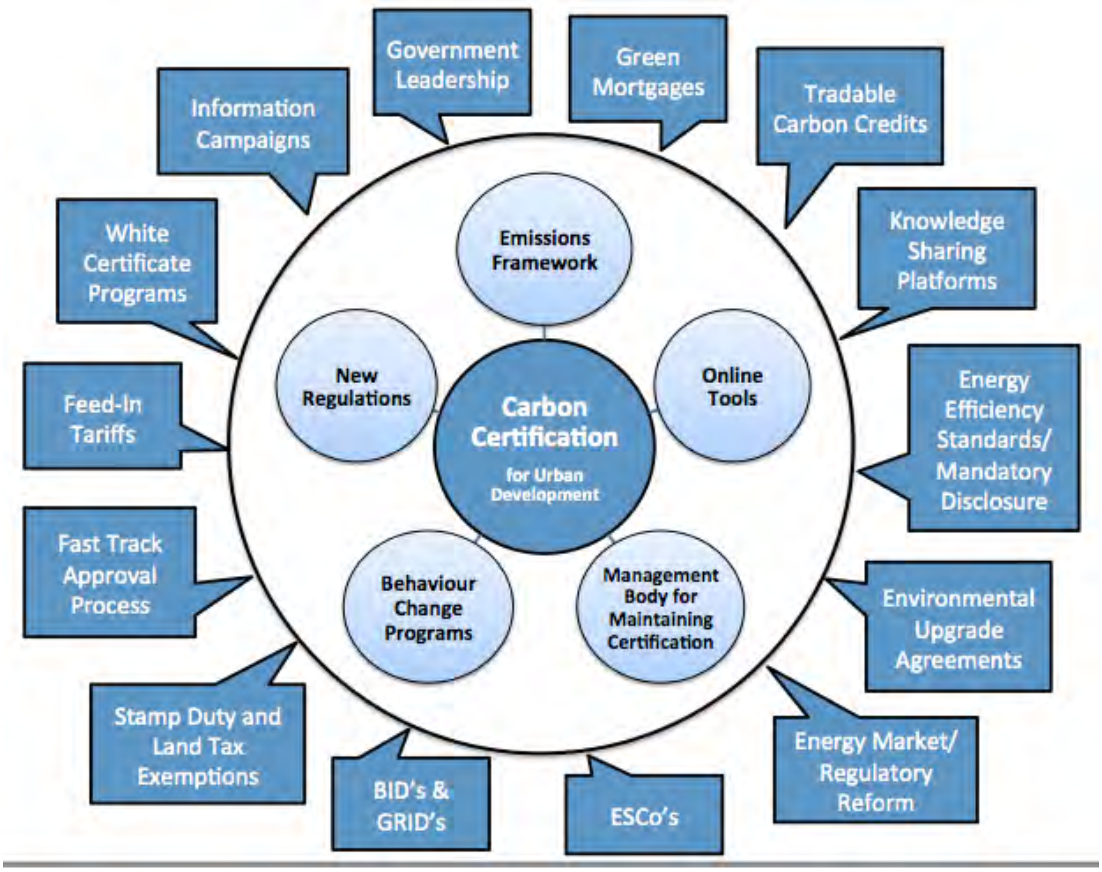

Figure 9.2. Opportunities to Assist with Mainstreaming the Concept of Low Carbon Development

9.1.5 Further Research

Further work is required in order to implement such a scheme, including the development of a set of streamlined, online carbon accounting tools that are affordable and easy for developers to use. Turning the carbon accounting framework proposed into an ISO standard for carbon accounting for urban development at the precinct scale is another option that would also require further work.

Some of the key opportunities identified will require further research, including the use of concepts such as the 'Greening, Revitalisation and Improvement District' or GRID, which has significant potential to help manage multiple stakeholders and the costs associated with implementing green infrastructure at the local precinct level. The increased adoption of ESCo's to run low carbon energy services locally, is likely to require changes to energy regulation, which will also require further investigation.

Enabling carbon credits to be generated from low carbon developments, which could then be tradable, is another key opportunity to promote and reward progressive developers, though work is needed to determine how this process would fit in with already established carbon trading schemes.

This could be a critical new dimension to climate change policy: with a well-developed carbon accounting framework and certification process in place, it is possible to take the next step and create a mechanism for trading carbon certificates within the built environment. This has the potential to create a significant financial incentive for decarbonising cities.

Afterword

In Australia (which has been the basis for much of this research), the recent change in government is likely to further complicate issues related to carbon and the built environment. The new Coalition Government has promised to repeal the current legislation on carbon pricing and replace it with its own 'Direct Action Plan' (DAP. However, few details are currently available as to what the DAP will specifically involve and how it will function.

The removal of the current carbon price (which was to become an emission trading scheme in July 2014) will be a huge step backwards for Australia, and will no doubt have an impact on carbon policy and climate action at the global level. If carbon falls off the public agenda altogether, this may have serious ramifications for progressing low carbon development in Australia.

Although it is also conceivable that the lack of action at the Federal Government level may spur an increase in voluntary action from industry and society, keen to take action on climate change. Furthermore, as current speculation suggests that the DAP may be built around a baseline and credit system that financially rewards participants for reducing below the baseline, this could well prove advantageous for low carbon development, which may become eligible for carbon credits. It could indeed help lay the foundations for the establishment of a carbon, or energy efficiency, trading scheme for the built environment. Detailed, prescriptive research is needed to determine the best way forward.

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Copyright Permission

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

The emails below are evidence of the permission granted to use pictures, figures, tables and graphs within this thesis. Permission was not sought for images that were prepared in joint reports between Curtin University and the Industry Partners involved in the ARC Industry Linkage Project, Decarbonising Cities and Regions, which this thesis was a part of.

Figure 2.1 – Global Greenhouse Gas Abatement Cost Curve

Vanessa Rauland **Friday, 22 November 2013 2:23:59 PM AWST**

Subject: Re: Copyright permission
Date: Friday, 22 November 2013 12:06:29 AM AWST
From: reprints@mckinsey.com <reprints@mckinsey.com> (sent by Kristen_Falcone@mckinsey.com <Kristen_Falcone@mckinsey.com>)
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Hi Vanessa,

Thank you for sending the requested material.

Per below, you may use the exhibit as it appears in your document for educational and informational purposes. We kindly ask that you cite the exhibit as follows:
Exhibit from "Impact on the financial crisis on carbon economies: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve", 2010, McKinsey & Company, www.mckinsey.com. Reprinted by permission.

Best regards,
McKinsey & Company

Vanessa Rauland ---11/16/2013 04:45:46 AM---Vanessa Rauland <V.Rauland@curtin.edu.au>

Vanessa Rauland <V.Rauland@curtin.edu.au>
11/16/2013 04:42 AM

To "reprints@mckinsey.com" <reprints@mckinsey.com>,
cc
Subject Re: Copyright permission

Hello again,

Thanks for your email. I would like to use the image (see below) in Chapter Two of my thesis, which is titled "The potential of Cities and Urban Development to Reduce Carbon". The subheading within this section is "Why cities are fundamental in tackling Climate Change". The text within this section is below.

I have also attached the entire thesis if you are interested in additional background.

I look forward to hearing from you!

Kind regards,

Vanessa

Vanessa Rauland

BA, MSc Environment and Resource Management
Project Coordinator | PhD Candidate
'Decarbonising Cities and Regions'
Curtin University Sustainability Policy (CUSP) Institute
3 Pakenham St| Fremantle | 6160
Research and Graduate Studies | Faculty of Humanities

Curtin University
Tel | +61 8 9266 9025
Fax | +61 8 9266 9031
Mobile | 0422 865 776

Figure 2.2 – Per Capita Transport Energy and Urban Density

Vanessa Rauland **Thursday, 21 November 2013 4:15:38 PM AWST**

Subject: Re: Your permission requested!
Date: Monday, 18 November 2013 4:50:16 PM AWST
From: Jeffrey Kenworthy <J.Kenworthy@curtin.edu.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Hi Vanessa

Of course you can. The data are 1995 from the Millennium Cities Database by Kenworthy and Laube (2001)… rushing to class…you will find this database referenced in just about any of our papers….

Cheers….see you in Feb!

Jeff

From: Vanessa Rauland <V.Rauland@curtin.edu.au>
Date: Monday 18 November 2013 09:26
To: Jeffrey KENWORTHY <j.kenworthy@curtin.edu.au>
Subject: Your permission requested!

Hi Jeff!

How are you? Slowing preparing yourself for a cold winter?

I'm just finalising a few last things with my PhD for final tick-off and just wanted to get your permission to use the graph below? I was also unsure how to reference it. As a source/reference (is the data published anywhere?) or just provide credit (I.e. 'Credit: Jeff Kenworthy").

An email response to this is sufficient for permission for use.

Many thanks!

Vanessa

1.1.1 Transport

Location and type of housing is another major factor contributing to the greenhouse gas emissions associated with our cities (Fuller & Crawford, 2011; Glaeser, 2010; Kahn & Glaeser, 2008; Newman & Kenworthy, 1999; Newman et al., 2009; Naess, 1995; Newton, 1997). The low-density design of Australian cities, like many modern cities around the world, has meant they are overwhelmingly car dependent, thus contributing significantly to transport greenhouse gas emissions. Road transport currently accounts for 87 per cent of Australia's transport emissions with the majority attributed to passenger vehicles (DCCEE, 2009).

Extensive research has demonstrated the correlation between density and transport emissions (see Figure 2.2), showing that as density increases in cities transport emissions decrease due to a decline in car dependency (Kenworthy, 2013 personal communication with new data; Newman & Kenworthy, 1999). This is because public transport uses considerably less energy per person than private vehicles, and public transport is generally only economically viable where sufficient density exists.

While climate change mitigation is an important reason to address Australia's car dependence and ensuing emissions, it is not the only motivation for addressing the issue. Increasing traffic

Page 1 of 2

Figure 2.3 – A Simplified View of Energy and Urban Density

Monday, 18 November 2013 3:33:59 PM Australian Western Standard Time

Subject: FW: Our Ref: 326112 - Copyright permission sought for my PhD!
Date: Monday, 18 November 2013 6:51:07 AM Australian Western Standard Time
From: Enquiries@csiro.au
To: Vanessa Rauland

Dear Vanessa,

Thank you for your request for copyright.

I believe you have received a direct response for your other request from Anne McKenzie, Environment Communication Advisor.

Regarding the Intelligent Grid image, you are allowed to reproduce the image, provided you credit the image to CSIRO and reference the report from which it is sourced.

I hope this assists with your enquiry. If you have any further enquiries regarding CSIRO and its research capabilities, please contact us at enquiries@csiro.au

Regards,

Andréa Gery
Information Officer| CSIRO Enquiries
Phone: +1300 363 400 | Fax: +61 3 9545 2175
enquiries@csiro.au | www.csiro.au
Private Bag 10, Clayton South, VIC 3169

From: Vanessa Rauland [mailto:V.Rauland@curtin.edu.au]
Sent: Monday, 11 November 2013 5:53 PM
To: Enquiries
Subject: Our Ref: 326112 - Copyright permission sought for my PhD!

To whom it may concern,

My name is Vanessa Rauland. I have just finished writing up my PhD in the area of Low Carbon Urban Development. I would like to use an image on page 69 of the report 'Intelligent Grid – A value proposition for distributed energy in Australia' (2009). It is Figure 3.1: A simplified view of electricity generation and transfer.

I am seeking copyright permission to use this in my thesis.

If you could confirm either way as soon as possible, that would be much appreciated!

Many thanks and kind regards,

Vanessa Rauland

BA, MSc Environment and Resource Management
Lecturer| Project Coordinator | PhD Candidate
'Decarbonising Cities and Regions'
Curtin University Sustainability Policy (CUSP) Institute
3 Pakenham St| Fremantle | 6160

Figure 2.5 - Energy Use for Water and Waste Services 2006/07

Vanessa Rauland **Thursday, 21 November 2013 5:22:37 PM AWST**

Subject: FW: Our Ref: TP 326122-Copyright Permission sought #2
Date: Thursday, 14 November 2013 11:34:12 AM AWST
From: Anne.Mckenzie@csiro.au <Anne.Mckenzie@csiro.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>
CC: Enquiries@csiro.au <Enquiries@csiro.au>, s.kenway@awmc.uq.edu.au <s.kenway@awmc.uq.edu.au>

Hi Vanessa,

You are welcome to use the figure in your thesis as requested.

Please acknowledge the source and copyright CSIRO.

Thanks, Anne

Anne McKenzie
Communication Advisor
CSIRO Environment Group
E anne.mckenzie@csiro.au **T** +61 8 9333 6221 **M** 0447 848 568
CSIRO Centre for Environment and Life Sciences, Underwood Ave, Floreat, WA 6014
www.csiro.au

From: Vanessa Rauland [mailto:V.Rauland@curtin.edu.au]
Sent: Monday, 11 November 2013 8:59 PM
To: Enquiries
Cc: Steven.Kenway@csiro.au
Subject: OUr Ref: TP 326122-Copyright Permission sought #2

Hello,

My name is Vanessa Rauland. I have just finished writing up my PhD in the area of Low Carbon Urban Development. I would like to use an image on page 11 of the report 'Energy use in the provision and consumption
of urban water in Australia and New Zealand', (Kenway et al 2008). It is regarding 'Figure 3: Energy use for water and wastewater services (2006/07)' on page 11.

I am seeking copyright permission to use this in my thesis.

If you could confirm either way as soon as possible, that would be much appreciated!

Many thanks and kind regards,

Vanessa Rauland

BA, MSc Environment and Resource Management
Lecturer| Project Coordinator | PhD Candidate
'Decarbonising Cities and Regions'
Curtin University Sustainability Policy (CUSP) Institute
3 Pakenham St| Fremantle | 6160
Research and Graduate Studies | Faculty of Humanities

Page 1 of 2

Figure 3.1 – BedZED

Vanessa Rauland **Thursday, 21 November 2013 8:34:39 AM AWST**

Subject: Re: A photo from you?
Date: Monday, 18 November 2013 6:28:19 PM AWST
From: Jan Scheurer <jan.scheurer@rmit.edu.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Vanessa - sure thing, i remember hanging out there once in the distant past... and three photos have materialised on my hard drive, hope they are any kind of useful. hi from the southern forests - Jan

On 16 November 2013 16:42, Vanessa Rauland <V.Rauland@curtin.edu.au> wrote:

Hi Jan!

Like I mentioned the other day, I am only looking for a photo of BedZED (I have the others now). Do you have any that I could use and if so, do I have your permission to have them published in my thesis?

Many thanks!

Vanessa

Vanessa Rauland

BA, MSc Environment and Resource Management
Project Coordinator | PhD Candidate
'Decarbonising Cities and Regions'
Curtin University Sustainability Policy (CUSP) Institute
3 Pakenham St| Fremantle | 6160
Research and Graduate Studies | Faculty of Humanities

Curtin University
Tel | +61 8 9266 9025
Fax | +61 8 9266 9031
Mobile | 0422 865 776

Email | v.rauland@curtin.edu.au
Web | http://sustainability.curtin.edu.au

Curtin University

From: Jan Scheurer <jan.scheurer@rmit.edu.au>
Date: Tuesday, 7 May 2013 12:48 PM
To: Vanessa Rauland <v.rauland@curtin.edu.au>
Subject: SNAMUTS presentation

Vanessa - i hope you had a good rest...
i was wondering if my presentation from last week has been uploaded to the CUSP site yet (i can't find it, but then i might not know where to look) as i've had a few requests... thanks! and hi from the chilled eastern lands - JAN

--

Dr Jan Scheurer

Figure 3.3 – A mixed use Street in Vauban

Vanessa Rauland **Thursday, 21 November 2013 5:26:10 PM AWST**

Subject: Re: Copyright permission
Date: Monday, 11 November 2013 3:52:06 PM AWST
From: Peter Newman <P.Newman@curtin.edu.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Yes of course, with acknowledgement!
Peter Newman

Prof. Peter Newman
John Curtin Distinguished Professor of Sustainability
Director | Curtin University Sustainability Policy (CUSP) Institute,
3 Pakenham St, Fremantle, WA 6160.
Research and Graduate Studies | Faculty of Humanities

Curtin University
Tel | +61 8 9266 9032
Fax | +61 8 9266 9031
Mobile | 0407 935 133

Email | p.newman@curtin.edu.au
Web | http://sustainability.curtin.edu.au

Curtin University

From: Vanessa Rauland <V.Rauland@curtin.edu.au>
Date: Monday, 11 November 2013 10:44 am
To: Peter Newman <P.Newman@curtin.edu.au>
Subject: Copyright permission

Hi Peter,

I have used some of your photo's in my thesis (I.e. Masdar and Vauban). I just wanted to confirm whether this is ok and whether I have permission to reproduce them?

Thanks,

Vanessa

Vanessa Rauland

BA, MSc Environment and Resource Management
Project Coordinator | PhD Candidate
'Decarbonising Cities and Regions'
Curtin University Sustainability Policy (CUSP) Institute
3 Pakenham St| Fremantle | 6160
Research and Graduate Studies | Faculty of Humanities

Curtin University
Tel | +61 8 9266 9025
Fax | +61 8 9266 9031
Mobile | 0422 865 776

Email | v.rauland@curtin.edu.au
Web | http://sustainability.curtin.edu.au

Figure 3.6 – Masdar, UAE

Permission granted from Peter Newman in above email.

Figure 3.8 – City of Sydney Local Government Area

Vanessa Rauland **Thursday, 21 November 2013 2:47:44 PM AWST**

Subject: Re: Copyright permission sought for my PhD!
Date: Thursday, 21 November 2013 2:47:27 PM AWST
From: Vanessa Rauland <V.Rauland@curtin.edu.au>
To: Geoff Burton <gburton@cityofsydney.nsw.gov.au>

From: Geoff Burton <gburton@cityofsydney.nsw.gov.au>
Date: Thursday, 21 November 2013 10:33 AM
To: Vanessa Rauland <V.Rauland@curtin.edu.au>
Subject: RE: Copyright permission sought for my PhD!

Vanessa,
Sorry for the delay, I had to verify a few things through our legal team first.
The City gives you permission to use the graphic for the purpose of your thesis. Please insert, "© The Council of the City of Sydney" beside the graphic.
Good luck with your thesis.
Thanks
Geoff

Geoff Burton
Business Planning and Performance Manager
City of Sydney Council

ph: 02 9246 7547
FAX: 02 9265 9387
Mob: 0414 275 466
gburton@cityofsydney.nsw.gov.au

From: Vanessa Rauland [mailto:V.Rauland@curtin.edu.au]
Sent: Thursday, 21 November 2013 11:49 AM
To: Geoff Burton
Subject: Re: Copyright permission sought for my PhD!
Importance: High

Hi Geoff,

Thanks for your reply. Yes I am still seeking permission. But I need to submit my PhD by tomorrow so it's kind of urgent!

I would much appreciate if you help follow this up. All I need is an email reply to this confirming I can use it.

This is the photo I would like to use.

Page 1 of 4

Figure 3.9 – Arial View – City of Fremantle

Vanessa Rauland **Thursday, 21 November 2013 2:43:29 PM AWST**

Subject: Re: URGENT permission sought! (sent by contact form at Love Freo)
Date: Thursday, 21 November 2013 2:39:51 PM AWST
From: Phil Martin <phil@lovefreo.com>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Hi Vanessa,

Yes, it's fine to use the image so long as it's not for a commercial purpose and you credit the photo to Love Freo.

Thanks
Phil

Phil Martin
phil@lovefreo.com
www.lovefreo.com

LOVE
FREO

On 21/11/2013, at 2:36 PM, Vanessa Rauland wrote:

> Hi Phil,
>
> I think your Dad (or someone's Dad..!) is the photographer.
>
> http://www.lovefreo.com/2013/04/29/fremantle-by-helicopter/
>
> Thanks,
>
> Vanessa
>
> ---
>
> **From:** Phil Martin <phil@lovefreo.com>
> **Date:** Thursday, 21 November 2013 10:19 AM
> **To:** Vanessa Rauland <V.Rauland@curtin.edu.au>
> **Subject:** Re: URGENT permission sought! (sent by contact form at Love Freo)
>
> Hi Vanessa
>
> Apologies, that no one has got back to you. Please can you send me a link to the page where the picture is. I need to check who the photographer is.
>
> Phil

Figure 3.10 – Arial View of Proposed Position of NPQ

Vanessa Rauland **Thursday, 21 November 2013 5:41:56 PM AWST**

Subject: RE: Copyright Permission sought!
Date: Monday, 18 November 2013 11:27:28 AM AWST
From: Chris Carman <Chris@benchmarkprojects.com.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Hi Vanessa

I have changed the copy to reflect the project's current status as it is past tense.

The credit should be to Benchmark Projects Australasia as project manager for NPQ Pty Ltd.

Cheers

Chris Carman | Managing Director
Benchmark Projects Australasia
PO Box 6645 East Perth WA 6892
Ph 089225 4255 | Fax 089225 4833 | Mob 0418 954 138
www.benchmarkprojects.com.au

From: Vanessa Rauland [mailto:V.Rauland@curtin.edu.au]
Sent: Sunday, 17 November 2013 2:14 PM
To: Chris Carman
Subject: Re: Copyright Permission sought!

Hi Chris,

Thanks for your reply. I have used the image below (but if you have another would you would prefer I use, that's fine). Can I credit you? If so, I need your written permission to use the image in my thesis. Email confirmation (i.e. A reply to this email) would suffice.

I need to finalise my thesis by this coming Wednesday 20th.

Many thanks!

Kind regards,

Vanessa

1.1.1 North Port Quay – Western Australia

North Port Quay (NPQ) was a proposed coastal island development located near Fremantle, Western Australia, with a bold vision to be 'carbon free' and provide an international benchmark in sustainability. The proposed development was to be located on the seabed attached to the Fremantle harbour and will cover a total land area of 245.5 hectares, protected by a 3.5 kilometre breakwater, which would also provide protection from erosion to the current beaches. It was proposed to be a mix-use development providing over 10,000 residential dwellings. The islands were be completely powered by renewable energy and employ new and innovative low carbon options for managing resources.

Page 1 of 4

Figure 4.1 – Carbon Neutral Working Group

Vanessa Rauland **Thursday, 21 November 2013 5:58:31 PM AWST**

Subject: RE: Permission to use your photo!
Date: Thursday, 21 November 2013 5:52:55 PM AWST
From: ANKETELL Katherine [South Fremantle Snr High Schl] <Kathy.Anketell@education.wa.edu.au>
To: Vanessa Rauland <V.Rauland@curtin.edu.au>

Hi Vanessa,

I give permssion for the photo of the Carbon Neutral Working Group meeting taken at Moore and Moore.

Kind regards

Kathy Anketell
South Fremantle Senior High School
Carbon Neutral Program Director
Lefroy Rd Beaconsfield 6162
9337 0529 Tues & Thurs
NAVIGATING TO SUCCESSFUL, SUSTAINABLE FUTURES

From: Vanessa Rauland [V.Rauland@curtin.edu.au]
Sent: Thursday, 21 November 2013 4:12 PM
To: ANKETELL Katherine [South Fremantle Snr High Schl]
Subject: Permission to use your photo!

Hi Kathy,

I am attempting to submit the final copy of PhD tomorrow and as usual, have some very last minute things to finish off. One such thing was seeking permission from you to use a photo you had taken at one our carbon neutral committee meeting at Moore and Moores. Yes, SFSHS made it into my thesis!!

If you could confirm that this is ok (an email response to this is sufficient), that would be brilliant.

Thanks for all your constant hard work and being such an inspirational eco-warrior/activist and carbon champion!

Vanessa

Page 1 of 1

Appendices

Appendix A - Comparison of Selected Precinct Sustainability Assessment Tools

Tool name	Organisation	Country	Type of tool	Themes/categories targeted	Measurement system	Use of Weighting	Phase targeted
BREEAM Communities	UK Green Building Council	UK	An international sustainability rating and certification tool	• Climate and Energy • Community • Place Shaping • Transport • Resources • Ecology • Business • Buildings	Uses points system (1-100), final score given as a percentage. 51 criteria split between eight categories. Up to 3 credits under each criteria. Not all the categories and credits are mandatory.	Yes	Design
LEED Neighbourhood Development (ND)	US Green Building Council	USA	An international sustainability rating and certification tool	• Smart location and linkage • Neighborhood pattern and design • Green Infrastructure and buildings • Innovation and design process • Regional Priority	Points-based system. 53 criteria spread over three primary categories and two additional ones. The number of credits per criteria varies (i.e. some criteria are awarded up to 10 credits). All criteria are mandatory.	Yes	Design
CASBEE Urban Development (UD)	Green Building Council	Japan	A national sustainability - rating and certification tool	• Natural environmental quality in urban development • Service function for the designated area • Contribution to the local community • Environmental impact on microclimates, facades & landscape • Social infrastructure • Management of the local environment	80 criteria split between 4-6 categories. Each criterion awarded between 1-5 points. Overall score is averaged between categories.	Yes	Design
One Planet Communities	BioRegional	International	An international sustainability design and branding tool	• Zero carbon • Zero waste • Sustainable transport • Sustainable materials • Local and sustainable food • Sustainable water • Land use and wildlife • Culture and heritage • Equity and local economy • Health & happiness	Assesses unique targets set by individual developments to ensure they comply with the 10 principles. Requires annual reviews to ensure action plan is being delivered and targets met.	No	Design and performance (annual review)
Green Star Communities	Green Building Council of Australia	Australia	A national sustainability rating and certification tool	• Governance • Design • Liveability • Economic Prosperity • Environment • Innovation	Uses points system (1-100) to give overall rating in stars (4-6 stars). 38 credits available over 6 categories.	Yes	Design
Enviro-Development	Urban Development Institute of Australia (UDIA)	Australia	A national sustainability branding and certification system	• Ecosystems • Waste • Energy • Materials • Water • Community	Points-based. Uses leaves. Uses technical standards and requires per cent improvement. Can certify a single area or up to all six.	No	Design. Also offers ongoing certification based on performance rating tools
PRECINX	Landcom (NSW Government Land Development Agency)	Australia	Quantitative decision-making tool for urban development. No certification	• Onsite energy • Embodied CO2 • Potable water • Transport • Housing diversity • Storm water	Uses quantifiable numbers to measure predicted performance i.e. tonnes of GHG's, mL of water, vehicle kilometres traveled (VKT), affordability.	Yes	Design
eTool	eTool	Australia	Life Cycle Assessment (LCA) software to aid low carbon design. Certification possible	• Carbon associated with life cycle of buildings, developments and infrastructure projects	Quantitative Life Cycle Assessment of carbon within a development	No	Design & performance

Appendix B – Comparison of Carbon Neutral Certification Schemes

Company	Name of certification /logo	Est.	Country of Origin	Current Market	Third party verification required	Type of company/org	ISO 14065 accreditation	Supply Offsets
carboNZero	Carbon Zero CEMARS	2001	New Zealand	International	Yes No	Government partnership	Yes	Yes
Carbon-Neutral	CarbonNeutral® Global Standard	1997	UK	International	Yes	Private, for profit	No	Yes
British Standards Institution	PAS 2060:2010 - Specification for the demonstration of carbon neutrality	2010	UK	UK	Yes but no follow up	Government	N/A	No
Carbon Neutral	None/Can certify under a range of standards	2001	Australia	Australia	Depends on standard chosen	Private, Not for profit	No	Yes
Climate Friendly	Climate Friendly Business/Event Taking Action With Climate Friendly	Not listed	Australia	International	No	Private, for profit	No	Yes
Carbon Reduction Institute	NoCO2 LowCO2 Carbon Neutral	2006	Australia	Australia	No	Private, for profit	No	Yes
ICLEI (Carbon Neutral Framework)	None	1990 2008	Canada	International	Yes	Association	N/A	No
Low Carbon Australia	NCOS Carbon Neutral certification	2010	Australia	Australia	Yes	Government	No	No

Appendix C - Submission - Review of the National Carbon Offsets Standard – Discussion Paper

Curtin University of Technology

Curtin University Sustainability Policy (CUSP) Institute

Office location:
3 Pakenham Street
Fremantle

Postal address:
GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 9030
Facsimile +61 8 9266 9031
Web www.sustainability.curtin.edu.au

CRICOS Provider Code 00301J

12 October 2011

SUBMISSION

REVIEW OF THE NATIONAL CARBON OFFSETS STANDARD – DISCUSSION PAPER

Carbon Neutrality Section, Land Division
Department of Climate Change and Energy Efficiency
GPO Box 854
CANBERRA ACT 2601
NCOSReview@climatechange.gov.au

About CUSP

Curtin University Sustainability Policy (CUSP) Institute was established in January 2008 and is based in Fremantle, Western Australia. With Professor Peter Newman as its director, CUSP aims to be a leading-edge, internationally renowned provider of research, teaching and policy advice in the area of sustainability policy. It takes an innovative approach to implementation through demonstrations and partnerships with business, government and the community. CUSP is a key player in the Australian Sustainable Development Institute (ASDI), which encompasses a broad range of Curtin research centres and teams involved in sustainability scholarship.

We have several researchers and projects at CUSP investigating various carbon related issues. One ARC funded industry linkage project titled 'Decarbonising Cities and Regions', is looking into how to design, develop and accredit carbon neutral urban precincts and towns. We also have multiple projects funded through the Sustainable Built Environment National Research Centre (SBEnrc) under the 'Greening the Built Environment' research stream, looking at performance evaluation of green buildings and the future of biophillic urbanism in Australian cities.

In addition to larger government and industry-funded projects, we have researchers taking on smaller projects to help promote sustainability and low carbon initiatives and actions on a more local level. Some of these projects include feasibility studies for co- and tri-generation for local councils as a means of reducing emissions and assisting a local high school in being the first to achieve NCOS Carbon Neutral accreditation.

The comments made in this submission primarily relate to some of the areas mentioned above. The first section is overall comments followed by specific comments for schools and urban development. We can be contacted on the details below with any further queries.

Kind regards,

Vanessa Rauland
Project Coordinator & PhD Candidate
CUSP Institute
3 Pakenham St, Fremantle 6160
v.rauland@curtin.edu.au

Samantha Hall
PhD Candidate
CUSP Institute
3 Pakenham St, Fremantle 6160
sjhall04@gmail.com

Pertaining to the Discussion Paper

3.1. Generation of Domestic and International Offsets

- *"Since GreenPower is essentially equivalent to the purchase and voluntary retirement of GreenPower-eligible renewable energy certifications (RECs), the NCOS also allows companies to retire such RECs in order to report zero electricity emissions without going through a GreenPower electricity supplier."*

Question/suggestion:
Could companies purchase additional REC's if they want to offset other emissions i.e. in addition to their own electricity? This would potentially create another form of domestic offset. Or are these ineligible because they are generated through an activity that is covered in our Kyoto Reporting?

- *"Stakeholder views are sought on the merits of including GreenPower purchases as an eligible offset and the proposed new approach for dealing with VCS and Gold Standard land sector based credits."*

Comment:
We agree with the current approach of GreenPower being used to eliminate emissions for purchased electricity from a company's inventory.

Suggestion:
However, we would like to see the idea investigated of GreenPower also providing offsets. This could be done through the purchase of additional GreenPower, beyond a company's own electricity consumption. The price paid for the offset may only have to be the price above the standard electricity price (i.e. the difference between the standard price and the price or GreenPower).This means the company wanting to go carbon neutral has essentially enabled some third party to invest in GreenPower (this could also be assisting their CSR i.e. if the carbon neutral company helps a not for profit organisation to purchase GreenPower). The company going carbon neutral will need to pay for offsets/'electricity units' equivalent to the amount of emissions from other activities within their organisation that need to be offset. Each additional unit of GreenPower purchased by a third party means a unit less (or the emissions associated with one unit) of coal-fired electricity. This could potentially provide another form of domestic offset.

A simpler option may be, however, and as mentioned earlier to simply allow organisations to purchase REC's directly. This will place greater demand on the overall amount or REC's available and increase the economic viability of renewable energy projects.

4.6. Scope 3 requirements

We agree with the proposal within the discussion paper in removing the list of scope 3 emissions, concurring that it is misleading and restrictive. We believe, however, that something should take their place. We recommend a series of basic guidelines for various sectors (i.e. for organisations, products, events, major projects, urban development, schools and local councils). The guidelines do not have to be particularly detailed but could provide a broader list of scope three emissions relevant to specific sectors that could/should potentially be included (and of course a justification of why they are not). Over time this list of inclusions/exclusions could become standard practice for the various sectors.

- *The Government acknowledges that calculating scope 3 emissions can present significant challenges to NCOS users and recognises that these challenges are likely to persist for some time. Organisations should take into account the challenges inherent in producing a scope 3 inventory when considering whether to pursue carbon neutrality under the NCOS.*

We strongly agree with the above statement and appreciate that recognition of these difficulties has been made. To assist this we suggest providing some information sheets to help enable organisations/schools/councils etc to be able to undertake (or at least help to prepare as much as possible) the emissions inventory required for accreditation. This is by far the largest cost burden associated with the accreditation process and beyond the means of many schools and community groups.

Below are some suggestions for two areas: Schools and urban development.

SCHOOLS

As mentioned earlier, CUSP is currently assisting a local school to apply for NCOS accreditation. While CUSP has researchers with experience in carbon accounting methodologies, it is our concern that many schools without access to this knowledge would find it very difficult either to create and manage the emissions inventory themselves, or to come up with the funds to pay a consultant to assist them.

Although the NCOS accreditation follows the NGERS Protocol, this is a lot of information to interpret, particularly for Not-For-Profit organisations, local councils and schools with limited resources. It would be helpful to provide simplified guidelines and templates as a tool kit addressing topics relevant to particular types of organisations applying for accreditation (i.e. schools versus factories will have vastly different reporting requirements).

Below are some suggestions on how to make the process easier for schools to undertake the task in house.

Data collection:

a. How to collect and collate data (paper copies of all bills/proof of emissions) and a clear spreadsheet template.
b. Interpreting a utilities bill – addressing issues such as gas units being equivalent to kWh (noting that this varies state to state).
c. Scope 3 emission guides, such as how to calculate waste and convert to emissions.
d. Transportation – this area could easily be underreported on for schools. It is important that records be obtained for school operated and owned vehicles such as school buses.
e. EPA Victoria provide some helpful information on this which could potentially be duplicated: http://www.epa.vic.gov.au/climate-change/carbon-management/resources.asp

Section 3:
Carbon offsets – The new CFI offsets are welcomed, as the issue around locally generated offsets is often raised. Purchasing REC's or GreenPower may provide another option for locally generated offsets.

Section 4:
We are also seeking further clarification on how to integrate a major project into an organisations inventory. For example, a new building is being constructed at a school. Would the increase in emissions as a result of this mean a re-calculation of the base year?

- Section 4.6: Business travel for employees' should also include "travel related to the operation of a business". For example, schools should include all the emissions associated with transport for field trips for students.

Section 5:
Clarification regarding the EMP. It needs to be clearly stated that previous initiatives, which have already been put into place can be documented in the EMP, as long as they occurred after the base year. This was an issue with the school we are working with as they have put in place several impressive initiatives since 2006, which have saved considerable emissions, that they were worried would not be recognised.

Some overall barriers we are seeing to uptake of NCOS for schools is also the cost and complication of the process. Some approximate guidelines on the cost and time required to put into the process would be helpful, with case study examples of initiatives that have been put into place in other schools and the benefits/savings these initiatives have bought.

We are working with the school in order to provide this information to other schools also wishing to apply for carbon neutral accreditation. We would be happy to work in conjunction with the DCCEE to provide this.

URBAN DEVELOPMENT

Urban Development is another area that requires specific guidelines. Arguably, it may be considerably harder to achieve than a school, as there are many ongoing issues to address (i.e. once a developer has sold the development, who would be responsible for the ongoing accreditation?).

Within our project "Decarbonising Cities and Regions", we are working to create a framework and set of guidelines for developers that wish to gain carbon neutral accreditation. As we are seeing many new developments in Australia and around the world begin to claim various carbon related titles (i.e. carbon neutral, carbon positive, net zero emissions, low carbon, carbon free etc), we believe it is necessary to provide a set of structured guidelines to assist with the credibility of claims.

The framework we have developed so far would require developers to conduct a carbon analysis of the developments, which will include calculating the emissions associated with the following:

(a) GHG's used in the materials of the buildings and the infrastructure, comparing the variations when regional and recycled and low carbon materials are used;
(b) GHG's used in the construction process and how this varies with different approaches;
(c) Electrical power and natural gas used in the buildings including the differences with different building types and their variations when provided from centralised or distributed sources (including renewables);
(d) Transport fuels used in the construction and the on-going use of the area by residents (including the variations in emissions relating to different transport modes);
(e) GHG's produced in the full water cycle (pumping water in and out) including GHG's linked to gardens, public landscaping and different forms of water infrastructure (centralised or distributed, recycled and stormwater re-use);
(f) GHG's associated with the solid waste generated by the community and its variations when more re-use and recycling is available.

Significance and benefit

This will be the most comprehensive carbon analysis carried out on a neighbourhood or precinct level in Australia to date.

The project will:

- Help to bring credibility to the concept of carbon neutrality and how this can be achieved within the built environment;
- Provide a laboratory for land developers to experiment with and develop new, innovative ideas and technologies for larger developments;
- Encourage a more integrated approach in planning and designing sustainable developments by promoting a closer working relationship with a variety of people (i.e. urban planners, designers, contractors, energy and water utilities, community and local businesses etc);
- Demonstrate what can be done above and beyond business as usual by showcasing some of the most unique, innovative and extraordinary examples of decarbonised developments in Australia
- Increase community wealth by ensuring lower energy bills and enabling communities to become energy providers
- Examine various incentives to encourage such innovative developments such as land tax exemptions, reduced approvals waiting time and early mover incentives.

CUSP would welcome the opportunity to work with the Federal Government and DCCEE on developing these accreditation requirements and guidelines for carbon.

Appendix D – White Certificate Schemes

Country	Start Date	Name of scheme	Summary
Australia (South Australia)	2009	Residential Energy Efficiency Scheme (REES)	• Energy retailers with more than 5,000 residential customers must surrender sufficient certificates • Targets only residential sector • Certificates are generated through pre-approved Energy Efficiency Activities
Australia (NSW)	2009	Energy Savings Scheme (ESS)	• Liable energy retailers must obtain and surrender sufficient certificates to meet their target • Accredited Certificate Providers generate certificates from Recognised Energy Saving Activities (RESA's) • Targets businesses and households
Australia (Victoria)	2009	Victorian Energy Efficiency Target (VEET) scheme	• Energy retailers who are liable under the scheme must purchase & surrender a specified number of Victorian Energy Efficiency Certificates (VEEC's) annually • Certificates are generated from Prescribed (energy efficiency) Activities by accredited entities • Activities can be targeted at both residential and commercial sectors
India	2011	Perform, Achieve and Trade system (PAT)	• Designated consumers (energy intensive industries and facilities) that are responsible for 54% of emissions. • Purchase tradable Energy Savings Certificates
United Kingdom	2010	Carbon Reduction Commitment (CRC) Energy Efficiency Scheme	• Energy suppliers with over 50,000 customers (residential) • Large public and private sector (i.e. supermarkets, banks, government departments)
United Kingdom	2010	CRC Energy Efficiency Scheme	• Tackles emissions not covered under current ETS. • Cap and trade scheme targeting non energy-intensive industries. • Organisations whose annual electricity use in 2008 exceeded 6MwH required to report emissions.
Italy	2005	Energy Efficiency Certificates (TEE: Titoli Efficienza Energetica)	• Distributors of electricity and gas with more than 100,000 customers are obliged to deliver a certain number of white certificates per year
France	2006	French White Certificates	• Energy suppliers with minimum 400 GWh/year sales and all suppliers of residential heating oil
Denmark	2006	Energy Efficiency Obligation (Looking to change to trading scheme)	• Obligations are put on electricity, gas, district heating and oil companies