Resilient Cities

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Abstract

In order to create resilience in cities, globally and in Australia, there will need to be: renewable energy strategies showing how to progressively tap local resources; carbon–neutral strategies that can enforce energy efficiency, integrate with the renewables strategy and direct the carbon offsets into the bioregion; distributed infrastructure strategies that enable small–scale energy and water systems to flourish; biophilic or green infrastructure strategies that include the photosynthetic resources of the city and which can enhance the green agenda across the city through food, fibre, biodiversity and recreation pursuits locally; eco–efficiency strategies linking industries to achieve fundamental changes in the metabolism of cities; sense–of–place strategies to ensure the human dimension is driving all the other strategies; and sustainable transport strategies. This paper explores how elements of these requirements have been achieved nationally and internationally and what more needs to be done to achieve resilient cities in Australia.

Introduction

Resilience is increasingly being used as a way to describe human activities that are smart, secure and sustainable. They are smart in that they are able to adapt to the new technologies of the twenty first century, secure in that they have built–in systems that enable them to respond to extreme events as well as being built to last and sustainable in that they are part of the solution to the big questions of sustainability such as climate change, peak oil and biodiversity. Resilience thinking has been applied mostly to regions and natural resource management systems (Walker and Salt 2006) but can also be applied to cities (Newman *et al.* 2008).

The question of what kind of infrastructure helps cities to be more resilient is the focus of this chapter. Seven characteristics are outlined to help define these features and they are illustrated from around the world. These are then applied briefly to Australian cities.

Innovations in resilient infrastructure cities

Globally, there are seven features of resilience that are emerging in infrastructure. These are described as seven archetypal cities:

- the ‘Renewable Energy City’
- the ‘Carbon–Neutral City’
- the ‘Distributed City’
- the ‘Biophilic City’
- the ‘Eco–Efficient City’
- the ‘Place–Based City’
- the ‘Sustainable Transport City’.

These city types are obviously overlapping in their approaches and outcomes, but each provides a perspective on how attempts to improve the resilience of a city can be achieved.

While no one city has shown innovation in all seven areas, some are quite advanced in one or two. The challenge for urban planners is to apply all of these approaches together, to generate a sense of purpose through a combination of new technology, city design and community–based innovation in resilient infrastructure.

The 'Renewable Energy City'

There are now a number of urban areas that are partly powered by renewable energy techniques and technologies, from the region to the building level. Renewable energy enables a city to reduce its ecological footprint and, if using biological fuels, can be part of a city's enhanced ecological functions.

Renewable energy production can and should occur within cities, integrated into their land–use and built form and comprising a significant and important element of the urban economy. Cities are not simply consumers of energy, but catalysts for more sustainable energy paths and they can increasingly become a part of the earth's solar cycle.

While some solar city projects are underway (including Treasure Island in San Francisco) there are presently no major cities in the world that are powered entirely by renewable energy. Movement towards a renewable–energy future will require much greater commitment from cities themselves at all levels, including the local and the metropolitan.

Masdar City in the United Arab Emirates is an important first example of a city built from scratch with 100 per cent renewable energy and zero car use (in theory). It is being built with a 60 megawatts solar photovoltaic plant to power all construction, and eventually a 130 MW solar photovoltaic plant for on–going power as well as a 20 MW wind farm and geothermal heat pumps for cooling buildings. Electric automatic pod cars on an elevated structure will be the basis of the transport. Masdar has begun to be built.

North Port Quay in Western Australia is planned to be home to 10 000 households and is designed to be 100 per cent renewable through solar photovoltaic, small wind turbines called wind pods and a nearby wave power system. The development will be dense and walkable with an all–electric transport system featuring electric public and private transport, all linked to renewable power through battery storage in vehicles. The concept has had a mixed response and will be several years in its planning phase as such developments are not easy to accept into town planning schemes designed around fossil–fuel based development.

Urban planning is necessary to create the infrastructure needed to support solar and wind power at the scale necessary to help power a city. While finding locations for large wind farms near urban areas has been controversial, there are significant opportunities to harness solar and wind power. Studies are also now showing that wind, like photovoltaic solar, can be integrated into cities and their buildings.

The shift in the direction to the renewable city can occur through many actions: demonstration solar or low energy homes created to show architects, developers and citizens that green can be appealing; procurement actions that source regionally produced wind and other renewable energy to power municipal transit, lights and buildings; and green building standards and requirements for all new public as well as private buildings.

Freiburg has incorporated solar energy in all major new development areas including Resielfeld and Vauban, which are new compact green growth areas in the city. Both active and passive solar techniques are employed in these projects and the city also mandates a stringent energy standard for all new homes. In Vauban, some 5 000 zero–energy homes – homes that produce at least as much energy as they need – have been built and a zero–energy office complex was added in 2006, along with two solar garages where photovoltaic panels cover the roof of the only allowable parking in the area (Scheurer and Newman 2008).

The City of Adelaide envisions itself as a renewable city, as part of its larger green city initiative. It has designated solar precincts for the installation of photovoltaic panels on the rooftops of buildings, including Parliament House. There is a solar schools initiative, with the goal of 250 solar schools (schools with rooftop installations that incorporate solar and renewable energy into their educational curricula). This idea has since been taken up by the Australian Government to be applied to every school in the country. Most creatively, the city has been installing grid–connected photovoltaic street lamps that produce some six times the energy needed for the lighting. These new lights are designed in a distinctive shape of a local mallee tree. This is one of the few examples of solar art or solar 'place' projects.

Along with incentives (financial and otherwise), solar cities recognize the need to set minimum regulatory standards. Barcelona has a solar ordinance, which requires new buildings and substantial retrofits of existing buildings to obtain a minimum of 60 per cent of hot water needs from solar. This has already led to a significant growth of solar thermal installations in that city.

Transport can also be a major part of the renewables challenge. The more public transport moves to electric power, the more it can be part of a renewable city. Calgary Transit's creative initiative called 'Ride the Wind' provides all the power needed for its light rail system from wind turbines in the south of Alberta, Canada. Private transport can now also be part of this transition through a combination of electric vehicles and new battery storage technology, together called 'Renewable Transport' (Went *et al.* 2008; Curtin University Sustainability Policy Institute 2009). Not only can electric vehicles use renewable electricity to power their propulsion, they can also be plugged in during the day and, through their batteries, provide storage for intermittent renewable energy as their power systems store four times their consumption. Thus they can provide a critical role in enabling renewables to build up as a much higher proportion of the urban energy grid.

Renewable power enables cities to create healthy and liveable environments while minimising the use and impact of fossil fuels. But, by itself, this will not be enough to ensure resilient urban development.

The 'Carbon–Neutral City'

Carbon–neutral can become the goal for all urban development, just as it has become for some businesses and households. This will require a three–step process:

- reducing energy use wherever possible – especially in the building and transportation sectors
- adding as much renewable energy as possible, while being careful that the production of the renewable energy is not contributing significantly to greenhouse gases and
- offsetting any CO_2 emitted through purchasing carbon credits, particularly through tree planting.

In 2007, the head of News Corporation, one of the biggest media empires in the world, announced that his company would be going carbon–neutral. This has led to some remarkable innovations within the company as it confronted the totally new territory of becoming a global leader in energy efficiency, renewable energy and carbon offsets (News Corporation 2009).

Many businesses, universities and households are now committing to minimizing their carbon footprint and even becoming carbon–neutral. But can it become a feature of whole neighbourhoods and even complete cities? There are those who suggest it is essential if the world is to move to 'post–carbon cities' (Lerch 2007).

There is a number of initiatives that focus on helping cities to reach these goals, including ICLEI–Local Governments for Sustainability's 'Cities for Climate Change', 'Architecture 2030', The Clinton Foundation's 'C–40 Climate Change Initiative' and UN–Habitat's 'Cities for Climate Change Initiative' (CCCI). And as mentioned in the above section, many municipalities have started to offer incentives and/or require that new buildings meet certain green–building standards. Minimizing carbon at the building level has momentum, as it is easier to integrate the technology into new buildings and the benefits have been proven – not just in energy savings but in increased productivity and fewer sick days in green office buildings.

In Sydney, the BASIX programme has mandated that new homes must now be designed to produce 40 per cent fewer greenhouse gas emissions compared with an existing house (after initially requiring 20 per cent and finding it was relatively easy to achieve) as well as 40 per cent less water use. The programme aims at reducing CO_2 emissions by 8 million tonnes and water use by 287 billion litres in ten years (Farrelly 2005). This is an important role for urban planning, through the assessment process, which can help to set up carbon–neutral suburbs. The next phase of this project is called 'Precinx' and seeks to establish the statutory planning governance for carbon–neutral neighbourhoods and sub–divisions.

The United Kingdom government has decided that all urban development will be carbon–neutral by 2016, with phasing in from 2009. The 'Beddington Zero Energy Development' initiative is the first carbon–neutral community in the UK. It has extended the concept to include building materials and, as it is a social housing development, it has shown how to integrate the carbon–neutral agenda with other sustainability goals, making it a more resilient demonstration.

Malmo, Sweden, has stated that it has already become a carbon neutral city; Vaxja, Sweden, has declared its intention to become a fossil–fuel–free city, and Newcastle, in the UK, and Adelaide, in Australia, also aspire to be carbon–neutral. Each has taken important steps in the direction of renewable energy.

Vancouver's new Winter Olympic Village has been built as a model North American demonstration in carbon–neutral urban development.

The link to the green agenda of a city is very direct with respect to the carbon–neutral approach of bioregional tree–planting schemes. By committing to be carbon–neutral, cities can focus their offsets into bioregional tree–planting, as part of the biodiversity agenda as well as climate change.

In all Australian cities, the carbon and greenhouse gas emissions associated with many municipal motor pools are being offset through innovative tree–planting initiatives and through organizations such as Green Fleet, which has recently planted its 2–millionth tree. Firms, such as airlines, offer carbon–neutral services and schools as well as many businesses are committed to being carbon–neutral. The carbon–offsetting is accredited through a Federal Government scheme called 'Greenhouse Friendly' and provides a strong legal backing to ensure that tree–planting is real, related to the money committed and is guaranteed for at least 100 years as required by the Kyoto Convention. Many of the carbon–offsetting programmes are going towards biodiversity plantations that are regenerating a bioregional ecology around cities. A particular example is the 'Gondwana Links' project, which is regenerating an ecological link over 3 000 km between the coastal ecosystems of the Karri forest to the inland woodlands by joining up various reserves across the whole south coast of

Western Australia. The project is driven by many big firms using their carbon offsets from energy use to create this biodiversity–based tree–planting (Newman and Jennings 2008).

All these are good programmes, but none are committed yet to a comprehensive city–wide carbon–neutral approach that can link tree–planting to a broader biodiversity cause. If this is done, cities can raise urban and bioregional re–forestation to a new level and contribute to reducing the impact of climate change, simultaneously addressing local and regional green agenda issues.

The Carbon–Neutral City will receive a big boost when a global compact on carbon trading can be achieved as this will enable the voluntary carbon–trading market to become mainstream.

The 'Distributed City'

The development of distributed power and water systems aims to achieve a shift from large centralized power and water systems to small–scale and neighbourhood–based systems within cities. The distributed use of power and water can enable a city to reduce its ecological footprint, as power and water can be more efficiently provided using the benefits of electronic control systems and community–oriented utility governance.

Most power and water systems for cities over the past 100 years have become bigger and more centralized. While newer forms of power and water are increasingly smaller scale, they are often still fitted into cities as though they were large. The movement that tries to see how these new technologies can be fitted into cities and decentralized across grids is called 'distributed power and distributed water systems' (Droege 2006).

The distributed water system approach is often called ‘water sensitive urban design’. It includes using the complete water cycle, i.e. using rain and local water sources like groundwater to feed into the system and then to recycle ‘grey’ water locally and ‘black’ water regionally, thus ensuring that there are significant reductions in water used. This system can enable the green agenda to become central to the infrastructure management of a city, as stormwater recycling can involve swales and artificial wetlands that can become important habitats in the city. Grey water recycling can similarly be used to irrigate green parks and gardens and regional black water recycling can be tied into regional ecosystems. All these initiatives require ‘smart’ control systems to fit them into a city grid and also require new skills among town planners and engineers, who are so far used to water and energy management being a centralized function rather than being a local planning issue (Benedict and McMahon 2006).

In large cities, the traditional engineering approach to providing energy has been through large centralized production facilities and extensive distribution systems that transport power relatively long distances. This is wasteful because of line losses, but also because large base–load power systems cannot be turned on and off easily, so there is considerable power–shedding when the load does not meet the need. However, renewable, low–carbon cities aim at developing more decentralized energy production systems, where production is more on a neighbourhood scale and both line–losses and power–shedding can be avoided. Whether from a wind turbine, small biomass combined heat and power plant (as in London’s new distributed energy model), or a rooftop photovoltaic system, renewable energy is produced closer to where it is consumed, and, indeed, often directly by those who consume it. This distributed generation offers a number of benefits, including energy savings, given the ability to better control the power production, lower vulnerability and greater resilience in the face of natural and human–made disaster (including terrorist attacks). Clever integration of these small systems into a grid can be achieved with new technology control systems that balance the whole system in its demand and supply from a range of sources as they rise and fall and link it to storage, especially vehicle batteries through vehicle–to–grid, or ‘V2G’, technology. A number of such small–scale energy systems are being developed to make cities more resilient in the future (Sawin and Hughes 2007).

Distributed power and water provision in cities needs community support. In Toronto, communities began forming ‘buying–cooperatives’ in which they pooled their buying power to negotiate special reduced prices from local photovoltaic companies that had offered an incentive to buy solar photovoltaic panels. The first co–op was the ‘Riverdale Initiative for Solar Energy’. In this initiative, 75 residents joined together to purchase rooftop photovoltaic systems, resulting in savings of about 15 per cent in their purchase cost. This then spread across the city. The Toronto example suggests the merits of combining bottom–up neighbourhood approaches with top–down incentives and encouragement. This support for small–scale distributed production – offered through what are commonly referred to as standard offer contracts (often referred to as ‘feed–in tariffs’ in Europe) – has been extremely successful in Europe where they are now common. The same can be done with new technologies for water and waste, such as rain–water tanks and grey–water recycling. One other model example is the redevelopment of the Western Harbour in Malmö, Sweden. Here the goal was to achieve distributed power and water systems from local sources. This urban district now has 100 per cent renewable power from rooftop solar panels and an innovative storm water management system that recycles water into green courtyards and green rooftops. The project involves local government in the management and demonstrates that a clear plan helps to drive innovations in distributed systems (City of Malmo 2005).

Distributed infrastructure is beginning to be demonstrated in cities across the globe. Utilities will need to develop models with city planners of how they can carry out local energy and water planning through community–based approaches and local management.

The 'Biophilic City'

Biophilic cities are using natural processes as part of infrastructure. Growing energy and providing food and materials locally is therefore becoming part of urban infrastructure development. The use of photosynthetic processes in cities reduces their ecological impact by replacing fossil fuels and can bring substantial ecological benefits through emphasis on natural systems.

There has been a positive trend in planning in the direction of an expanded notion of urban infrastructure that includes the idea of 'green infrastructure' based on photosynthetic processes. Green infrastructure refers to the many green and ecological features and systems, from wetlands to urban forests, that provide a host of benefits to cities and urban residents – clean water, storm–water collection and management, climate moderation and cleansing of urban air, among others. This understanding of green infrastructure as part of the working landscape of cities and metropolitan areas has been extended to include the photosynthetic sources of renewable energy, local food and fibre.

Renewable energy can be tapped from the sun and wind and geothermal sources using small–scale decentralized technology, as described in the previous section. However, renewable energy can also be grown through biofuels. The transition to growing fuels is drawing on crops and forests that can feed into new ways of fuelling buildings and vehicles. Farms and open areas around cities are being developed as the source of renewable energy, especially the production of biofuels. However, biofuels are also being produced as part of improving the urban environment. This means more intensive greening of the lower density parts of cities and their peri–urban regions with intensive food–growing, renewable energy–crops and forests, but greening the high–density parts of cities as well.

The City of Vaxja in Sweden has developed a locally based renewable energy strategy that takes full advantage of its working landscapes, in this case the abundant forests that exist within close proximity of the city. Vaxja's main power plant, formerly fuelled by oil, now depends on biomass almost entirely from wood chips, most of which are a by–product of the commercial logging in the region. The wood, more specifically, comes from the branches, bark and tops of trees and is derived from within a 100 km radius of the power plant. This 'Combined Heat and Power' plant (Sandvik II) provides the entire town's heating needs and much of its electricity needs. Its conversion to using biomass as a fuel has been a key element in the city's aspiration to become an oil–free city. Clearly, each city can develop its own mix of local renewable sources, but Vaxja has demonstrated that it can transition from an oil–based power system to a completely renewable system without losing its economic edge. Indeed, cities that develop such resilience early are likely to have an edge as oil resources decline.

The metropolitan landscape can be viewed as the pallet for a creative mix of solar design and renewable energy projects, and every city and region will have its own special opportunities and resources and in doing so will help integrate the green and brown agendas.

One of the most important potential biofuel sources of the future will be blue–green algae that can be grown intensively on roof tops. Blue–green algae can photosynthesize, so all that it requires is sunlight, water and nutrients. The output from blue–green algae is ten times faster than most other biomass sources, so it can be continuously cropped and fed into a process for producing biofuels or small scale electricity. Most importantly, city buildings can all utilize their roofs to tap solar energy and use it for local purposes without the distribution or transport losses so apparent in most cities today. According to one advocate of this approach, '*every roof should be photosynthetic*', meaning a green roof for biodiversity purposes, water collection, photovoltaic collectors or biofuel–algal collectors. This can become a solar ordinance set by town planners as part of local government policy.

Few cities have done much to take stock of their photosynthetic energy potential. Municipal comprehensive plans typically document and describe a host of natural and economic resources found within the boundaries of a city – from mineral sites, through historic buildings, to biodiversity – but estimating incoming renewable energy (sun, wind, wave, biomass or geothermal) is usually not included. In advancing the renewable energy agenda in Barcelona, the city took the interesting step of calculating incoming solar gain. As a former sustainable city counsellor noted, this amounted to '*10 times more than the energy the city consumes or 28 times more than the electricity the city is consuming*' (Puig 2008). The issue is how to tap into this across the city.

As well as renewable fuel, cities can incorporate food in this more holistic solar and post–oil view of the future. Food, in the globalized market place, increasingly travels great distances – apples from New Zealand, grapes from Chile, wine from South Australia, vegetables from China. 'Food miles' are rising everywhere and already food in the US travels a distance of between 1 500 and 2 500 miles from where it is grown to where it is consumed. Any exotic sources of food come at a high–energy cost. The growing, processing and delivering of food in the US consumes vast amounts of energy on par with the energy required to power homes or fuel cars (Starrs 2005).

After the collapse of the USSR in the late 1980s, Cuba lost Soviet aid, which had provided the country with modern agricultural chemicals. Thus 1 300 000 tons of chemical fertilizers, 17 000 tons of herbicides and 10 000 tons of pesticides could no longer be imported. Urban agriculture was one of Cuba's responses to the shock, intensifying the previously established ‘National Food Programme’, which aimed at taking thousands of poorly utilised areas – mainly around Havana – and converting them into intensive vegetable gardens. Planting in the city instead of only in the countryside decreased the need for transportation, refrigeration and other scarce resources. By 1998, over 8 000 urban farms and community gardens had been established, run by over 30 000 people in and around Havana. Today, food from the urban farms is grown almost completely with active organic methods. Havana has banned the use of chemical pesticides in agriculture within city boundaries (Murphy 1999).

Cities need to find creative ways to promote urban farming where it is feasible, without creating tension with redevelopment for reduced car dependence through increased density. This may mean that a city can utilize the many vacant lots for commercial and community farms in areas that have been blighted (for example the estimated 70 000 vacant lots in Chicago). However, if these areas are well served with good transit and other infrastructure, then such uses should be seen as temporary and, indeed, can be part of the rehabilitation of an area, leading to the development of eco–villages that are car free and models of solar building, as in Vauban. Many cities have embarked on some form of effort to examine community food security and to promote more sustainable local and regional food production. These can be integrated into ecologically sustainable urban and regional rehabilitation projects (Beatley 2005) and can utilize the intensive possibilities of urban spaces, as in urban permaculture (see Newman and Jennings 2008).

In Madison, Wisconsin, a model urban garden called 'Troy Gardens' has emerged from excess land owned by a state–owned mental hospital. Dubbed the 'Accidental Eco–village' by those involved in its transformation, the land was being sold in 1995 when the community who used it as a garden and park stepped in and formed an association to try and buy the land. Through partnerships with other NGOs and the University of Madison Department of Urban and Regional Planning, the 'Friends of Troy Gardens' was able to create a diversity of uses that enabled the money to be found. Thus on the site now is a mixed income co–housing project involving 30 housing units, a community garden with 320 allotments, an intensive urban farm using traditional Hmong agricultural techniques for a community supported agriculture enterprise, and a prairie restoration scheme which is regenerating local biodiversity (Campbell and Salus 2003).

Progress in moving away from fossil fuels also requires serious localizing and local sourcing of building materials. This, in turn, provides new opportunities to build more photosynthetic economies. The value of emphasizing the local is many fold and the essential benefits are usually clear. Dramatic reductions in the energy consumed as part of making these materials is, of course, the primary benefit. It is also about strengthening local economies and helping them to become more resilient in the face of global economic forces and it is also about re–forming lost connections to place.

At the Beddington Zero Energy Development project in London, more than half of the building materials for the project came from within a 35–mile radius, and the wood used in construction, as well as a fuel in the neighbourhood's combined heat and power plant, comes from local council forests. A biophilic approach to urban use of fibre will mean an added reduction in fibre miles as well as potential to help re–grow bioregions.

The 'Eco–Efficient City'

In an effort to improve eco–efficiency, cities and regions are moving from linear to circular or closed–loop systems, where substantial amounts of their energy and material needs are provided from waste streams. Eco–efficient cities reduce their ecological footprint by reducing wastes and resource requirements and can also incorporate green–agenda issues in the process.

A more integrated notion of energy and water entails seeing cities as complex metabolic systems (not unlike a human body) with flows and cycles and where, ideally, the things that have traditionally been viewed as negative outputs (e.g. solid waste, wastewater) are re–envisioned as productive inputs to satisfy other urban needs, including energy. The sustainability movement has been advocating for some time for this shift away from the current view of cities as linear resource–extracting machines. This is often described as the eco–efficiency agenda (Girardet 2000).

The eco–efficiency agenda has been taken up by the United Nations and the World Business Council on Sustainable Development, with a high target for industrialized countries of a 10–fold reduction in consumption of resources by 2040, along with rapid transfers of knowledge and technology to developing countries. While this eco–efficiency agenda is a huge challenge, it is important to remember that throughout the industrial revolution of the past 200 years, human productivity has increased by 20 000 per cent. The next wave of innovation has a lot of potential to create the kind of eco–efficiency gains that are required (Hawken *et al.* 1999; Hargrove and Smith 2006).

The urban eco–efficiency agenda includes the 'cradle to cradle' concept for the design of all new products and new systems like industrial ecology, where industries share resources and wastes like an ecosystem (McDonaugh and Braungart 2002). Good examples exist in Kalundborg, Germany, and Kwinana, Australia (Jennings and Newman 2008).

The view of cities as a complex set of metabolic flows might also help to guide cities dealing with situations (especially in the shorter term) where considerable reliance on resources and energy from other regions and parts of the world still occurs. Policies can include sustainable sourcing agreements, region–to–region trade agreements, urban procurement systems based on green certification systems, among others. Embracing a metabolic view of cities and metropolitan areas takes global governance in some interesting and potentially very useful directions.

This new paradigm of sustainable urban metabolism (seeing them as complex systems of metabolic flows) requires profound changes in the way cities and metropolitan regions are conceptualized as well as in the ways they are planned and managed. New forms of cooperation and collaboration between municipal agencies and various urban actors and stakeholder groups will be required. Municipal departments will need to formulate and implement integrated resource flow strategies. New organizational and governance structures will be necessary, as well as new planning tools and methods. For example, municipal authorities that map the resource flows of their city and region will need to see how this new data can be part of a comprehensive plan for integrating the green and brown agendas.

Toronto has a trash–to–can programme, which allows the city to capture methane from waste to generate electricity. This not only reuses waste and provides an inexpensive energy source but also captures a significant amount of methane that would otherwise be released into the air. Before it reached capacity in its operation, it is estimated that Toronto's Keele Valley landfill generated three to four million dollars annually and provided enough power for approximately 24 000 homes (Clinton Climate Initiative 2009).

One extremely powerful example of how this eco–efficiency view can manifest in a new approach to urban design and building can be seen in the dense urban neighbourhood of Hammarby Sjöstad, in Stockholm. Here, from the beginning of the planning of this new district, an effort was made to think holistically to understand the inputs, outputs and resources that would be required and that would result. For instance, about 1 000 flats in Hammarby Sjöstad are equipped with stoves that utilize biogas extracted from wastewater generated in the community. Biogas also provides fuel for buses that serve the area. Organic waste from the community is returned to the neighbourhood in the form of district heating and cooling. There are many other important energy features in the design as well. The neighbourhood's close proximity to central Stockholm and the installation (from the beginning) of a high–frequency light rail system have made it truly possible to live without a private automobile (there are also 30 car–sharing vehicles in the neighbourhood). While not a perfect example, it represents a new and valuable way of seeing cities and requires a degree of interdisciplinary and inter–sectoral collaboration in the planning system that is unusual in most cities (Newman *et al.* 2008).

The 'Place–Based City'

Cities and regions are increasingly understanding sustainability more generally as a way of building their local economies, building onto a unique and special sense of place and as a way of nurturing a high quality of life and a strong commitment to community. The more place–oriented and locally self sufficient a city's economy is, the more it will reduce its ecological footprint and the more it will ensure that its valuable ecological features are enhanced.

Local economic development has many advantages in the context of sustainable development, including the ability of people to travel less as their work becomes local. Finding ways to help facilitate local enterprises becomes a major achievement for cities in moving towards a reduced ecological footprint. Initiatives designed to help small towns in the US to grow their own jobs have been developed (Sirolli 1999). What the pioneers of these initiatives have both found, time and time again, is that place really matters. When people belong and have an identity in their town or city, they want to put down their roots and create local enterprise.

Local economic development is a first priority for most cities. As part of this, many cities are placing increasing emphasis on local place identity, as social capital has been found to be one of the best ways to predict wealth in a community (Putnam 1993). Thus when communities relate strongly to the local environment, the city's heritage and its unique culture, they develop a strong social capital of networks and trust that forms the basis of a robust urban economy.

This approach to economic development, which emphasizes place–based social capital, has many supporters but very few relate this to the sustainability agenda in cities. For example, energy expenditures – by municipalities, companies and individuals – represent a significant economic drain, as they often leave the community and region. Producing power from solar, wind or biomass in the locality or region is very much an economic development strategy that can generate local jobs and economic revenue from land (farmland) that might otherwise be economically marginal, in the process re–circulating money, with an important economic multiplier effect. Energy efficiency can also be an economic development strategy. For example, research on renewable energy and the creation of related products have developed into a strong part of the economy in Freiburg, Germany.

All the efforts at localizing energy, food, materials and economic development remain dependent on the strength of the local community. The Beddington Zero Energy Development project shows the critical importance of thinking beyond the design of buildings and seeing urban development through a more holistic community–oriented design lens. However impressive the passive solar design and smaller energy demands of this project are (300 mm insulation, an innovative ventilation and heat recovery system, for instance), much of the sustainability gain will come from how residents actually live in these places. Here, residents are being challenged to re–think their consumption and mobility decisions – there is a car–sharing club on site, for example, a food buying club and a community of residents helping each other to think about creatively reducing their ecological impacts and footprints is emerging. This is actually a hallmark of European green projects and an important lesson for projects elsewhere.

A study that examined a range of European urban ecology innovations concluded that when the innovations came from a close and committed community they became ingrained in people's lifestyles, giving the next generation a real opportunity to gain from them. However, many architect–designed innovations that were imposed on residents without their involvement tended to fall into neglect or were actively removed (Scheurer 2003).

Sense of place is about generating pride in the city about all aspects of the economy, the environment and the culture. The ‘Magic Eyes’ project in Bangkok has illustrated how a solid waste project can be facilitated through sense of place (UN Habitat 2009).

Sense of place in a city requires paying attention to people and community development in the process of change – a major part of the urban planning agenda for many decades. This localized approach will be critical to integrating the green and brown agendas. It creates the necessary innovations as people dialogue through options to reduce their ecological footprint, which in turn creates social capital that is the basis for on–going community life and economic development (Beatley and Manning 1997; Beatley 2005). City dwellers in many countries already increasingly want to know where their food is grown, where their wine comes from and where the materials that make up their furniture come from. This can increasingly move towards every element of the built environment. Thus, as well as a slow movement for local foods, a slow fibre and slow materials movement for local fabric and building purposes can also help create a sense of place and bring the green and brown agendas together.

City economies in the past had their own currencies and it has been argued that national currencies often fail to express the true value of a city and its bioregion (Jacobs 1984). Transforming urban economies towards a more bioregional focus has been assisted in some places by adopting complementary currencies that provide an alternative to national currencies and by establishing local financial institutions. It has been argued that a complementary local currency not only facilitates change but also creates a community with a mutual interest in productive exchange among its members in the bioregion (Korten 1999). In this way, a community affirms its identity and creates a natural preference for its own products. Over a thousand communities around the world have issued their own local currencies to encourage local commerce. How this has been related to urban planning is set out in Newman and Jennings (2008) using the example of Curitiba.

Most developed cities have created development bonuses similar to Curitiba's that are part of the non–monetary economy of the city. For example, in Vancouver, the city requires that 5 per cent of the value of a development be directed into social infrastructure. This is worked out by the developer and council in discussion with the local community who may want more landscaped streetscapes, more pedestrianised areas or a community meeting space, even an art–house cinema. Social housing is worked out on the basis of receiving a density bonus for more development rights. The more Vancouver exercises these complementary currency requests, the more the development process works to create better public spaces to go with the private spaces developed by the market. Thus sustainability can be made to mean something at a very local level through the planning system.

All cities have the opportunity through their planning systems to create their own currencies that work in a parallel but complementary way with normal money. These 'sustainability credits' are not owned by the developer or by the city but they are in fact, owned by the community, as it is their values that are expressed in the development bonuses granted. Thus cities can create community banks of sustainability credit through their planning systems. Most cities in developing countries do not have much to invest in their public spaces hence the whole city economy suffers. Curitiba showed how cities could break that mould. Through the planning system, cities can create their own sustainability currencies for what they most need as determined by their local citizens – they just need to define them as ‘development rights’. These new ‘sustainable development rights’ could be related to biodiversity credits, greenhouse reduction credits, salinity reduction credits, affordable housing credits or anything else that a community can create a ‘market’ for in their city and its bioregion.

The ‘Sustainable Transport City’

Transport is the most fundamental infrastructure for a city, as it creates the primary form of the city (Newman and Kenworthy 1999). Cities, neighbourhoods and regions are increasingly being designed to use energy sparingly by offering walkable, transit–oriented options, more recently supplemented by vehicles powered by renewable energy (Went, James and Newman, 2008). Cities with more sustainable transport systems have been able to increase their resilience by reducing their use of fossil fuels, as well as through reduced urban sprawl and reduced dependence on car–based infrastructure. This issue is considered in a separate chapter.

The agenda for large cities now is to have more sustainable transport options so as to reduce traffic whilst reducing greenhouse gases by 50 per cent by at least 2050, in line with the global agenda set through the International Panel on Climate Change. For many cities, the reduction of car use is not yet on the agenda, apart from seeing it as an ideal to which they aspire. Unfortunately, for most cities, traffic growth has been continuous and appears to be unstoppable. To reduce a city’s ecological footprint and enhance its liveability, it is necessary to manage the growth of cars and trucks and their associated fossil–fuel consumption.

Urban planning for resilient urban infrastructure development

The above seven Resilient City types suggest that in order to create resilience in cities, there will need to be:

- renewable energy strategies showing how to progressively tap local resources (such strategies should involve recognition of renewable resources in and around a city as part of the capital base of the city and establishing ordinances on buildings that facilitate the application of renewable energy)
- carbon–neutral strategies that can enforce energy efficiency, integrate with the renewables strategy and direct the carbon offsets into the bioregion (this can be enforced through planning schemes that mandate standards for significant reductions in carbon and water in all development, that prevent the loss of arable and natural land in the bioregion and direct planting to areas that are most in need of revegetation)
- distributed infrastructure strategies that enable small–scale energy and water systems to flourish (this can be built into the requirements for urban development and can be facilitated by providing incentive packages with new buildings for technologies such as photovoltaic cells, grey water systems and water tanks, local plans for the governance of community–based systems and region–wide strategies for recycling sewage)
- biophilic or green infrastructure strategies that include the photosynthetic resources of the city and which can enhance the green agenda across the city through food, fibre, biodiversity and recreation pursuits locally (this can be achieved through development controls that focus on how the roof–tops (and walls) of buildings can be used for photosynthetic purposes as

well as zoning areas for urban photosynthetic activity, including growing bio–fuels, food and fibre and biodiversity in and around the city)

- eco–efficiency strategies linking industries to achieve fundamental changes in the metabolism of cities (this can be done by taking an audit of all the wastes of the city and seeing how they can be re–used through stakeholder participation and government facilitation)
- sense–of–place strategies to ensure the human dimension is driving all the other strategies (this can be assisted by local economic development strategies, by place–based engagement approaches to all planning and development processes and by the innovative use of 'sustainability credits', or complementary currencies, to implement local sustainability innovations as development bonuses)
- sustainable transport strategies incorporating: (i) quality transit down each main corridor which is faster than traffic; (ii) dense transit oriented developments (TOD) built around each station; (iii) pedestrian and bicycle strategies for each centre and TOD with cycle links across the city; (iv) plug–in infrastructure for electric vehicles as they emerge; (v) cycling and pedestrian infrastructure as part of all street planning; and (vi) a green–wall growth boundary around the city preventing further urban encroachment.

Application to Australian cities

The ideas discussed above apply to Australian cities in a range of ways:

- Renewable energy strategies in Australian cities are not well developed with no clear plan yet for how they will address the national goal of 20 per cent by 2020. Wind power, solar and wave technologies will be needed as the focus with some geothermal possibilities.

- Carbon–neutral strategies that can enforce energy efficiency are beginning to be created though no city–wide attempt has yet been made to direct carbon offsets into the bioregion. A carbon plan is needed for each Australian city.
- Distributed infrastructure strategies that enable small–scale energy and water systems to flourish have not been considered because Australian cities are almost fully sewered and have a fully reticulated water supply system and complete grid for electricity covering all buildings. As the small–scale systems for water, energy and waste become more mature it will be possible to put these back into the city whilst retaining the central grids for back–up. Only the City of Sydney has begun to consider such a plan.
- Biophilic or green infrastructure strategies are starting to be considered to supplement biodiversity strategies but no Australian city yet has a biophilic strategy. An urban agriculture strategy is not yet in place anywhere either despite good examples of community gardens in a number of inner city councils.
- An eco–efficiency strategy has been developed in Kwinana and in Gladstone. Few other examples of industrial ecology are obvious.
- Sense–of–place strategies to ensure the human dimension of resilience is part of the policy mix are now apparent in most Australian cities. Urban design and development is constantly being re–evaluated in terms of their

cultural relevance but how this relates to the sustainability agenda is not clear in most cities.

- Sustainable transport strategies are now firmly on the agenda in all Australian cities with plans for doubling rail capacity in most cities and federal funding for the first time being directed to this goal. Walkability and cycling agendas are also being pursued though often still have to fight for funds when roads are more easily funded. Dense TODs are suggested to be built around each station in Australian cities but few are happening as local planning schemes are not adapted to this agenda. Plug–in infrastructure for electric vehicles has begun to be considered and the Australian Government is promoting demonstrations of the 'Smart Grid Smart City'. This is an obvious next step for each city's innovation and resilience. A growth boundary around each Australian city preventing further urban encroachment is constantly on the agenda and rarely is able to be achieved leaving a legacy of non–resilience for the future in the areas developed on the old sprawl model.

Peter Newman is the Professor of Sustainability at Curtin University and is on the Board of Infrastructure Australia that is funding infrastructure for the long–term sustainability of Australian cities. His two new books 'Resilient Cities: Responding to Peak Oil and Climate Change' and 'Green Urbanism Down Under', were both written with Tim Beatley. Peter invented the term 'automobile dependence' to describe how we have created cities where we have to drive everywhere. For 30 years since he attended Stanford University during the first oil crisis he has been warning cities about preparing for peak oil. Peter's book with Jeff Kenworthy 'Sustainability

and Cities: Overcoming Automobile Dependence' was launched in the White House in 1999. He was a Councillor in the City of Fremantle from 1976-80 where he still lives.

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