Sustainable Cities

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His research and teaching is concerned with the sustainable city and how to make it happen. He has produced seven books (many in partnership with Brendan Gleeson, now professor at Griffith University), 14 chapters in books, 35 articles in international refereed journals, 4 research monographs and numerous conference papers.

He has won two large research grants (‘Discovery Grants’) from the Australian Research Council (1996, 2003) and a number of smaller research awards. His book, *Justice, Society and Nature* (with Brendan Gleeson) won the international prize, the Harold and Margaret Sprout Award of the International Studies Association of the USA. He convened the international conference on environmental justice of the University of Melbourne in 1997. His book *Australian Urban Planning* (with Brendan Gleeson) won the national prize for planning scholarship in 2001. He is a consultant to the Volvo Research and Educational Foundation and was recently co-moderator of the VREF conference on ‘Future Urban Transport’. He is a member of the editorial team of the Australian international journal on urban affairs *Urban Policy and Research* and a member of the editorial advisory boards of three other international journals.

Recent Books:
Making Urban Transport Sustainable, (Palgrave-Macmillan, Basingstoke UK 2003).
Governing for the Environment, (Palgrave-Macmillan, Basingstoke UK 2001)
Australian Urban Planning, New Challenges, New Agendas, (Allen and Unwin, Sydney 2000)
Consuming Cities, The urban environment in the global economy after Rio, (Routledge, London and New York 2000)
Global Ethics and Environment, (Routledge, London and New York, 1999)
Justice, Society and Nature, An exploration of political ecology, (Routledge, London and New York 1998)
Planning, Politics and the State, (Unwin-Hyman, London 1991).

Sustainable Cities

In the twentieth century, town planners had visions of whole cities. The plan was essentially a city viewed from 10,000 metres up in the air. Their visions were of spatial and social patterns and included massive engineering feats of water and energy supply, and transport systems. They brought into being new towns and green belts, but they also made possible urban sprawl and profligate consumption of the environment.

Visions for sustainable cities have to be shaped in a different way — not from the air but from ground level, in the street, from the front door. Geographical pattern-making biases planning in favour of the whole system, to the neglect of the small parts, the micro-texture of city life. It is misleading to talk about 'the sustainable city' as though there were one particular type or form of city that is sustainable. There are choices: high, medium or low density? Energy saving or green energy? What mix of walking, public transport or low energy private vehicles? How fair and how much market freedom?

Building the green city does not mean that the system-wide perspective should be abandoned, but that the order of consideration should be reversed. Instead of starting with the whole pattern and working down to the units of which it is composed, it is best to start with the units and work up to the systems in which they are organised.

<u>Sustainable homes</u>
Michael Mobbs is one of a growing number of people around the world who have built 'sustainable houses[1]. Mobbs is a Sydney lawyer specialising in environmental law. Mobbs and his family took three years to research the technology necessary to make the house self-sustaining and ecologically undamaging. The aim was to achieve four things: no rainwater to leave the property, no sewage to leave the property, water needs to be met from water falling on the roof, and all electricity and heating needs to be met from solar energy: solar hot water and an array of photovoltaic cells. In addition, plantation and regrowth timber only would be used in construction (no rainforest timber); only building materials produced by pollution-free manufacturing processes would be used; there would be no use of materials in the house that discharge toxic chemicals (for example formaldehyde); and no use would be made of PVC plastics.

The three main systems contributing to sustainability are the waste treatment and drinking water systems and the solar energy system. Remarkably the whole water treatment plant fits into a tiny backyard no bigger than the ground floor area of the house itself, and still leaves space for a small garden and wetland nursery for frogs.

At the opposite end of the world a house designed for her own use by professor of architecture at Oxford Brookes University (UK), Susan Roaf, also generates electricity from a rooftop array of photovoltaic cells; so much electricity in fact that the excess power is enough to fuel an electric car (Figure 1)[2]. But the water system is not so elaborate as the Mobbs house. More than the Mobbs's house, Roaf's 'ecohouse' is designed to maintain an even temperature inside even on the coldest and hottest days. England's maximum daytime temperatures in winter can go down to 5 degrees Celsius — and, judging from the heatwave of 2003, it seems the nation must now expect top temperatures at times nearly comparable with Melbourne's hottest (40 plus). A comfortable internal temperature is maintained by a combination of orientation to the sun, trapping the sun, insulation, ventilation and clever use of 'thermal mass'. Thermal mass is the 'heat bank' principle: heavy materials warm up and cool down slowly. So if heavy materials — bricks, concrete floors and concrete block walls, stone, even water — are located inside the house the construction acts like a heat bank, heating up slowly during the day and releasing the warmth at night. The ecohouse has concrete floors and high density concrete block internal walls to make optimum use of thermal mass.

The main windows of Roaf's ecohouse face south to catch the sun. The advantage of a north-south orientation is that the low level winter sun can shine right into the house, heating the heavy internal construction materials, while the summer sun, higher in the sky, does not penetrate and can easily be kept out by overhanging eaves or pergolas. The idea of a glass sunspace or conservatory is now very popular in the colder latitudes and could be attractive in winter even in warmer climates. The two storey ecohouse has a sunspace that rises from floor to roof level on the south side trapping the warmth of the sun like a greenhouse. But of course good ventilation of the sunspace is essential. Sometimes it is necessary to lose heat quickly. Twenty per cent of the glazing of the sunspace is openable and hot air can be quickly drained out of the top.

The Oxford ecohouse is designed with good cross ventilation but little infiltration. Infiltration is uncontrolled movement of air through a building. Up to half of the heat loss from buildings can come from infiltration: air leaking in or out where it is not intended or wanted. Air movement is always important to clear stagnant air but it needs to be controlled. Ventilation need not be through openable windows. Opening windows in winter can let in air that is too cold, and on very hot days in summer the windows are also best kept closed. An experimental 'Passivhaus' in Darmstadt takes air in through plastic pipes buried three to four metres underground. The thermal mass of the earth warms the air to at least 8 degrees Celsius before it enters the house. A heat exchanger then warms the air up to 70 per cent of the temperature of the stale air leaving the house. Even though the Passivhaus is sealed off from direct contact with the outside air, there is a constant flow of fresh warm air through the house. In effect this is a passive method of air conditioning. Unsurprisingly use of the house design to save energy is called 'passive solar design'.

Figure 1. The Ecohouse designed by Professor Susan Roaf in Oxford, UK

Different ecohouses emphasise different qualities. The Chapman's house in Footscray in Melbourne is equipped with a solar hot water system, photovoltaic panels, a water collection and recycling system and energy efficient design. But the existence of the Rolls Royce of all sewage treatment plants at Werribee in Melbourne's West means that sewage composting with the Dowmus system, as in Mobbs's Sydney house, is unnecessary.

Design for the local climate is also critically important. In tropical conditions of more or less constant high temperature and high humidity the use of internal thermal mass will be redundant. Making the most of cooling breezes will be more important. In Australia it is not just heating and cooling that consumes energy. In fact the Australian Greenhouse Office has estimated that 53 per cent of greenhouse emissions from the domestic (home) sector come from the use of electric appliances and equipment. That is because most electricity in Australia is generated by coal burning power stations which emit prodigious amounts of greenhouse gas. It is particularly important, then, that Australian housing be equipped with alternative renewable sources of electricity, the obvious candidate for the job being photovoltaic panels.

Traditionally Australian homes have been based on designs imported from the USA with a view to style — some would say of dubious merit — but with scant attention to climatic comfort. The notion that one design fits all has to be abandoned but there are some general design principles for the ecohouse that might be summarised as follows:

- Design for the local climate.
- Orientate the house so that main windows face north (south in the northern hemisphere).
- Make good use of thermal mass.
- Provide high value insulation.
- Design for good ventilation but minimize leakage of air or heat.
- Manage water wisely.
- Use localized energy systems with the national or local grid as back-up.
- Aim at zero greenhouse gas emission from daily life in the house ('operational energy').

With 'sustainable suburbs' we can add some further principles, without losing sight of those of the 'sustainable house'. Sustainable suburbs are a step up in scale and therefore involve such matters as social interaction, community and transport.

Sustainable suburbs

Sustainable suburbs are already springing up in European cities. These new suburban housing developments combine all the elements of sustainable housing described above. They also contain a mixture of activities, not only affordable housing but also workplaces, shops, cafés, sports facilities, child care centres and schools. They leapfrog over the minimal conditions for greenhouse gas reduction laid down by the Kyoto protocol on global warming, and even go beyond the 60 per cent reduction in greenhouse emissions recommended by the scientists of the Intergovernmental Panel on Climate Change (UN). These new city extensions aim at zero net greenhouse emissions. Three examples are the Beddington Zero (Fossil Fuel) Energy Development (BedZed) in the London Borough of Sutton, UK; the new suburb of Kronsberg in the city of Hannover, Germany; and the waterside development of Västra Hamnen (Western Harbour), in the city of Malmö, Sweden.

BedZed (Figure 2) was jointly designed by the environmental consultant, Bioregional, and the architect Bill Dunster for The Peabody Trust, one of the largest and oldest non-profit organizations in Britain providing affordable housing[3]. BedZed is a medium density development consisting of 82 flats and houses and 1600 square metres of workspace. It was built on a former sewage works and so saves green field land that would otherwise be needed. Renewable building materials were chosen from sources, wherever possible, not more than thirty five miles from the site, thus reducing the energy consumed in long freight journeys.

Figure 2. Beddington Zero Fossil Fuel Emission Development (BedZed) in the London Borough of Sutton.

The housing is designed to conserve energy and provide a comfortable interior climate. The buildings face south, with south facing glass conservatories (sunspaces) to trap the sun. Heavy (high thermal mass) internal walls prevent overheating in summer and store warmth in winter. An 'overcoat' of insulation of roofs, walls and floors retains heat from sunshine, lights, appliances, hot water, and everyday activities such as cooking. Windows are triple-glazed and the frames designed to prevent cold bridges through which warmth could leak out. Britain has a cool climate and therefore for much of the year heat loss is the issue. But, in some Australian climates (such as in Melbourne, Adelaide or Perth, and to some extent Sydney and Brisbane) where there are hot days and cooler nights, the same principles apply in reverse. What works to keep warmth in also works to keep excessive afternoon heat out.

Heat exchangers in the wind-driven domestic ventilation system recover between sixty and seventy per cent of the heat in outgoing stale air. Kitchens are fitted with energy-saving appliances and low energy lighting. It is estimated that residents can expect to reduce their need for energy by up to sixty per cent and for heat by up to ninety per cent. All BedZed's needs for additional heat and electricity are met by a single central combined heat and power unit (CHP or co-generation unit). Trees in people's gardens and local parks around Sutton produce a great deal of excess growth. This would normally be lopped and dumped in the Council's landfill tip. BedZed's CHP unit, however, uses the material as fuel. The CHP unit has been designed to generate as much electricity as will be used at BedZED. It will generate electricity and distribute hot water via insulated pipes to domestic hot water tanks positioned centrally in every home and office so that they can double as heaters during cold weather. The CHP is linked to the national grid so that, at peak times, electricity from the grid supplements that generated by the CHP unit. At other times, excess electricity is exported from the CHP unit to the National Grid.

Moving now to a larger scale, in the late1990s the city of Hannover in Germany decided to create a new city district on a green field site long designated for the city's expansion and close to the Hannover World Expo 2000 site[4]. The Kronsberg development is part of the city's contribution to the Expo and to meeting its obligations under the United Nations 'Agenda 21' and the Aalberg Charter. The whole development is co-ordinated by the Kronsberg Environmental Liaison Agency (KUKA). The development will eventually provide some 6,000 homes and accommodate about 15,000 people. Three children's day care centres, a primary school, a district arts and community centre, a health centre and a shopping centre are all operating today. This city extension is laid out on a grid pattern incorporating avenues, parks, urban squares and planted courtyards to frame the buildings. In keeping with the scale of the development, and to ensure a diversity of approach, many different architects, developers and building contractors have been involved in different projects on the site. Each section of the district contains about 1000 dwellings grouped around a neighbourhood park.

The energy target set was at least a 60 per cent reduction in greenhouse gas emissions compared with current standards for conventional housing. Like BedZed it combines low energy housing, on principles of good passive solar design, with district heating and the use of renewable energy. The City Council of Hannover maintains a high standard of low energy design — called the Kronsberg Standard — by frequent site inspections backed up by a training programme for all contractors working on the site. KUKA offers certificated 'fast response' courses to upgrade the builders' skills. Thus in addition to building a green suburb a newly skilled building profession is also being created. Some ninety of the dwellings will be built as ‘passive houses’ like the Darmstadt experimental Passivhaus requiring extremely small energy to keep the temperature inside the house at a constant comfortable level.

Finally, the new suburb of Västra Hamnen in Malmö, Sweden, was designed as a ‘city of tomorrow’ in conjunction with Bo 01, the city’s international housing exhibition of 2001[5] (Figure 3). The new neighbourhood is located on an industrial site formerly used by a major shipyard (Kockums) and the vehicle manufacturer Saab. When these activities contracted, a polluted wasteland was left behind. The new city district occupies old industrial land fronting the sea on one side and the harbour on the other. The district will eventually combine housing for between ten and twenty thousand people with commercial and social services. The section already built is a new neighbourhood built on the most attractive seafront site with 559 dwellings consisting of houses, terraces and blocks of flats up to six stories. The six storey flats are built along a seafront promenade and boardwalk with a breathtaking view across the Öresund (The Sound) to Denmark and the bridge to Copenhagen. These flats also provide a felicitous and necessary barrier against the wind and weather, providing a calmer interior for the neighbourhood which contains smaller scale houses and flats.

Figure 3 Västra Hamnen docklands development in Malmö, Sweden

The sustainable alternative, says the literature, ‘must prove itself to be at least as convenient, financially advantageous, comfortable, pleasant, exciting and beautiful as any conventional housing scheme’. With waterfront housing being popular almost everywhere in the world today, and being within easy reach of the city, Västra Hamnen has something of a head start in financial viability and excitement. The dwellings are expensive (between 1 and 4 million kronor — a quarter of a million to a million Australian dollars) and are selling well. Some of them are selling to commuters from Copenhagen just across the water and now easily accessible by train. When the entire dockland district is developed it will accommodate a larger proportion of affordable housing provided by the state and housing associations, but the strategy was to build the high income housing first. The seaward promenade and rocky beach has become a favourite resort for Malmö's citizens. Ten thousand visitors were recorded on a hot day in summer, not necessarily to the pleasure of the overlooking residents but adding to the social mix of the neighbourhood's users.

Västra Hamnen is supplied entirely by renewable sources of energy mostly generated on site (see Figure 5), and can therefore claim, like BedZed, to be a zero fossil fuel energy development. Warmth is extracted by heat pump from an underground aquifer and from the seawater, as well as being generated in large scale solar collectors (1400 m^2). Electricity for the neighbourhood is generated by a single wind turbine, in the North Harbour a kilometre away, and a limited array of photovoltaic cells (120 m^2). Biogas (mostly methane) from the city's waste is used to heat homes and power vehicles. In addition the homes in the district are subject to passive solar design principles and so minimise energy demands for heating. All the power sources on site are connected to the city's energy and district heating-cooling grid. The 100 per cent renewable energy equation is based on an annual cycle. At some periods the neighbourhood borrows from the city and at other times the reverse, arriving at a net zero fossil fuel balance.

Providing an integrated system of greenspace encouraging habitats for non-human species is part of the plan. A number of habitats are being created for different plant and animal species. Rabbits, a pest in Australia, are now at home in the neighbourhood's greenspace. A 'Green Points' list provides ideas about how construction companies and developers can help as many species as possible to become established in the district. Each apartment may have a bird nesting box. Frog biotopes are established where frogs can survive the winter and nesting boards for swallows have been set up on the sides of buildings. A large tree has been planted in each courtyard. This supports the microclimate until other trees and shrubs have grown up and become well established. A so-called green area factor guarantees that all courtyards are planted up with plenty of vegetation, on walls, roofs (sedum roofs as at BedZed) and in the courtyards. Rainwater and melted snow are collected in small pools and mini-channels. This is also a means of creating the special conditions for species of flora and fauna that depend on watery environments. There was a rich bird-life in the Bo01 area before building began. A comparable biotope is now being created in the harbour area of Malmö and an ecologist is employed to oversee the development of the site's biodiversity.

These developments do not just contain wish lists for environmental conservation. All of them have quantified targets and all are being carefully monitored to see that they achieve them.

Figure 4. Alternative energy sources built into the housing. Vacuum tube, high performance solar hot water heaters, Västra Hamnen, Malmö.

<u>Sustainable housing</u>
The following principles can be distilled from these examples which apply both to the design of new neighbourhoods and the refurbishment and retrofitting of existing urban areas:
1. Minimize the use of resources: the atmosphere, water, land, and rare or toxic materials. All housing should seek to become self-sufficient in renewable energy whether the 'self' be the house, the neighbourhood or the whole city district. The era of the national grid is passing.

2. Integrate housing with energy generation and saving, and a range of transport options.

3. Be responsive to the local environment, and integrate landscape into the plan for the neighbourhood; make open space useful and attractive, and acknowledge and cater for its non-human inhabitants.

4. Minimise the need for travel, and maximise low energy modes of transport (pedestrian, bike and public transport), to enable people to connect easily with the local neighbourhood and the wider city.

5. Allow people to enter, leave and move through the site easily. Keep space public and, as far as possible, occupied. Allow no privatised public space or 'gated communities'. In a word, design for 'permeability'.

6. Design public space for personal safety. This means that places where people walk should be open to view, overlooked and well occupied. Putting up gates on housing estates and surrounding them with walls is nothing more than a symbolic gesture. It does not provide safety; in fact 'gated communities' can become targets for burglars who treat the costly defences as an easy challenge.

7. Insist on affordability and inclusiveness. Housing of different price ranges may be developed, but housing should include everybody and be delivered to everybody whatever their budget, or physical capacities. This includes the special housing needs of the disabled, older people, immigrants and people of different cultures.

<u>Sustainable transport</u>

Urban transport is one of the fastest growing contributors to greenhouse emissions. Whereas greenhouse emissions in other industry sectors are stable or only slowly growing, emissions in the transport sector are increasing rapidly. One estimate for Australia has suggested that if current performance continues, by 2010 there will be a 67% increase in emissions in the transport sector above 1990, with by far the largest contribution coming from road use (Allen Consulting Group 2000:62). Additionally, transport systems based predominantly on roads have many other social, environmental and economic (opportunity) costs of a more local nature.

Transport networks in cities need to be used much more efficiently. On the one hand, roads are overused for journeys that could easily be made by other transport modes. On the other hand public transport systems, which can handle large scale people movement very efficiently, are underused.

Four things can be done to help:

1. Public transport in cities needs to be co-ordinated as a single network with a variety of modes each serving their optimum function. Australian cities are well equipped with heavy rail networks but these networks are poorly used

because the transport system is unco-ordinated. As far back as the Melbourne Transportation Study of 1969 recommendations were made to have rapid feeder bus routes deliver passengers to rail stations, with their timetables co-ordinated with those of the trains. Instead bus systems compete with rail systems for passengers. This is inefficient. The best practice public transport in Europe is now to have a single government authority plan timetables and routes. Private companies then bid to service the routes. This partnership means that the network is planned as a whole and therefore can achieve benefits of co-ordination, while private companies sensitive to customer demand provide the route services. This has been found to be the only way of getting people out of cars on to the public transport system. The result has been a higher level of public transport patronage overall, from which all stakeholders (including of course the private service operators), benefit.

2. Private transport must by co-ordinated with the public transport network and include mobility by walking and cycling. Fixed rail systems and bus terminals and stops need to be linked to pedestrian and cycle path networks. Cycle paths should be planned to serve the journey to work and appropriate facilities provided to shelter and secure bikes and assist their users. Substantial investment is needed to improve interchange facilities.

3. Federal and state governments need to shift spending on urban roads to urban public transport. Australian cities are well equipped with grids of arterial roads. The problem of congestion is caused largely by the use of cars, mostly containing a single occupant, for journeys to work. This picture appears to be confirmed by the recently published report *Driving Around Melbourne* prepared for VicRoads by Drummond Research (reported in *The Age*, Melbourne Oct 27th pp. 1 and 6). Private cars occupy much larger amounts of road space to transport a given number of people than buses, trams and trains. Public transport can also take better advantage of environmentally friendly fuels and by reducing vehicle-kilometres travelled increased public transport use can reduce greenhouse emissions.

4. Housing and transport need to be considered together. One option that the BedZed development hopes to offer is car pooling. Car pooling is a growing trend in European cities. An Edinburgh car pooling club estimates that one pool car can displace about five privately owned vehicles. The great incentive here is cost saving. A motorist travelling between 17,000 and 20,000 kms per year, it is estimated, can save up to $3600AUD (£1500) in motoring costs. The new suburb of Kronsberg is built around an environmentally responsible transport concept serving a compact community. A new tramline will connect Kronsberg and the EXPO site to the city centre. This tramline is designed to generate ribbon development along the track, physically connecting the new settlement with the old. No dwelling will be more than 600 metres from a tramstop. Residential density increases closer to the tramstops, and the streets are laid out so as to channel the heaviest traffic flow along service roads parallel to the tramline to minimise disruption by vehicles. From the main service road the district is covered by a network of minor streets. There will

be no through traffic and all vehicles will have to drive slowly (including 30 Kph zones). A specially constructed cycle path crosses the district from north to south. A finely branched network of footpaths is laid out through the quiet inner courtyards, offering safe play spaces for children.

In the California a new ‘transit development’ (‘The Crossings’) has been built adjacent to the CalTrain commuter rail station. A 1960s car-oriented shopping mall was redeveloped into a mixed use, pedestrian-oriented community neighbourhood consisting of small lot single family houses, townhouses, row houses and apartment units. The average density was 55 dwellings per hectare. The old shopping mall was recycled as rubble for the foundations of the houses. (Figure 5).

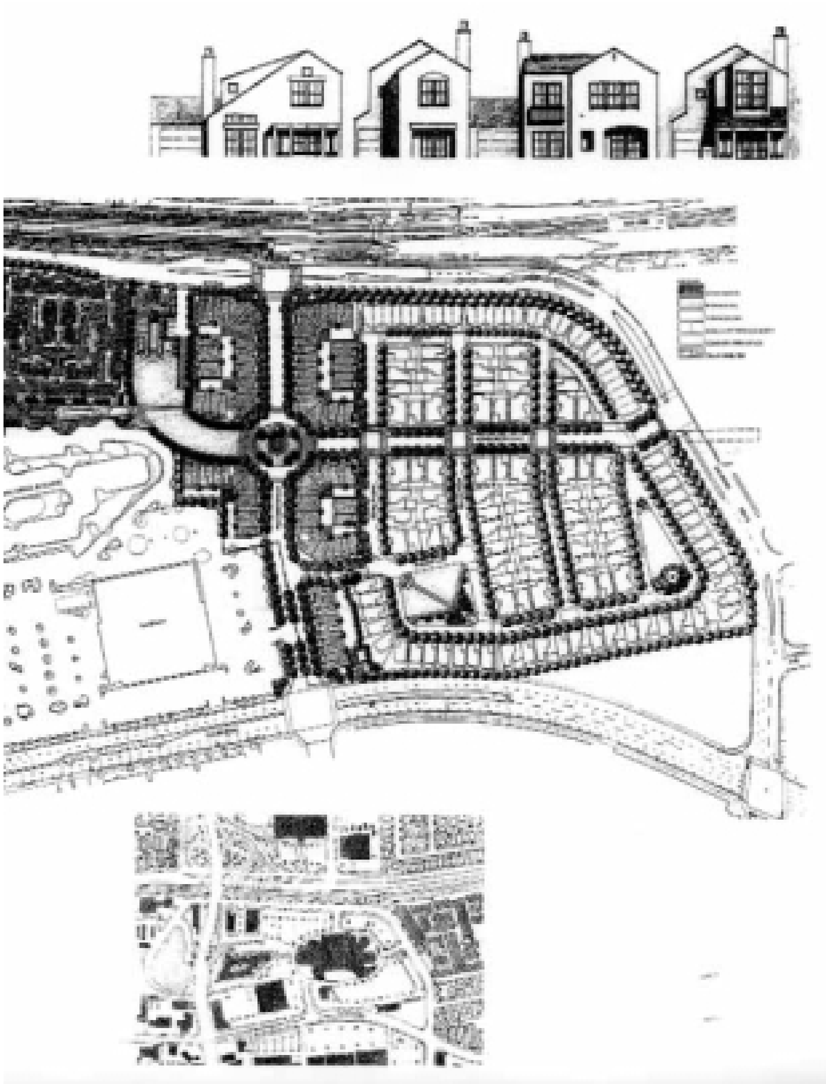

Figure 5 The Crossings: one of the best known ‘transit city’ developments in the USA

<u>The city on foot</u>

Travel on foot costs the environment almost nothing and mainly takes two forms: walking and riding a bicycle. In some cities of Japan (Kyoto for example) cyclists are kept off the roads and restricted to the footpaths. But, as anyone who has had to share a narrow footpath with numerous bikes well knows, cyclists and walkers do not mix comfortably and should be separated.

Transport planning in Australia, both in the amount of urban space and taxpayers' money allocated to facilitating the movement of vehicles on roads, places vehicle needs above human needs . This priority serves only the most repetitive and utilitarian forms of movement, leaving vast gaps in the whole human experience of travel. Reversing the customary order of priorities in favour of walking does not mean *artificially* privileging 'walking' over other 'modes of transport', but instead starting correctly with human activity and attending to human need.

As is evident at Västra Hamnen in Malmö, if it is essential, there is no reason why a particular bus route should 'make money' any more than the service road it runs on should 'make money'. In every society there is a necessary role for governments to provide collectively what individuals and businesses cannot provide for themselves. In fact the long run economic success of a city may depend on it.

The enormous commercial success of the pedestrian precincts created in the historic centres of many European cities is just such an example of collective investment. In these centres the utilitarian activity of shopping and work life has been turned into a varied, delightful and sociable experience. This is so not only for the many tourists who visit these centres from all over the world but also for the local people without whom the places would be dead.

In the 1960s the City of Birmingham in England, at the heart of Britain's motor industry, built a motorway box tightly around the central business district. The traffic managers tried to move traffic flowing to the city efficiently and quickly through the rather constricted streets of the central business district. The result by the 1980s was heavy air and noise pollution, peak hour traffic jams, and slow vehicle movement. Under these circumstances the historic nineteenth century core of the city with its splendid Victorian civic buildings could not flourish economically. Worse, however, the motorway box stopped the expansion of commercial development by cutting off the supply of land in the central area.

In the 1990s the City Council decided to turn most of the major streets into walking thoroughfares. A pedestrian priority crossing at street level was established across the motorway. Almost immediately the area on the other side of the motorway began to be redeveloped. Eventually Birmingham demolished part of the motorway to allow full pedestrian access to the Eastside. Most of the central core is now a single walking precinct (Figure 6).

Figure 6 The CBD of the city of Birmingham, UK. This was once a congested traffic infested main street.

Birmingham is a Victorian city like Melbourne supporting the arts and music. It will never be beautiful — it is primarily a city of business. But the city is making the best of its urban environment and people flock to work and shop there. New developments around the Bull Ring are further extending the pedestrian area and linking it with New Street railway station. In a Foreword to the 2003 ‘Locate in Birmingham’ brochure, architect Richard Rogers says ‘A well designed sustainable city will attract people back into its centre … A sustainable city is compact, polycentric, ecologically aware and based on walking’.

Montpellier in southern France is a very different sort of town from Birmingham. Its renaissance city centre occupies a plateau (‘L’Écusson: the escutcheon) rising above the surrounding town (Figure 7). All the streets surrounding the huge Place de la Comédie and the square itself are banned to vehicle traffic except for a tramline which connects the pedestrian centre to the suburbs and flows quietly among the walking traffic. The mixture of trams and walkers seems to be entirely safe and workable, as can also be seen in the pedestrian main shopping street of Zürich, the Bahnhofstrasse.

Figure 7 Montpellier’s modern tram system sweeps suburbanites right into the walking-based CBD quickly and frequently.

In Europe the creation of safe zones for walkers and cyclists began in the Netherlands with the *Woonerf* system where car access in residential streets is allowed but at very low speeds with physical restrictions. Copenhagen’s Strøget was one of the earliest pedestrian shopping streets, pushed through by a strong Mayor against massive opposition from retailers. The subsequent popular and commercial success of Strøget and other pioneering examples of walking streets (e.g. Cologne in Germany, York in the UK) encouraged many other European towns and cities to follow suit. The function of city centres changed from convenience shopping to comparison shopping and ‘shopping tourism’: a mixture of shopping, socialising, eating and drinking, strolling, and visiting art centres, concert halls, exhibitions and parks. From pedestrian streets European city planning moved on to ‘car-free’ city centres, as in Montpellier in France and Freiburg and Nuremberg in Germany. ‘Car free’ is a catchy term meaning not the complete banning of cars from the city but the careful management of traffic access with priority to people on foot.

The very success of pedestrian precincts means that traffic tends to increase around the perimeter. This does not help sustainability or the quality of the environment beyond the precinct. The ‘car-free’ city limits car access to residents, and to businesses within restricted hours, and encourages much other travel to the centre by public transport. This ‘area-wide access control’ has been introduced in Bologna and Florence in Italy and Lübeck and Aachen in Germany. in Europe a ‘car-free’ day has been instituted every year in September in which cities actively discourage residents and visitors from using the car and promote walking and cycling activities. Figure 8 shows the central area of Gothenberg in Sweden on car-free day 2003. Mixed access may sometimes be allowed with vehicles limited to walking speed and on-street parking banned. Access to business vehicles is allowed for deliveries at certain times. Alternatively footways and roads may be separated but the width of the footway greatly increased, and road traffic restricted to 20 kph or less. Pedestrian crossings can be provided where cars have to give way to walkers at all times without traffic light controls.

Figure 8 The City of Gothenberg in Sweden on European ‘car free’ day September 2003.

Planning for bicycle use requires a step up in spatial scale. Bikes have a comfortable range of 15 to 20 kilometres, so the green city needs a fully connected bicycle network that can provide separated bike access to destinations over a very large area. In Australia both Canberra and Melbourne, for example, have some good bike paths but in neither city are they planned as a network designed to connect homes and workplaces and co-ordinated with public transport. Melbourne's Yarra Trail is a beautiful off-road path but its purpose is primarily recreational and it meanders with the Yarra river. Canberra's sections of bike path frequently just end in a road without any form of bicycle priority.

The City of Copenhagen (population of the metropolitan region 1.5 million) has been developing a bicycle network since the late 1980s. Back in the '50s Copenhagen already had 200 kilometres of cycle track but the Danish tradition of cycling diminished in the '60s as cyclists found themselves in increasing danger on the roads from the growth of car traffic. Citizen pressure, however, put cycle tracks back on the political agenda, and the city has built a network of separate tracks with special treatment for cyclists at intersections . Today Copenhagen has more than 320 kilometres of cycle track, mostly alongside established roads but separated from them by kerbs. There are 43 kilometres of 'green' (off road) cycle tracks. One fifth of all journeys and one third of the journeys to work are made by bicycle – about the same as car journeys to work in Copenhagen. Cyclists ride over a million kilometres every day.

While these initiatives appear to be heading in the right direction from the point of view of sustainability, unlike the housing case there has been little or no evaluation of the actual effect of walking or cycling schemes in reducing car dependence or greenhouse emissions. There may be little effect at all if car parking and use is simply shifted elsewhere, for example if the same amount of car parking is provided but relocated to the periphery of pedestrian zones. Walking zones need to be linked effectively with a public transport network if they are to be effective in greenhouse abatement. Research which would quantify the effect of walking and cycling in different kinds of schemes in different cities (e.g. in vehicle kilometres travelled over time) is now urgently needed.

New partnerships

All of these examples show that we need to think of new ways of combining the virtues of government with those of the private sector, planning with the market, and partnering among traditionally segregated departments. For instance, before trying to combine land use and transport planning, it is first necessary to plan all modes of urban transport as single unified city-wide systems. Sustainable housing must be considered together with sustainable energy — that is non-fossil fuel consuming — and non-motorized transport.

Another submission to the parliamentary committee by Professor Andrew Blakers of the ANU has proposed that energy companies enter into partnerships with housing producers and finance companies to retrofit housing with insulation and solar hot water, and even photovoltaic arrays, adding the costs of borrowing to regular household energy bills. That is exactly the kind of synergistic partnership required. Governments should take the lead in developing such partnerships. Government agencies should also lead in developing cutting edge zero emission developments like those described above. There is good precedent in Australia in the pioneering work of Landcom NSW and VicUrban in Victoria. Further encouragement should be given to those public sector agencies with the expertise to develop zero emission housing.

But why is urban sustainability so important, not only to the environment but to the future economy? There are two interlocking reasons for change in the way cities are planned and developed: The peak of oil and human induced global warming.

The peak of oil

Dr Colin Campbell earned his doctorate in geology at Oxford University. In 1958 he joined the oil industry and worked as a field geologist. Ten years later he joined the head office of an oil company in New York, becoming the company's regional geologist for South America. Following two years as chief geologist in Ecuador, he was sent to Norway for ten years as exploration manager, and later became executive vice president. In the course of his work Campbell became aware of a worrying trend: less and less new oil was being discovered. He began to realise that the discovery of oil fields peaked around the 1960s and that the supply of oil would reach a plateau in the early years of the twenty first century and then gradually decline. He also realised that the world, especially the economic powerhouse of America, is failing to take note of this fact, and is in fact becoming more and more dependent on oil — especially for transporting people and goods.

Rising demand, not only from the USA and Europe but now also from the future mega-economies of China and India, combined with static or declining supply, can mean only one thing in an open market: rising price. Since cheap transport is a key factor in economic growth the result of a rising oil price will be to place a long lasting dampener on the whole global economy until transport and production systems adapt, that will have particularly pernicious effects on those cities and nations that fail to free their transport systems from oil dependence. Campbell therefore helped found the Association for the Study of the Peak of Oil (ASPO), a network of concerned scientists in which most European countries are represented and which acts as an advisor to European governments and the European Union. Its influence, however, has not reached North America and Australia.

The key premise is that no new oil is being created within the Earth. Disputing that premise is a bit like disputing evolution. Like 'creation science', faith is contradicted by evidence. The evidence overwhelmingly supports the theory that oil deposits, along with other fossil fuel such as natural gas and coal, were deposited on the Earth's surface and seabeds at periods of extreme global warming, the last two such periods being 145 and

90 million years ago. Oil volumes are still rather quaintly measured in barrels. The essential facts are that production was running at an annual rate of 23 gigabarrels (billion barrels) at the turn of the century, 850 gigabarrels had been produced up to that time, another 850 gigabarrels are held in 'proved and probable' oil reserves — in the language of oil production. What then remains to be found? Campbell argues that only another 150 gigabarrels are yet to be discovered. In total the world oil industry can produce no more than another 1000 gigabarrels.

The issue is somewhat clouded by three issues: the simple economics of oil search, the 'illusion' of technology and the politics of oil reporting. There is probably a lot more oil in the ground than will ever be extracted (perhaps another 1850 gigabarrels). That is because as oil becomes scarce it becomes more expensive to find. Oil in a known field, determined by geophysical mapping, does not lie in a convenient natural tank buried beneath the rocks. It lies in fissures and seams interlaced with a very large area of rocky matrix. Extracting the oil is rather like sticking a needle in a human body and hoping to find an artery but, whereas human bodies come in more or less standard forms and the arteries and veins are in much the same locations in all human bodies, each oil body is different and the location of the oil bearing 'arteries' cannot be exactly predicted. Drilling a bore is costly, and oil extraction is therefore limited by the number of non-productive bores that have to be made before an oil strike is made.

Oil companies want their investment in an oil field to maximise the financial return they get for the oil. When an oil company finds a prospect it is normal for it to announce an estimate of the oil volume in the 'reserve' on the basis of its initial programme for development of the prospect. These 'reserves' find their way into nationally reported statistics. But these initially reported reserves are subject to progressive modification as the company seeks to prolong the life of production from the prospect. As work proceeds, the reported reserve estimates are revised upwards. This increase is commonly attributed to advances in technology and managerial skill, whereas in reality it is no more than the increasing application of existing technology. The illusion is, however, created that advances in technology can increase the extraction of oil from reserves. Campbell writes: 'The industry has treated reserves from discovery as a form of inventory to be drawn down as best serves financial purposes. No conspiracy is implied: the practice was consistent with prudent management'[6]. Thus *reporting* of oil reserves should not be confused with the realistic, geologically based estimates of the actual *size* of oil reserves. No more than 40 per cent of the oil in a prospect can be commercially extracted. If companies routinely under-report oil reserves, several countries belonging to the powerful Organisation of Petroleum Exporting Countries (OPEC) have at times exaggerated their reserves in order to increase the production quota allowed to them by OPEC. None of this variety in reporting affects the real size of reserves that can be estimated by objective geological and statistical techniques.

About half the world's remaining oil reserves is situated in just five Middle East countries (Abu Dhabi, Iran, Iraq, Kuwait and Saudi Arabia). The price of oil is not controlled. It is determined by the behaviour of a large number of actors in the market buying and selling the commodity. And this behaviour is determined by perceptions. These perceptions in turn are influenced by beliefs about what will happen to the price in the future. If most of the world's oil is produced by just a few countries there is a much greater likelihood that those countries, through OPEC, will influence the oil price by imposing restrictions of supply — in order to maximise the returns from their oil and for a variety of geopolitical reasons.

This is what happened in 1974 and again in 1979 (in what became known as the 'oil shocks'). As a result of the nationalisation of oil production by the key Middle East countries, and the testing of their new power in 1974 and 1979, oil companies began opening up new oil provinces outside the Middle East. The Middle East countries took on a 'swing' role to make up the difference between world demand and what the rest of the world can produce within its resource constraints. The 'swing' share dropped from about 35 per cent in the 1970s to about 20 per cent in the 1980s and the oil price fell. But because of oil depletion outside the Middle East the swing share later rose to about 30 per cent in 2000 and now stands at about 35 per cent.

Colin Campbell, writing in 2000 (though published in 2003), predicted what was coming in Iraq two years before Gulf War 2: 'Iraq's oil will soon be desperately needed, and with the boot on the other foot, Iraq is unlikely to be sympathetic to Western demands, carrying risks that new pretexts may be found for Western military intervention'[7]. Iraq's oil once it begins flowing freely —if it does — will merely postpone for a few years the impending oil shortage and chronically rising prices.

Human induced global warming

Successive reports of the Intergovernmental Panel on Climate Change (IPCC) have reaffirmed the scientific conclusion that the atmosphere is warming and that the warming is caused by human activity (IPCC 2001). It is also becoming clear that Australia is highly susceptible to the effects of global warming.

The evidence for warming has thus become steadily firmer. But scientists are cautious people. The core of the IPCC work is directed at finding out whether the records of temperature observations confirm whether global warming is occurring or not, and whether the observations of the Earth's atmosphere correspond with what the theoretical models predict.

Now any scientific endeavour is attended by uncertainty. It is well known that the Earth has warmed and cooled naturally at intervals over its lifespan of billions of years. However, what is new and dangerous about the current phenomenon is the extraordinary speed with which the new warming seems to be happening. Over a million years, or even perhaps ten thousand, the Earth's inhabitants — plants and animals including humans — stand a chance of adapting to the changing climatic conditions. Though we humans are very adaptable creatures and can live in very hot or very cold climates, we are still dependent for food on the adaptability of the plants and animals in the ecosystems that support human life. There is little chance of adaptation if the change takes place over a few hundred years or less. The Earth's biosphere may itself adapt simply by shrugging off the cause of global warming: humans. For us, however, global warming means much more than a change in the weather. Failure to adapt our economy to reduce global warming will bring death and misery on a scale never seen before in human history.

While much of the debate over global warming has been about observations, a different way of looking at the matter, which is perhaps not so well known, brings the problem into sharper focus. The Earth sustains what is called the 'carbon cycle' in which carbon in the form of gas is transferred between places where carbon is stored. Such places are the atmosphere which contains carbon dioxide gas, the land biosphere — the Earth's cover of vegetation on land which contains solid carbon in plant and animal matter, and the oceans which contain both plant and animal matter and dissolved carbon dioxide. These are the main storages of carbon, 'carbon pools' or 'carbon sinks'.

An exchange of carbon is continually occurring among these carbon pools, and over the billions of years of the Earth's existence a rather fine balance developed so that the flow of carbon into the atmosphere has been approximately equalled by its reabsorbtion by the other carbon pools: the ocean and land biosphere. In fact the balance is tilted slightly in favour of absorbtion of gas from the atmosphere by the other pools. Thus in a study of the period 1980-1989 the surface layer of the ocean each year absorbed about 92 gigatonnes of carbon (billion tonnes) and gave up about 90 gigatonnes into the atmosphere. The land biosphere absorbed about 61.4 gigatonnes from the atmosphere and gave up about 60 gigatonnes into the atmosphere. There was also an exchange of carbon between the deep ocean and the surface layer, But here the surface ocean absorbed 100 gigatonnes from the deep and sent back 91.6[8].

Into this system intrudes human activity. According to the International Energy Agency emissions of carbon dioxide from the burning of fossil fuels sent 6.14 gigatonnes of carbon dioxide into the atmosphere in 1999 (with zero in return to the source since power stations do not absorb any greenhouse gas!). Changing land use, including land clearing, sent another 1.1 extra gigatonnes net into the atmosphere. It is very clear that the major factor responsible for upsetting the existing balance is the emission of carbon dioxide, most of it coming, directly or indirectly, from the growth of cities. Given what is known and agreed by scientists about the effect of carbon dioxide and other greenhouse gases in the atmosphere, it is becoming absurd to argue that global warming is not being caused by human activity.

It is not just people that produce greenhouse gas but the production of commodities and services including travel: in short fossil-fuelled economic growth. But of course economic growth can occur with more or less greenhouse gas emissions. We need to know how much greenhouse gas is emitted per dollar of growth, and how that is changing over time. Is the world emitting less greenhouse gas in the drive for growth, or more? Is the rate of economic growth itself outstripping any improvements in greenhouse emissions per dollar?

The IPCC has developed forty scenarios containing a number of different assumptions about world economic growth. They are wildly varying, but all of them indicate that, unless the world takes immediate action, emission levels are going to grow to dangerous levels in the next fifty years. Depending on the scenario, the level of global greenhouse emissions by 2050 is predicted to be between 9 gigatonnes per year and 27 gigatonnes per year. The former, the most optimistic, is dependent on full adoption of the Kyoto protocol and continuous progress beyond Kyoto to reduce greenhouse emissions. The latter, a business as usual scenario, is today far more probable.

To stabilise the balance in the global climate system the atmosphere must retain the capacity each year to absorb some of the carbon already deposited there by industrial growth over the last hundred years. Fortunately in this respect we have nature on our side. Climatologists of the IPCC tell us that the world has to get its greenhouse emissions down to about 2 gigatonnes per year within fifty years. This figure is now accepted by the Royal Commission on Environmental Pollution in the UK and by Dr Graeme Pearman, the chief atmospheric scientist of the CSIRO. By contrast all credible scenarios suggest that in fifty years time the world will be emitting between 9 and 27 gigatonnes and maybe much more. Even the lower, optimistic figure, when compared with the total global exchange between the atmosphere and the surface of the planet of about 150 gigatonnes, represents an enormous disturbance of the carbon cycle. Therefore, given what we know today about the greenhouse effect and the climate system, it is highly improbable that a disturbance of such a scale would NOT cause a global climate catastrophe. If such a catastrophe is to be averted, action to meet the real target, a 60 to 70 per cent reduction in emissions (from the 2003 figure) over fifty years, must begin immediately.

Notes

[1] Michael Mobbs (1998) *Sustainable House*, Marrickville, Australia: Choice Books.

[2] Susan Roaf, Manuel Fuentes and Stephanie Thomas (2003) *Ecohouse 2, A Design Guide*, London: Architectural Press.

[3] *Beddington Zero Energy Development* (2003) London: Bioregional Development Group, 24 Helios Road, Wallington, Surrey SM6 7BZ England email: info@bioregional.com

[4] *Hannover Kronsberg, Model for a Sustainable Urban Community* (2002) City of Hannover, Germany.

[5] See *Västra Hamnen, The Bo01-area, A City for People and the Environment* (2003) City of Malmö, (available in English from The City of Malmö Urban Planning and Architecture Office 205 80 Malmö, Sweden) email: ekostaden@malmo.se

[6] Colin Campbell 'The Peak of Oil, Economic and Political Turning Point for The World' chapter 3 in *Making Urban Transport Sustainable*, (N.Low and B. Gleeson editors, Basingstoke UK, Palgrave-Macmillan, 2003) p. 47

[7] Colin Campbell 'The Peak of Oil, Economic and Political Turning Point for The World' chapter 3 in *Making Urban Transport Sustainable,* (N.Low and B. Gleeson editors, Basingstoke UK, Palgrave-Macmillan, 2003) p. 58

[8] J.T.Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A Kattenberg and K. Maskell eds (1996) *Climate Change 1995, The Science of Climate Change,* Cambridge UK: Cambridge University Press (from notes compiled by Professor Ian Simmonds, School of Earth Sciences, The University of Melbourne)