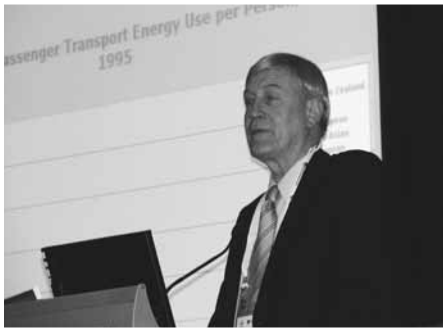
Clean, green cities beckon…

P. Newman



ABSTRACT

Clean, green cities have been the agenda of the Clean Air Movement for over a century. This paper picks up on the imminent demise of the Internal Combustion Engine (ICE) automobile and suggests how much cleaner and greener cities can emerge as we build them around (1) revitalised electric transit with accompanying focussed land use, (2) new plug-in electric vehicles associated with smart grids and local renewables, (3) natural gas and biofuels for industry, freight and regional transport especially in agriculture and remote settlements, (4) telepresence, high speed rail and airships for longer distance linkages. This vision for change is seen as being an essential part of the next technological era and early signs beckon us towards its rapid emergence.

Keywords: clean, electric, green cities,natural gas, transport,

INTRODUCTION

The Challenge
The clean air movement has driven a lot of the change in transport policy over recent decades but now is somewhat less dominant in public policy due to the climate change and peak oil issues. These of course are part of an overall challenge where the three issues are complementary and synergistic. The clean, green cities of the future will have solved the three problems – clean air, energy security and carbon neutral fuels.

The New Era
The period from the 1930s to 2008 was the era of cities based on the ICE. The Global Financial Crisis (GFC) of 2008 and the issues of peak oil and climate change seem to have ended the domination of this technology though it will take some time for it to phase out. This technological era has been the focus of the recent Clean Air movement, just as it was coal burning that was the focus in the previous technological era. The limitations of the ICE technology have exercised the minds of many technologists and regulators who have struggled to make cleaner and greener cities. Now we are faced by the astonishing phenomena of a nationalised General Motors and reducing car use over the past five years in the US and a $2 billion rescue package for the used car industry in Australia.

My reading of the trends in technology, global climate change governance, peak oil, city planning, urban economics and urban cultural change suggest that we have at this point in history a convergence towards a new kind of city building based around renewables and electric transport. It promises to create much cleaner and greener cities than could have been imagined before (Newman *et al.* 2009). This paper will outline how I see this unfolding.

THE HISTORICAL OPPORTUNITY

At each point in industrial history the different waves of innovation have shaped our cities. In Figure 1 the waves of innovation as set out by Hargraves and Smith (2005) can be seen to rise and then fall with a major economic downturn punctuating each of the industrial phases. My interest has been in how transport changes the nature of cities and hence facilitates these economic eras (Newman and Kenworthy 1999). It can help us to see how the history of cities and the future of cities can be explained and indicate the emergence of the next era of clean, green cities.

Early industrial innovation began in the old walking cities which were linked by water transport and began using water power to make industrial products. The limits to this began to be obvious in space and materials. Thus the next phase of innovation, which arose from the global economic downturn of the 1840s, saw the arrival of the steam engine and railway. Cities began to spread out along the rail tracks and to build much bigger production based on steam power and steel. Then in the 1890s the incredible pollution of living on top of steam boilers and their coal-based air pollution collapsed into a global depression from which came the amazing innovation of electricity. This enabled electric trams and electric trains to spread the city along corridors and the production systems to be separate from their power source – as well as the delights of lighting a city. They increased coal-fired power enormously with growing consequences. By the 1930s these cities were reaching their limits and a new era was created around the automobile, cheap oil and highways, which enabled cities to spread in every direction and much further out. This was the era that the modern Clean Air movement has attempted to modify and regulate the ICE so that cities could breathe. The older dirty industries still needed a bit of help also but it has been the ICE that has taken the main focus of attention.

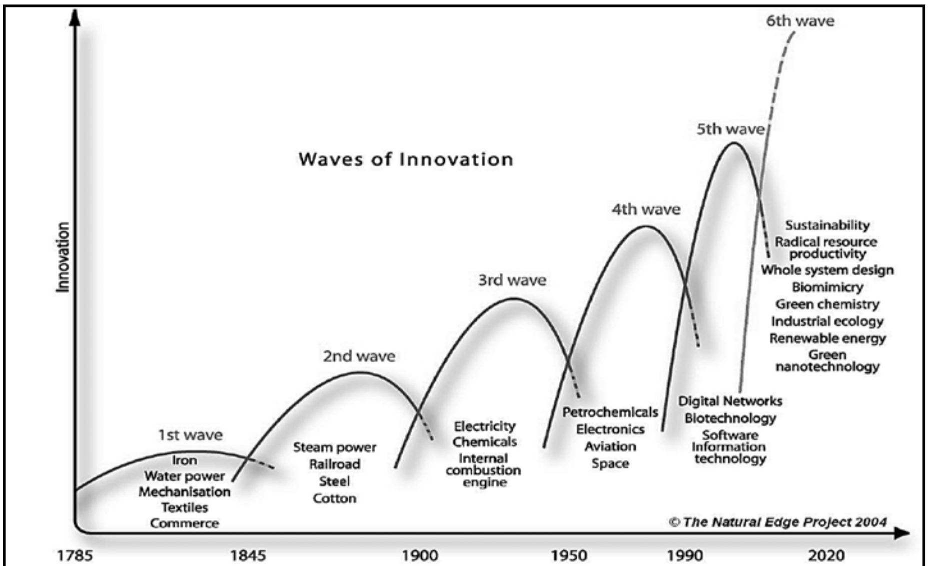


Figure 1. The waves of economic innovation showing the booms and busts related to how cities have adopted technologies and built themselves around these (Hargraves and Smith 2005).

SO WHAT COMES NEXT?

The limit of peak oil, of fossil fuels in general due to climate change and the limit due to cities sprawling beyond their viable distance, is now apparent. Climate change governance is requiring plans be implemented to reduce greenhouse gases 80% by 2050, which has undermined most long term planning based on the fourth wave economy. Peak oil happened in 2008 (at least for conventional oil sources) when oil prices tripled and the areas where cities had spread or indeed scattered beyond normal commuting times simply crashed as they had no local services, no local jobs and no public transport. The sub-prime mortgage meltdown was the financial mechanism but it was obviously based in some areas much more than others – those with the greatest car dependence. Many of these suburbs are now abandoned and the Obama administration is even contemplating bulldozing some urban areas that are beyond any conceivable urban need. Added to this are the signs of decreasing car use, increasing transit, increasing density and no further urban highway building (which are expanded below). It seems like an era is ending (expanded in Newman *et al.* 2009).

The next phase in the innovation waves according to Hargraves and Smith (2005) in Figure 1 is a combination of the digital economy and the sustainability economy. I believe it is a combination as the sustainability innovations all require the benefits of ICT, which are now enabling these technologies to flourish. In terms of transport it seems that the main innovations are electric transit and electric vehicles based on renewable energy. What are these and what will they mean for our cities, especially the need for cleaner air?

I believe we will see a combination of the following technologies shaping our transport and from that our cities:

1. New generation electric transit systems and their associated TOD, POD and GOD structures.
2. Renewable energy-based electric vehicles linked through Smart Grids.
3. Natural gas and biofuels in industry, freight and regional transport, especially agriculture and remote settlements.
4. Telepresence, high speed rail and airships for long distance linkages.

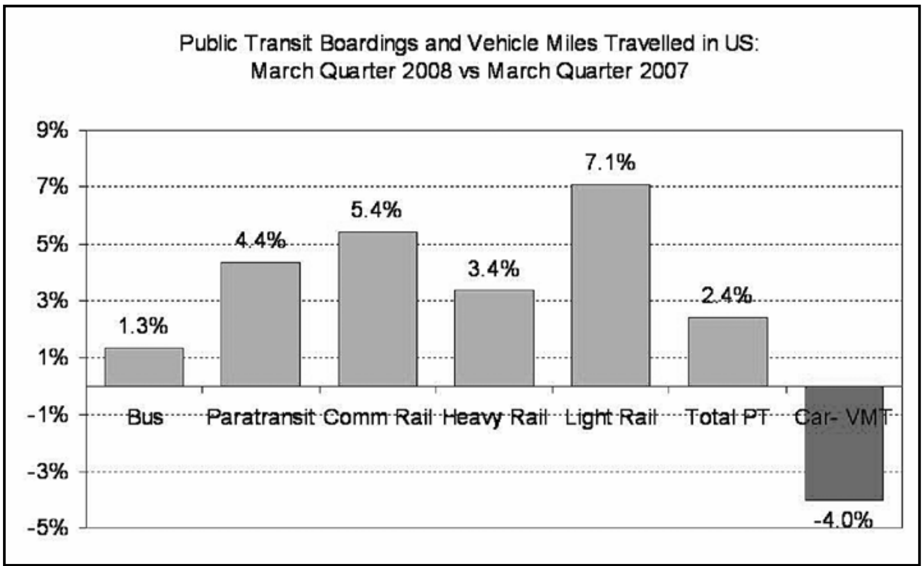


Figure 2. Recent performance in public transport and car use in the US (Puentes and Tomer 2009).

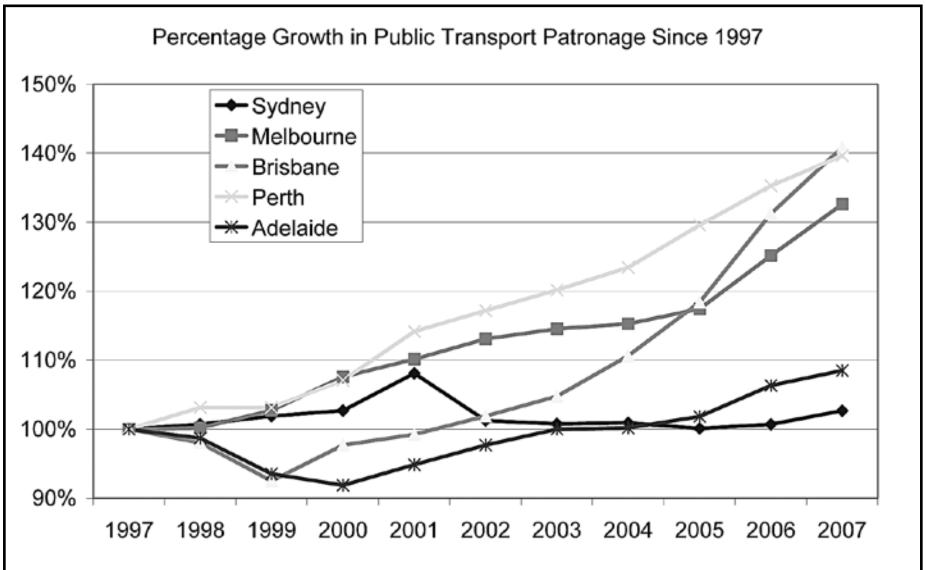


Figure 3: Recent trends in public transport in Australian cities (Glazebrook 2009).

NEW GENERATION ELECTRIC TRANSIT SYSTEMS AND THEIR ASSOCIATED TOD, POD AND GOD STRUCTURES

Around the world there is a dramatic revival of electric public transport systems and their associated centres. This section will show how electric transit based on renewable energy (once carbon constraints kick in) can bring about dramatic reductions in car use and their associated emissions.

This is a correction to the total automobile dominance in the past decades of planning and city building because it is socially and economically as well as environmentally limited. Car based city building has not created the interactive, walkable city centres that are needed for the service-oriented knowledge economy. It has created shopping centres and dormitory suburbs. As traditional centres have retained and grown with these jobs they have also attracted residential development for those wanting this more urban lifestyle. Now the need for these centres has shifted to the middle and outer suburbs and the mechanism for doing this seems to be based around good rail systems that can attract development around them – transit oriented development (TOD).
As outlined below these also need to be Pedestrian-Oriented Development (POD) and Green-Oriented Development (GOD).

Data on the growth in American city transit systems (and the decline in car use) is set out in Figure 2 and the dramatic growth in transit in Australian cities is set out in Figure 3.

When cities provide a combination of transportation and land use options that are favourable for green modes, and offer time savings compared to car travel, then the switch to transit is inevitable. This means wherever transit is reasonably competitive with traffic in major corridors, then people will use it. Those cities where transit is relatively fast are those with a reasonable level of support for it (Kenworthy and Laube 2001). The reason is simple – they can save time. Perth began this transition to modern fast rail first in Australia and its successful model has now become the basis for rail growth in each of the other Australian cities, especially given the new Federal Government funds from Infrastructure Australia, 56% of which went on urban rail (Commonwealth of Australia 2009).

With fast rail systems, the best European and Asian cities with the highest ratio of transit to traffic speeds have achieved a transit option that is faster than the car down the main city corridor. Rail systems are faster in every city in our 84- city sample by 10-20km per hour (kph) over bus systems, as buses rarely average over 20-25 kph (Kenworthy *et al.* 1999). Busways with a designated lane can be quicker than traffic in car-saturated cities, but in lower density car-dependent cities it is important to use the extra speed of rail to establish an advantage over cars in traffic. This is one of the key reasons why railways are being built in over a hundred US cities that shut down high quality rail in the beginning of the Fourth Wave and are now regretting their unbalanced transport systems.

Rail has a density-inducing effect around stations, which can help to provide the focused centres so critical to overcoming car dependence. Thus transformative change of the kind that is needed to rebuild car-dependent cities comes from new electric rail systems as they provide a faster option than cars and can help build transit-oriented centres.

We need to stop increasing road capacity and provide major increases in transit capacity if we are going to help this transition to a clean, green city and its associated economy. This is not easy given the funding systems that have developed around the car and truck. However evidence from the US shows that car use is beginning to spiral downwards and last year had its biggest drop for 50 years at 4.3% per year; transit use increased 6.5% also a record (Puentes and Tomer 2009). The transition process seems to be underway with urban freeway building almost stopped in US cities.

How much is it possible to change our cities? It is possible to imagine an exponential decline in car use in our cities that could lead to 50% less passenger kms driven in cars? The key mechanism is a quantitative leap in the quality of public transport whilst fuel prices continue to climb, accompanied by an associated change in land use patterns.

Figure 4 shows the relationship between car passenger kms and public transport passenger kms from the Global Cities Database (Kenworthy and Laube 2001). The most important thing about this relationship is that *as the use of public transport increases linearly the car passenger kms decrease exponentially.* This is due to a phenomenon called Transit Leverage whereby one passenger km of transit use replaces between 3 and 7 passenger kms in a car due to more direct travel (especially in trains), trip chaining (doing various other things like shopping or service visits associated with a commute), giving up one car in a household (a common occurrence that reduces many solo trips) and eventually changes in where people live as they prefer to live or work nearer transit (Newman and Kenworthy 1999).

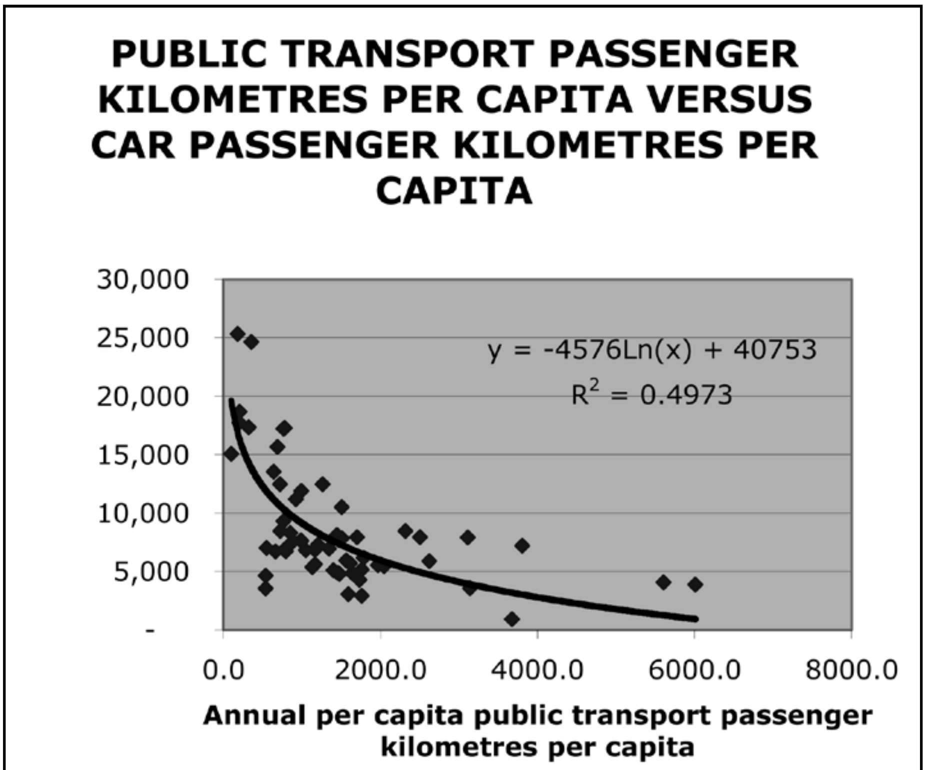


Figure 4: Car travel vs. Public transport use in global cities, 1995 (Kenworthy and Laube 2001).

Table 1. Car and public transport use per capita in four Australian cities, 1996 (Kenworthy and Laube 2001)

City	Private transport use (passenger kms/ person)	Public transport use (passenger kms/ person)	Percentage of public transport as a share of total transport
Sydney	10,506	1509	12.6%
Melbourne	11,918	994	7.7%
Brisbane	12,487	720	5.5%
Perth	13,546	642	4.5%

The data on private transport use and public transport use in selected Australian cities for 1996 is given in Table 1 (passenger kilometres per capita in each case).

The values in Figure 4 compared to Table 1 show Australian cities are somewhat down the curve from the very high US cities, which have almost no transit (some around the 100 to 200 passenger kms per person) and very high private transport use of over 15,000 passenger kms per person.

The data show that the highest Australian city, Sydney, had 12.6% of its total motorised passenger kms on transit and that the lowest was Perth with 4.5% (this was before the remarkable increase in patronage associated with Perth’s rail revival).

If Sydney doubled its transit use to 3018 passenger kms per person it would from Figure 4 have a per capita private transport use of 4088 passenger kms per capita, a 61% reduction in car passenger kms per person over the 1996 figure. If Perth was able to continue the rapid growth in transit patronage and triple its 1996 use to around 2000 passenger kms per person then it would reduce its private transport use per capita to 6000 car passenger kms per capita, which is a reduction of 56% over the 1996 level. Similar calculations can be done for the other Australian cities. Indeed it is feasible that each city could set a target of increases in passenger kms per capita for public transport in order to achieve certain target reductions in car use as part of their commitment to reaching the national goal of 80% reduction in greenhouse gases by 2050.

The biggest challenge in an age of radical resource efficiency requirements will be finding a way to build fast rail systems back into scattered car-dependent suburban areas. The solution may well be provided by Perth that has built fast rail systems down freeways deep into car-dependent suburbs that were really hurting in the recent fuel price hike. Freeways are public facilities that may well be in decline in the future as car traffic faces the double whammy of increasing fuel prices due to peak oil and carbon taxes due to climate change. To build fast electric rail down the middle of these roads is easier than anywhere else as the right of way is there and engineering in terms of gradients and bridges is compatible. They are not ideal in terms of ability to build Transit-Oriented developments (TOD) but it can still be done using high-rise buildings as sound walls. Linkages from buses, electric bikes, and park and ride are all easily provided so that local travel to the system is short and convenient. The key is the speed of the transit system and in Perth the new Southern Railway has a maximum speed of 130 kph (80 mph) and an average speed of 90 kph (55 mph) that is at least 30% faster than traffic. The result is dramatic increases in patronage far beyond the expectations of planners who see such suburbs as too low in density to deserve a rail system. The Southern Suburbs Rail line opened in December 2007 and is now carrying 55,000 people a day where the bus system carried just 14,000 (data from Public Transport Authority). There is little else that can compete with this kind of option for creating a future in the car-dependent suburbs of many cities.

Fast electric rail services are not cheap. However, they cost about the same per mile as most freeways and we have been able to find massive funding sources for these in the past 50 years. In the transition period it will require some creativity as the systems for funding rail are not as straightforward. In Perth the state government was able to find all the funds from Treasury due to a mining boom and was even able to pay off the entire rail system, including the new Southern Railway even before it was opened. But for most cities this is not possible. Infrastructure Australia has stepped into the breach and provided $4.6 billion in Federal Government funding for urban rail systems – mostly in Melbourne, Adelaide and Gold Coast but planning studies indicate that Sydney and Brisbane will also build in a doubling of rail capacity to enable their cities to go down this transition. This is an historic commitment as Federal funds have only gone to roads in recent decades (Laird *et al.* 2001).

The funding solution will also need cities to find innovative partnership solutions such as financing transit through the use of taxes or direct payments from land development as in Copenhagen's new rail system or through a congestion tax as in London. Funding of transit in congested cities can occur as it has in Hong Kong and Tokyo, where the intensive requirements around stations means that the transit can be funded almost entirely from land redevelopment. In poorer cities the use of development funds for mass transit can increasingly be justified through the transformation of their urban economy. Peak oil and climate change will increasingly be part of that rationale (Cervero 2008).

The facilitation of TODs has been recognised by all Australian cities and many American cities in their metropolitan strategies, which have developed policies to reduce car dependence through centres along corridors of quality transit (Curtis *et al.* 2009). The major need for TODs is not in the inner areas as these have many from previous eras of transit building. However, the newer outlying suburbs, built in the past four or five decades, are heavily car-dependent with high fuel consumption and almost no TOD options available. There are real equity issues here as the poor increasingly are trapped on the fringe with high expenditures on transport. A 2008 study by the Center for Transit Oriented Development shows that people in TODs drive 50% less than those in conventional suburbs (CTODRA 2004). In both Australia and the USA, homes that are located in TODs are holding their value the best or appreciated the fastest under the pressure of rising fuel prices. The report suggested that TODs would appreciate fastest in up-markets and hold value better in down markets. This is the rationale for how TODs can be built as PPPs in rail projects (Blake Dawson 2008).

Thus TODs are an essential policy for responding to peak oil, especially when they incorporate affordable housing. The economics of this approach have been assessed by the Center for Transit Oriented Development and the NGO Reconnecting America (CTODRA 2004). In a detailed survey across several states these NGOs assessed that the market for people wanting to live within half a mile of a TOD was 14.6 million households. This is more than double the number who currently live in TODs. The market is based on the fact that those living in TODs now (who were found to be smaller households, the same age and the same income on average as those not in a TOD) save some 20% of their household income by not having to own so many cars – those in TODs owned 0.9 cars per household compared to 1.6 outside. This freed up on average $4,000 to $5,000 per year. In Australia a similar calculation showed this would save some $750,000 in superannuation over a lifetime. Most importantly, this extra income is spent locally on urban services, which means the TOD approach is a local economic development mechanism (Dittmar and Ohland 2004).

TODs must also be PODs, that is pedestrian-oriented development, or they lose, their key quality as a car-free environment where businesses and households are attracted. This is not automatic but requires the close attention of urban designers. Jan Gehl's transformations of central areas such as Copenhagen and Melbourne are showing the principles of how to improve TOD spaces so they are more walkable, economically viable, socially attractive and environmentally significant (Gehl 1987; Gehl and Gemzoe 2000; Gehl *et al.* 2006). It will be important for those green developers wanting to claim credibility that scattered urban developments, no matter how green in their buildings and renewable infrastructure, will be seen as failures in a post peak-oil world unless they are building pedestrian-friendly TODs.

At the same time TODs that have been well designed as PODs will also need to be GODs – green-oriented developments. TODs will need to ensure that they have full solar orientation, are renewably powered with Smart Grids, have water-sensitive design, use recycled and low impact materials, and use innovations like green roofs.

Perhaps the best example of a TOD-POD-GOD is the redevelopment of Kogarah Town Square in Sydney. This inner city development is built upon a large City Council car park adjacent to the main train station where there was a collection of poorly performing businesses adjacent. The site is now a thriving mixed-use development consisting of 194 residences, 50,000 square feet of office and retail space and 35,000 square feet of community space including a public library and town square. The buildings are oriented for maximum use of the sun with solar shelves on each window (enabling shade in summer and deeper penetration of light into each room), photovoltaic (PV) collectors are on the roofs, all rain water is collected in an underground tank to be reused in toilet flushing and irrigation of the gardens, recycled and low impact materials were used in construction, and all residents, workers and visitors to the site have a short walk to the train station (hence reduced parking requirements enabled better and more productive use of the site). Compared to a conventional development, the Kogarah Town Square saves 42% of the water and 385 tonnes of GHG – this does not include transport oil savings that are hard to estimate but are likely to be even more substantial (City of Kogarah 2009).

While the demand for TODs is growing, creating TODs can still present significant challenges given the complexity of financing TODs and the number of private and public actors involved. TODs are in great demand, which often results in housing priced out of the range of middle and lower-income households. Thus, along with the other green requirements for TODs there needs to be a requirement of a certain proportion of affordable housing. In Perth the 20 or so TODs being planned have been suggested to be progressed via a new TOD zoning that requires minimal amounts of parking, maximizes density and mix, includes green innovations and has a minimum of 15% affordable housing to be purchased by social housing providers.

The potential gains in economic and social benefit from TOD, POD, GOD urban development will drive the necessary transition to a substantial reduction in car use and increase in sustainable modes of transport. The gains for the environment will be obvious and indeed will lead to a much cleaner and greener city.

RENEWABLE ENERGY-BASED ELECTRIC VEHICLES LINKED THROUGH SMART GRIDS

Even if we manage to reduce car use by 50% as suggested above, by a rather herculean effort, we still have to reduce the oil and carbon in the other 50% of vehicles being used. The question should therefore be asked: what is the next best transport technology for motor vehicles? The growing consensus seems to be: plug-in electric vehicles (PEV). Plug-in electric vehicles are now viable alternatives due to the new batteries such as Lithium Ion, and with hybrid engines for extra flexibility they are likely to be attractive to the market in the transition period as electric recharging infrastructure builds up. The key issue for clean, green cities, is that plug-in electric vehicles not only reduce oil vulnerability but they are becoming a critical component in how renewable energy will become an important part of a city's electricity grid. The PEVs will do this by enabling renewables to have a storage function through vehicle-to-grid (V2G) linkages within a smart grid. Thus electric vehicles are becoming an essential part of how a city can become clean and green (Went *et al.* 2008 and www.sustainability.curtin.edu.au/renewabletransport).

After electric vehicles are recharged at night they can be a part of the peak power provision next day when they are not being used (around 90% of the time) but are plugged in. Peak power is the expensive part of an electricity system and suddenly renewables is offering the best and most reliable option. Hence the clean, green city of the future is likely to have a significant integration between renewables and electric vehicles through a smart grid. Thus electric buses, electric bikes, scooters and gophers, and electric cars have an important role in the future resilient city – both in helping to make its buildings renewably powered and in removing the need for oil in transport (Simpson 2009).

Electric rail can also be powered from the sun either through the grid powering the overhead wires or in the form of new light rail (with these new Li-Ion batteries) that could be built down highways into new suburbs without requiring overhead wires. The first example of this technology is now running in Bordeaux and the next generation Light Rail is likely to be battery-based with electric power through high-powered contactless charging at stations. These will work better if the stations are green developments with renewable power built into their fabric and available for quick recharging services to trains and to PEVs that can also help in local storage of power.

Signs that this transition to electric transport is underway are appearing in demonstration projects such as in Boulder and Austin, in Google's 1.6 MW solar campus in California (with 100 PEVs) and by the fact that oil companies are acquiring electric utilities. The Obama and Rudd stimulus packages contain support for the technology of smart grids, renewables and EVs.

What sort of immediate impact could there be? According to one study the integration of hybrid EV cars with the electric power grid could reduce gasoline consumption by 85 billion gallons per year. That's equal to:

- 27% reduction in total US greenhouse gases.
- 52% reduction in oil imports.
- $270 billion not spent on gasoline (Kinter-Meyer et al. 2007).

Al Gore has called the smart grid/renewables/EV transition the 'moonshot' as it has the potential to enable 100% renewables in a decade (Gore 2008). The Obama stimulus package included $11b for smart grids, $6b for renewables and $2b for PEVs with $7500 tax rebate for anyone who purchases an electric vehicle. Similar packages are being developed in Australia but no rebate is yet on the agenda.

The real test of a clean, green city will be how it can simultaneously be reducing its global greenhouse and oil impact through these new technologies whilst reducing the need to travel by car through the policies outlined in the first strategy on transit and TODs.

NATURAL GAS AND BIOFUELS IN INDUSTRY, FREIGHT AND REGIONAL TRANSPORT

What do you do with freight transport and regional transport outside of cities where electric grids are not so easily used with vehicles? And what about industries that presently use natural gas? Can they also go carbon-free?

There will almost certainly be a reduction in the amount of freight moving around as fuel prices eat into the transport economics of consumption. Containers will be reduced as their fuel costs move from being 10-15% to over 50%. Food miles will start to mean something to food prices when the cost of fuel triples. But trucks and trains and regional transport will still go on.

The transitional stage for larger vehicles, industry and regional transport would appear to be to switch to greater use of natural gas and biofuels. Trucks and trains and fishing boats can use CNG (compressed natural gas) or LNG (liquefied natural gas) in their diesel engines (with pay-off times of just a few years due to high diesel costs). Cars for regional transport can also be switched over as well (particularly if the manufacturer makes them standard as occurred in Sweden when the government committed to natural gas cars for their vehicle fleet). The attraction is that natural gas is already in place in terms of infrastructure with almost 80% of the population having access to reticulated natural gas.

Global natural gas production has had similar estimates on its peak as oil production and they range from 2010 to 2030 with a little less certainty than oil. The peak in discoveries occurred in the late 1960s to early 1970s so the same pattern as oil seems to be evident. It is not surprising that oil and natural gas patterns are parallel as they have similar geological origins in marine sediment (unlike coal which comes from ancient forests). In addition, oil and natural gas prices are closely linked so as oil goes up in price the same occurs for natural gas. Natural gas in reality can only be a small part of the transitional arrangements for oil; it cannot be seen as the long-term replacement as it is also peaking. It will however be an obvious way to ease the pressure on diesel supplies and this will be a great advantage to the clean air movement as well; gas buses have already shown their big advantages over diesel buses in air quality. Natural gas as presently constituted will need to be eventually phased out as part of our response to climate change.

The benefit of the transition to natural gas has always been seen as an enabler of the long-term transition to hydrogen. However if there can be a development of the hydrogenation of CO_2 using renewable energy, then natural gas can become a renewable fuel in itself which can be fed into the present natural gas grids and even be an export item through LNG (Creutz and Fujita 2001). There is large potential in this process, considerably more than clean coal as a totally new infrastructure will not be required for its distribution. Thus natural gas can be given a long-term future and can be part of the clean, green transition. Hence freight, industry and regional transport are likely to continue to expand into natural gas and transition into the use of renewable natural gas.

Biofuels have promised a lot but since they began being delivered they have become rather tarnished due to their impact on food prices when used to convert fuel from grain, and when some estimates suggested they may be worse than oil when it comes to climate change. However they still have a potentially significant role in some areas where there is surplus sugar for example, and eventually when the technology improves to make them from cellulose materials (agricultural and forestry waste) and from blue green algae. It is likely that biofuels will be used as a do-it-yourself fuel on farms (Mastny 2006). Thus biofuels may have a role in agricultural regions as a fuel to assist farmers in their production but as a widespread fuel for cities it is not an option that can be yet taken seriously.

TELEPRESENCE, HIGH SPEED RAIL AND AIRSHIPS

Transport to meet people by long distance or even short distance trips within cities may not be needed once the use of broadband-based telepresence begins to make high quality imaging feasible on a large scale. There will always be a need to meet face-to-face in creative meetings in cities, but for many routine meetings the role of computer-based meetings will rapidly take off.

Aircraft are not going to easily cope with the rapid rise in fuel price from the peak oil and carbon pricing double whammy. At the height of the 2008 fuel crisis there was panic amongst airlines as the price of fuel went to more than 50% of the price of a ticket (Demerjian 2008; McCartney 2008). Gilbert and Perl (2007) suggest a few ways that air travel will adapt but mostly they see little potential other than regional high-speed rail and a return to ship travel.

Perhaps the technology that could make a come-back is airships. These are able to fly at low levels at speeds of 150–200 kph and carry large loads with one tenth of the fuel of aircraft technology. They are already being used to carry large mining loads to remote areas and to take groups of 200 or so on eco-tourism ventures similar to a cruise ship (Bradbury 2008).

CONCLUSIONS

There are not many guidelines to the future of our cities and regions that take account of what could happen to transport in response to the triple challenge of clean air, climate change and peak oil. It is understandable therefore why some people get very upset about the possibilities of collapse. As Lankshear and Cameron (2005, p10) say:

> *'Peak oil has already become a magnet for post-apocalyptic survivalists who are convinced that western society is on the brink of collapse, and have stocked up tinned food and ammunition for that coming day.'*

The alternatives all require substantial commitment to change in both how we live and the technologies we use in our cities and regions. The need to begin the changes is now as they will take decades to get in place and the time to respond to peak oil and climate change is of the same order, probably less. But at least by imagining some of the changes as suggested above it is possible to see how we can get started on the road to clean, green cities.

The first signs of change towards these emerging technologies can now be seen: the dramatic growth in electric transit; the rapid move towards electric vehicles and smart grids with a 40% per annum growth in global renewables; the emerging use of natural gas and biofuels; and new technologies like telepresence. Their application into large scale urban demonstrations is now underway in places like Kronsberg and Vauban in Germany, Masdar in UAE and Dong Tan in China as well as Treasure Island in San Francisco and North Port Quay in Perth.

The potential for creating clean, green cities is there. We first need to imagine the changes that are available now in transport and urban design, and then begin the process of change through large-scale demonstrations. I remain hopeful that the clean, green city beckons.

REFERENCES

Blake Dawson, 2008, The new world of Value Transfer PPPs. *Infrastructure: Policy, Finance and Investment,* May, pp 12-13.

Bradbury, D., 2008, Airships float back to the future. *BusinessGreen.com,* 2 September, 2008.

Cervero, R., 2008, Transit-oriented development in America: strategies, issues, policy directions. *New Urbanism and Beyond: Designing Cities for the Future,* ed T. Hass, Rizzoli, New York, pp. 124-129.

City of Kogarah, 2009, *Achieving Sustainability – Kogarah Town Square Development,* www.kogarah.nsw.gov.au/www/html/2075-achieving-sustainability-kogarah-town-square-development.asp.

Commonwealth of Australia, 2009. *Nation Building for the Future,* Budget Papers, Department of Treasury and Finance, Canberra, May.

Creutz, C. and Fujita, E., 2001, *Carbon Dioxide as a Feedstock, in Carbon Management: Implications for R&D in Chemical Sciences,* CPSMA, National Research Council, Washington DC, USA.

CTODRA, 2004, *Hidden in Plain Sight: Capturing the Demand for Housing Near Transit,* Center for Transit Oriented Development and Reconnecting America, www.reconnectingamerica.org.

Curtis, C., Renne, J. and Bertolini, L., 2009, *Transit Oriented Development, Making it Happen,* Ashgate, London.

Demerjian, D., 2008, As fuel costs rise airlines can't make the math work. *Autopia*, 10 June, http://blog.wired.com/cars/2008/06/prices-for-jet.html.

Dittmar, H. and Ohland, G. (eds), 2004, *The New Transit Town,* Island Press, Washington DC

Gehl, J., 1987, *Life Between Buildings: Using Public Space,* translated by Jo Koch, Van Nostrand Reinhold, New York

Gehl, J. and Gemzøe, L., 2000, *New City Spaces,* The Danish Architectural Press, Copenhagen

Gehl, J., Gemzøe, L., Kirknaes, S. and Sondergaard, B. S., 2006, *New City Life,* The Danish Architectural Press, Copenhagen

Gehl Architects, 2009, *Perth 2009: Public Spaces and Public Life.* Gehl Architects ApS.

Gilbert R. and Perl A., 2006, *Transport Revolutions: Making the Movement of People and Freight Work for the 21st Century,* Earthscan, London.

Gore A., 2008, *A Generational Challenge to Repower America,* Speech to Daughters of the American Revolution, Constitution Hall, Washington DC, July 17th, www.ens-newswire.com

Hargraves C. and Smith M., 2004, *The Natural Advantage of Nations,* Earthscan, London.

Kintner-Meyer, M., Schneider, K. and Pratt R., 2007, *Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Pt1: Technical Analysis,* Pacific Northwest National Laboratory, US DoE, DE-AC05-76RL01830.

Kenworthy. J., and Laube, F., 2001, *The Millennium Cities Database for Sustainable Transport,* UITP, Brussels.

Kenworthy, J., Laube, F., Newman, P., Barter, P., Raad , T., Poboon, C.. and Guia, B., 1999, *An International Sourcebook of Automobile Dependence in Cities,* 1960-1990, University Press of Colorado, Boulder, USA.

Laird, P., Newman, P. and Bachels, M., 2001, Back on Track: *Rethinking Transport Policy in Australia and New Zealand,* UNSW Press, Sydney.

Lankshear, D.,and Cameron, N., 2005, Peak Oil: A Christian Response. *Zadok Perspectives,* **88,** 9-11.

Mastny, L. (ed), 2006, *Biofuels for Transportation,* Worldwatch Institute, GTZ, German Federal Ministry of Agriculture, Washington DC., USA.

Newman, P., Beatley, T. and Boyer, H., 2009, Resilient Cities: *Responding to Peak Oil and Climate Change,* Island Press, Washington DC, USA.

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

Puentes, R and Tomer, A., 2009, *The Road Less Travelled: an Analysis of Vehicle Miles Travelled Trends in the U.S.,* Metropolitan Infrastructure, Initiative Series, Brookings Institution, Washington, DC, USA. rookings Institution, Washington DC.

Seaney, R., 2009, *High Oil Prices Spell Disaster for Airlines,* ABC News Internet Ventures, http://a.abcnews.com/m/screen?id=4847008&pid=74. August 25.

Simpson, A., 2009a, The electric revolution is on track. *Business Spectator,* 1 September.

Simpson, 2009b, Environmental Attributes of Electric Vehicles in Australia. *CUSP Discussion Paper,* www.sustainability.com.au/renewabletransport.

Went, A., James, W. and Newman P., 2008, Renewable Transport. *CUSP Discussion Paper* 1/2008, www.sustainability.curtin.edu.au/renewabletransport.

AUTHOR

Peter Newman
Professor of Sustainability
Curtin University Sustainability Policy (CUSP) Institute
Curtin University, WA.
p.newman@curtin.edu.au