Opportunities for Public Transport in the Resilient City of the Future

By Peter Newman[i]

The Problem

Oil vulnerability has become a major focus of the world's cities in the early part of the 21st century. This is fundamentally because the world is peaking in oil production as many pundits have been predicting for the past two or three decades. Added to this is the climate change agenda which suggests that oil needs to be phased out anyway. Reducing oil use is thus a political necessity for many reasons. The waning of petroleum resources and the global climate change imperatives require all cities to act on their transport systems; if they don't their citizenry will not be impressed at the inevitable increase in prices. The price of oil went to $140 a barrel in 2008 leading to the collapse of sub-prime mortgages in highly car dependent areas; then as the world economy went into a tail spin the oil price collapsed. Now cities are uncertain how to build as the price may rise suddenly again or stay so low that alternatives to oil become destabilised. Such volatility has been predicted as part of the phenomenon around the oil peak.[1] However even if the fuel price was not driving this issue we should be reducing oil vulnerability anyway for the following reasons:

[1] See a summary of the peak oil issue in Newman P (2007) 'Beyond Peak Oil: Will Our Cities Collapse?', Journal of Urban Technology, 14:2, 15 – 30 and in Newman P, Beatley T and Boyer H (2009) Resilient Cities: Responding to Peak Oil and Climate Change, Island Press, Washington DC.

1. **Reducing oil use will reduce impacts on the environment.** Oil use is responsible for approximately one-third of greenhouse gases. Transport greenhouse is seen as the most worrying part of the climate change agenda as it continues to grow during a period when more renewable or efficiency options are available.

2. **Reducing oil use will reduce smog emissions**. Improvements in urban air quality from technological advances are being washed out by growing use of vehicles in thirty-nine different air quality districts in the United States that are over the required standards (this is 40 percent of the United States). Developing cities desperately need to lower air emissions as they are often well above WHO recommended health limits.

3. **Reducing car dependence will improve human health, safety and equity.** The inequities of heavily car dependent cities for the elderly, the young, and the poor, will be reduced; the health impacts of car dependence such as poor air quality, obesity due to lack of activity, and depression will be reduced; the social issues such as noise, neighborhood severance, road rage and loss of public safety will be reduced; the economic costs from loss of productive agricultural land to sprawl and bitumen, the costs of accidents, pollution and congestion, all will be reduced.

4. **Reducing our dependence on petroleum fuels will make us less economically vulnerable.** The next agenda for the global economy,

sometimes called the Sixth Wave is about sustainability, about responding with technology and services for a new and more clever kind of resource use. Cities will compete within this economic framework and those cities that get in first will likely do best. But the same economic competition is facing households depending on which city they live in and where they live in those cities. In U.S. cities the proportion of household expenditure on transportation increased from 10 percent in the 1960s to 19 percent in 2005, before the 2006 oil price increases (which only reduced the percentage to 18 percent), with very car dependent cities like Houston and Detroit having even higher percentages. A more detailed study by the Centre for Housing Policy shows working families with household incomes between $20,000 and $50,000 spend almost 30 percent on transportation. In Atlanta within this income range the percentage is 32 and for families who have found cheap housing on the fringe, it can be over 40 percent of their income. In Australia surveys show that 40 percent of household income goes to transportation in some urban fringe areas. Almost all of this is for car travel. Households on the fringes of car-dependent cities are more vulnerable as the cost of transport escalates. Cities, and parts of cities, are now economically vulnerable to oil depending on the extent of their car dependence.

5. **Reducing dependence on foreign oil is likely to result in more resilient, peaceful cities.** Cities that are able to successfully reduce their dependence on imported oil, especially from politically sensitive areas, will have greater energy security. Terrorism and war have many causes but

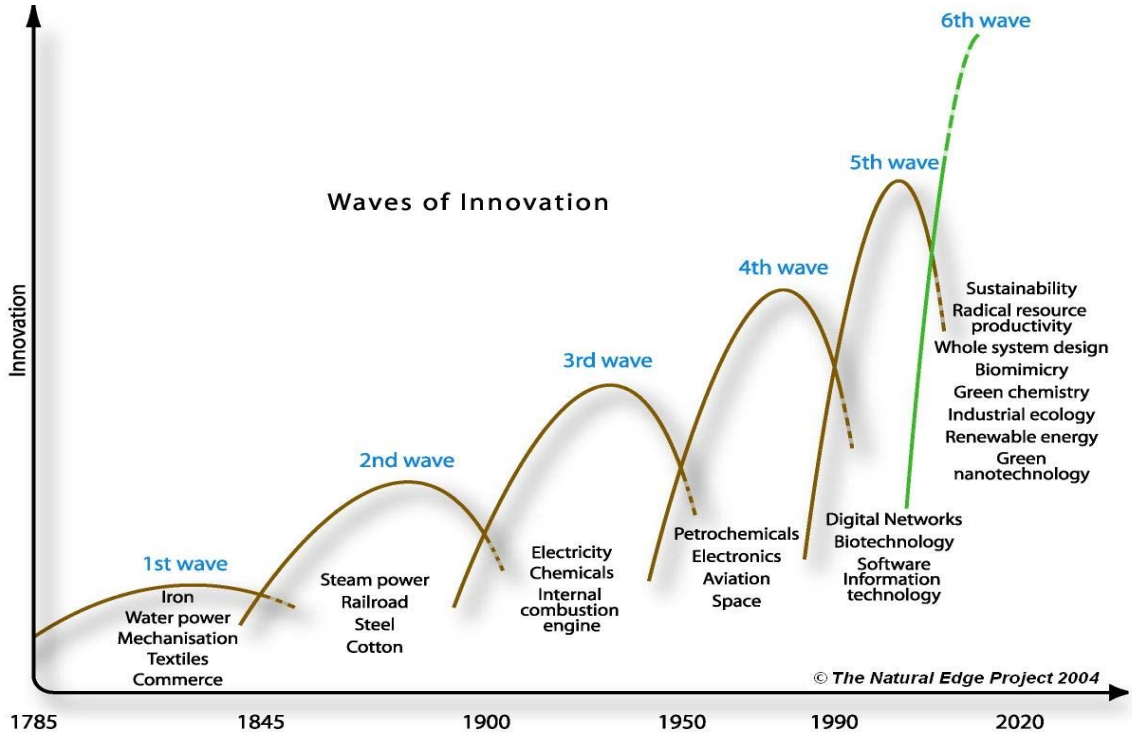
one deep and underlying issue is the need by high oil-consuming cities to secure access to oil in foreign areas, whether they be friendly or not. As oil becomes more and more valuable the security of supply will become a more and more central part of geopolitics. Fear can drive us to make security decisions that are not going to help create resilient cities. Thus underneath all these arguments is the fact that reducing our oil dependence could result in less war.

6. **Most importantly, resilient cities will be better places to live.** The many benefits of a resilient city include greater overall physical and emotional health; ease of movement from higher density, mixed-use communities that are walkable and have accessible transit options; better food that is produced locally and is therefore fresher; more energy efficient, affordable, and healthy indoor environments; access to natural environments; and more awareness of the local urban area and its bioregion enabling us to have a greater sense of place and identity. Some of these factors are challenging to quantify but are nevertheless real factors.

The Opportunity

The response to these challenges can often be one of panic - that it will have a severe impact on our economy. However it is also possible to see that this is a real opportunity and that the ability of cities to compete effectively in reducing oil will be a major part of their new economies. The next phase of innovation in our cities is seen by some to be based around sustainability innovations as set out by

Hargraves and Smith (2004) in Figure 1[2]. It is worth noting that these innovation cycles usually grow out of a period of economic downturn, eg the coal to oil transition occurred in the 1930's and we can expect something painful when the next transition occurs from oil to renewables and smart cities.



Thus radical resource productivity and renewable energy can be seen to be linked to the digital networks of the previous innovation phase to produce a whole new set of economic opportunities. These opportunities will make cities and their regions overcome their oil addiction and move towards a much greater degree of resilience. The question from this perspective then becomes: what are these opportunities and how can we best respond to them? This chapter will present

[2] Hargraves C and Smith M (2004) The Natural Advantage of Nations, Earthscan, London.

five areas where transport opportunities appear to be presenting themselves that could help make resilient cities and regions.

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 freight and regional transport.
4. Telepresence, high speed rail and airships.
5. Indigenous settlements going diesel-free.

All of these have a public transport dimension.

1. New generation electric transit systems and their associated TOD, POD and GOD structures.

Cities need to have a combination of transportation and land use options that are favourable for green modes, and offer a time savings when compared to car travel. This means transit needs to be faster than traffic down each major corridor. Those cities where transit is relatively fast are those with a reasonable level of support for it. The reason is simple - they can save time.

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 eighty-four city sample by ten to twenty kilometers per hour (kph) over bus systems, as buses rarely average over twenty to twenty-five kph. 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 U.S. cities.[3]

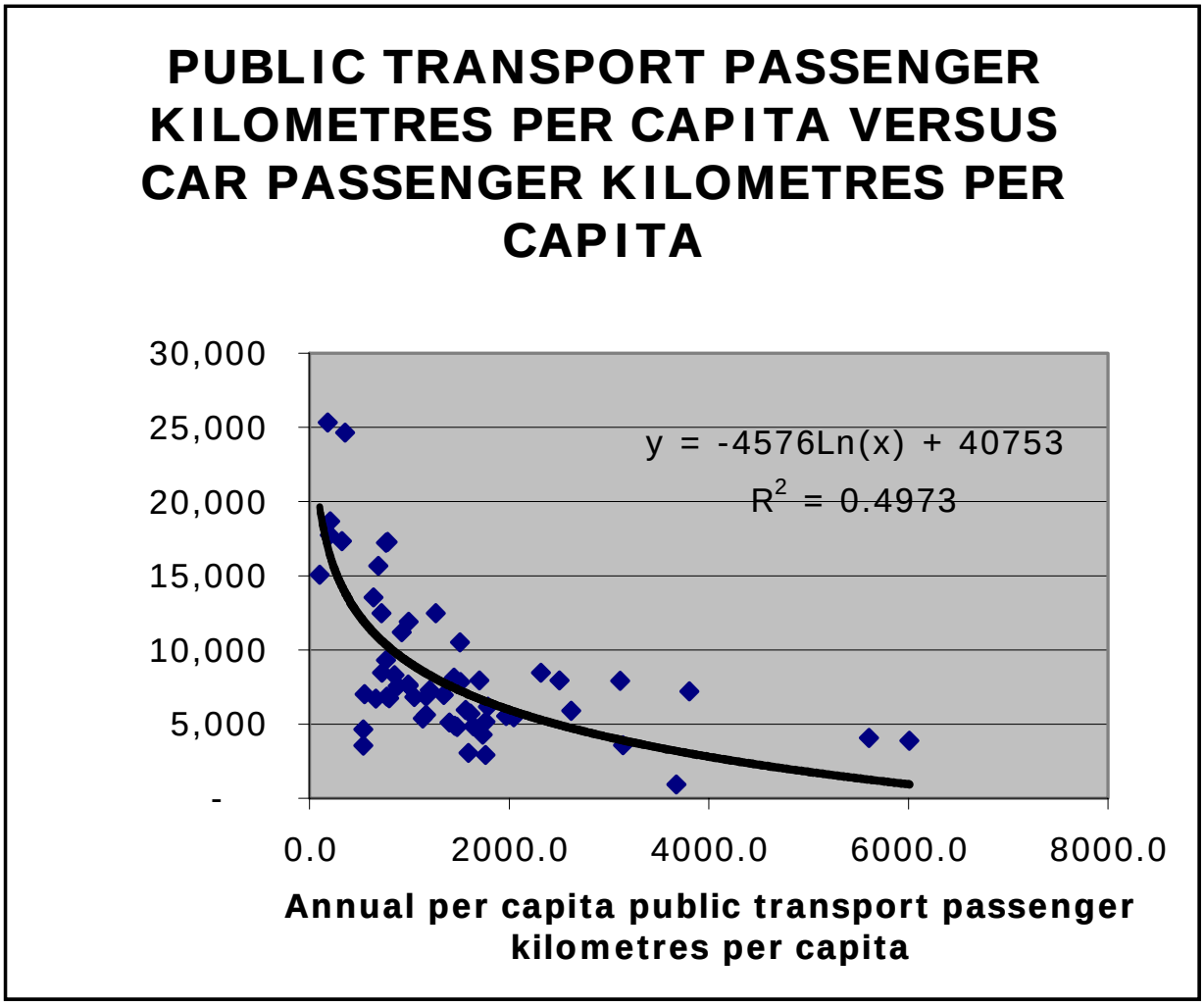
Rail has a density-inducing effect around stations, which can help to provide the focused centres so critical to overcoming car dependence. Thus transformative change of the kind that is needed to rebuild car-dependent cities comes from new electric rail systems as they provide a faster option than cars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

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 kilometres 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 2 shows the relationship between car passenger kms and public transport passenger kms from the CUSP Global Cities Database. 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

[3] Data are from Kenworthy J and Laube F (2001) The Millennium Cities Database for Sustainable Transport., UITP, Brussels, which was a study of 100 cities (16 were incomplete) and 27 parameters using highly controlled processes to ensure comparability of data. See also 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. Boulder: University Press of Colorado.

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.[4]



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).

[4] Newman P and Kenworthy J (1999) Sustainability and Cities: Overcoming Automobile Dependence, Island Press, Washington DC

City	Private transport use (passenger kms/person)	Public transport use (passenger kms/person)	Percentage of public transport as a share of total transport
Sydney	10506	1509	12.6%
Melbourne	11918	994	7.7%
Brisbane	12487	720	5.5%
Perth	13546	642	4.5%

Table 1 Car and public transport use per capita in four Australian cities, 1996

These values in Figure 2 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, from the trend line of Figure 2, it would have a per capita private transport use of 4088 passenger kms per capita which is 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.

These remarkable reductions suddenly become imaginable. But are they real? Could it happen?

The driving force would need to be a combination of *push and pull*. The *push* would come from fuel prices that rise inevitably as supply of oil declines and other alternative fuels just cannot fill the gaping hole in supply. In the US, there was a reduction in Vehicle Kilometres Travelled (VKT) of 4.3% and a substantial rise in transit patronage over 2008 during the rise in fuel though this followed a slightly smaller fall in the year before the price rise and indeed a plateau since 2004 as transit grew faster than ever[5].

This trend cannot continue unless there is a simultaneous *pull* from the provision of better transit infrastructure. Already capacity limits have been reached across Australian cities in their public transport so for a start substantial increases in trains, trams and buses are needed to fill the rapid growth in transit. There will also need to be new lines and new technology like Metros and light rail to increase the capacity and speed of transit to make it attractive to use.

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[5] Robert Puentes and Adie Tomer (2008) The Road Less Travelled: An Analysis of Vehicle Miles Travelled Trends in the US; Metropolitan Infrastructure Initiative, Number 4, Brookings Institution, Washington DC.

At the same time the cities will need to develop rapidly around transit stations. This can be a significant source of funding for the required rail infrastructure through 'Value Transfer PPPs' as in the very successful Chatswood Transport Interchange PPP which has created a new railway station and bus interchange along with a retail and residential complex that makes a small city around and over the station.[6] It can be the main mechanism for replacing the development of car dependent suburbs which are already beginning to die as the price of fuel climbs. Significant new local transit options linking across the heavy rail corridors – especially with light rail systems – will also be needed.

How realistic is it to assume public transport can increase as described, and what are the capacity implications of such an assumption for our public transport systems?

Table 2 below shows the medium population projections for the five largest Australian cities to 2051 (ABS 3222.0). As can be seen, these reveal that:

- The five largest cities are expected to grow by around 20% between 2004 and 2021, and by 45% by 2051
- They will increase their share of Australia's population slightly from 61% to 63% over that time
- Although all cities will grow, Brisbane is expected to grow the fastest (almost 90% growth by 2051) and Adelaide the slowest.

Table 2: Medium Population Projections for Australia, 2004 – 2051 ('000s)

City	2004	2021	2051	Growth % 2004-2021	Growth % 2004 -

[6] Blake Dawson (2008) 'The new world of Value Transfer PPPs', Infrastructure: Policy, Finance and Investment, May, pp 12-13.

					2051
Sydney	4225	4871	5608	15%	33%
Melbourne	3593	4252	5041	18%	40%
Brisbane	1778	2404	3355	35%	89%
Perth	1455	1875	2454	29%	69%
Adelaide	1123	1201	1203	7%	7%
Rest of Aust	7917	9268	10509	17%	33%
Australia	**20091**	**23871**	**28170**	**19%**	**40%**
Five City Sub-Total	**12174**	**14603**	**17661**	**20%**	**45%**
% in 5 largest cities	61%	61%	63%		

Source: ABS 32220.0: Population Projections 2004 - 2101

Table 3 below shows the implications in terms of per capita passenger-kilometres in those cities ranging from a doubling by 2051 for Sydney to a tripling for the small cities (Brisbane, Adelaide and Perth) as suggested in the analysis above. Thus they suggest per capita public transport use in Melbourne in 2021 would be slightly above that achieved in Sydney in 2004, while Perth and Adelaide's use in 2051 would equal that of Sydney currently.

Table 3. Assumed per-capita public transport use in Major Australian Cities (passenger kms per year)

City	1996	2004	2021	2051
Sydney	1509	1500	2100	3000
Melbourne	994	990	1600	2500
Brisbane	720	800	1300	2200
Perth	642	700	1200	2000
Adelaide	500	500	800	1500

The total public transport travel task implied by these predictions is shown in Table 4 combining the derived per capita growth figures with the predicted population increases. This shows that across the five largest cities total patronage would need to be lifted by 80% by 2021, and more than trebled by 2051.

Table 4: Implications for Overall Public Transport Use

Table 3: Estimated Passenger-kms (Billion)

City	2004	2021	2051	Growth % 2004-2021	Growth % 2004 - 2051
Sydney	6.3	10.2	16.8	61%	165%
Melbourne	3.6	6.8	12.6	91%	254%
Brisbane	1.4	3.1	7.4	120%	419%
Perth	1.0	2.3	4.9	121%	382%
Adelaide	0.6	1.0	1.8	71%	221%
Total	**12.9**	**23.4**	**43.5**	**81%**	**237%**

However the increase in patronage in peak periods would not need to be as large as in off-peak periods, given the much lower share achieved for non-work or education trips (such as social/recreation, shopping and business trips) which are largely made in off-peak periods. This is shown in table 5 below to illustrate the task in terms of augmenting public transport capacity at peak periods in each of the cities to achieve the above increase in public transport use.

Table 5. Estimated Increase in Peak and Off-Peak Capacity

	Growth %	2004-2021	Growth %	2004-2051
City	Peak	Off-Peak	Peak	Off-Peak
Sydney	**50%**	70%	**120%**	200%
Melbourne	**70%**	110%	**200%**	300%
Brisbane	**100%**	140%	**300%**	500%
Perth	**100%**	140%	**280%**	480%
Adelaide	**50%**	90%	**150%**	300%
Total	**65%**	**95%**	**160%**	**320%**

Hence to achieve major reductions in car use it would be necessary to increase capacity in Sydney by around 50% by 2021, and by 120% by 2051. For Brisbane the increases are more like a doubling in capacity by 2021 and a quadrupling by 2051. These are not difficult to imagine as they represent growth rates of around

2% per year. With such growth the transformation of Australian cities to achieve significant reductions in car use can then happen.

The biggest challenge in an age of radical resource efficiency requirements will be finding a way to build fast rail systems for the scattered car dependent cities of the New World. How can a fast transit service be built back into these areas? The solution may well be provided by Perth and Portland which have both built fast rail systems down freeways. Freeways are public facilities that may well be in decline as indicated by the recent travel data in US cities and which is likely to get much worse 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) which is at least 30 percent 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 Railway reached 55,000 passengers a day in its first year of operation whereas the previous bus system down the corridor carried just 14,000 a day. There is little else that can compete

with this kind of option for creating a future in the car dependent suburbs of many cities.

The TOD has become a major technique for reducing automobile dependence and hence tackling peak oil. For the full agenda of sustainability and peak oil to be addressed, TODs need to also be Pedestrian-Oriented Developments (PODs) and Green-Oriented Developments (GODs) as explained below.

The facilitation of TODs has been recognized 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. 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 percent less than those in conventional suburbs. 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 Urban Land Institute 2008 report, Emerging Trends in Real Estate, suggested that TODs would appreciate fastest in up-market and hold value better in down markets[7].

[7] http://www.uli.org/AM/Template.cfm?Section=News&CONTENTID=107907&TEMPLATE=/CM/ContentDisplay.cfm

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. In a detailed survey across several states they 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 percent 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 and 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 that mean the TOD approach is a local economic development mechanism.

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. 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 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, fifty thousand square feet of office and retail space and thirty-five thousand 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 percent of the water and 385

tonnes of greenhouse gas - this does not include transport oil savings that are hard to estimate but are likely to be even more substantial.

2. 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 hybrid vehicles (PHEV). 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. The key issue here is that plug-in electric vehicles not only reduce oil vulnerability but they are becoming a critical component in how renewable energy will be become an important part of a city's electricity grid. The PHEVs will do this by enabling renewables to have a storage function. Such plug-in vehicles can also be buses and light rail systems which will also become part of this exceptional new technology system as outlined below.

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 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 Resilient City of the future is likely to have a significant integration between renewables and electric vehicles

through a Smart Grid. Thus electric buses, electric 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.

Electric rail can also be powered from the sun in this either through the grid powering the overhead wires or in the form of new light rail (with these new Li-Ion batteries) which could be built down highways into new suburbs without requiring overhead wires. Signs that this transition to electric transport is underway are appearing in demonstration projects such as Google's 1.6 MW solar campus in California (with 100 PHEVs) and by the fact that oil companies are acquiring electric utilities.[8]

What sort of impact could there be? According to one study the integration of hybrid 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.[9]

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[8] http://www.google.org/recharge/; http://energysmart.wordpress.com/2007/06/22/rollerblading-to-a-phev-future/ The whole concept is developed in Went A, James W and Newman P (2008) Renewable Transport: How Renewable Energy and Electric Vehicles using Vehicle to Grid technology can make Carbon Free Urban Development, CUSP Discussion Paper 2008/1, www.sustainability.curtin.edu.au.

[9] (ref Michael Kintner-Meyer, Kevin Schneider and Robert Pratt (2007) IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS, PART 1: TECHNICAL ANALYSIS, Pacific Northwest National Laboratory, US DoE, DE-AC05-76RL01830)

The real test of a Resilient 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.

3. Natural gas and biofuels in 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?

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 next stage for larger vehicles and for regional transport would appear to be to switch to greater use of natural gas and biofuels. Regional buses, 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 can 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 although actual filling stations are not commonplace.

The conversion to natural gas is an obvious step in places like Australia where there is a good supply of natural gas available. However in Europe and in the United States this is not the case. Europe is going to faraway places in the east, such as Russia, to bring their gas and already some signs of an OPEC-like protection of the resource are developing. In the United States natural gas has already peaked and officials are now looking to import it using LNG tankers - starting an overseas dependence similar to oil.

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 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. Moreover its use will need to be eventually phased out as part of our response to climate change. The benefit of the transition to natural gas is that it enables the long term transition to hydrogen to be facilitated.

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. 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 and regional transport it is not an option that can be yet taken seriously.

4. **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. At the height of the 2008 fuel crisis the head of Virgin Airways said 'No airline can make money when fuel rises to 35% of the costs of running an airline.' Gilbert and Perl (2007) suggest a few ways that air travel will adapt but mostly they see little of potential other than regional high speed rail and a return to ship travel.[10] High Speed Rail between Australian cities needs to be seriously examined over the next decade as fuel prices rise again.

[10] R. Gilbert and A. Perl, Transport Revolutions: Making the Movement of People and Freight Work for the 21st Century (London: Earthscan)

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. It is not beyond imagination to see some public transport options here.

5. Indigenous settlements going diesel-free.

Remote settlements in Australia are under the spotlight due to serious health and social problems. The obvious lack of governance to enable decent services to these areas is likely to be overcome through federal and state commitments. But they must also begin to show how they can become diesel free as these settlements are highly vulnerable to price rises. Renewable power can be used in these settlements but not much is there yet for transport. These settlements need to be provided with upgraded road access to enable weekly services by 'bush bus' that can enable them to have reasonable access to regional towns. Fewer vehicles are likely to be the main response however to the global fuel crisis on these areas. It is important to see that the resilience of all settlement types will be challenged by the peak oil/climate change transition. Indigenous settlements, like all settlements, will need to forge ways of reducing their oil dependence whilst improving the quality of life for their citizens. Part of this will need to be a public transport system appropriate to their needs.

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 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) 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.'*[11]

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 more resilience and sustainability in our settlement transport systems. Public transport will be the critical dimension that makes the resilience of our cities feasible.

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

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