Transport and Urban Planning for the Post Petroleum Era

By Jeff Kenworthy

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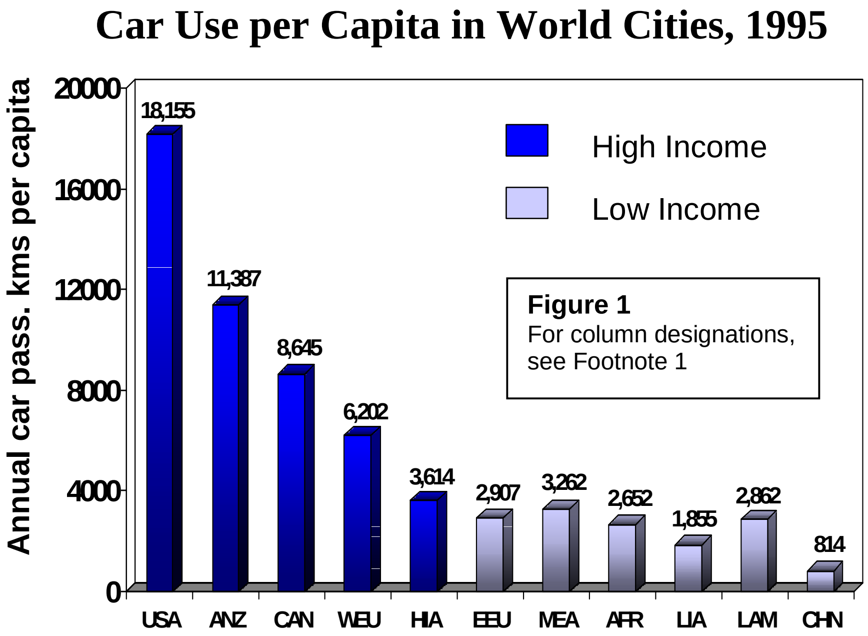

Figure 1
For column designations, see Footnote 1

As a way of setting the scene, we begin with a brief international overview of passenger transport energy consumption and modal energy efficiencies in a large global sample of cities, together with some of the key factors that underpin the level of consumption of this globally critical resource. The source of the data is the *Millennium Cities Database for Sustainable Transport*.[1]

A very wide range of cities from quite small (around 300,000 people) up to very large are included in the database, from high and low income regions. The largest metropolitan area is Tokyo with some 33 million people. Among the 60 "higher income" cities are those such as London, Paris, Stockholm, Tokyo, Singapore, Sydney, Los Angeles, New

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[1] Kenworthy, J and Laube, F (2001) *The Millennium Cities Database for Sustainable Transport.* (CDROM Database) International Union (Association) of Public Transport (UITP), Brussels and Institute for Sustainability & Technology Policy (ISTP), Perth. This is currently the only large, standardised set of comparative data on land use, transport, economics and the environment for urban areas in a wide range of nations and continents. From early 1998 until 2001 the UITP in Brussels funded this collection of data from 100 cities in 50 developed and developing nations on all continents. Up to 175 entries of primary data were made for each city, depending on the level of administrative complexity and multi-modality of the transport systems. The length of the project is indicative of the long periods required for collection, release, acquisition, and collation of international data before analysis can even begin. By the time the database had been finalised and released in 2001, the 1995 data were already 6 years old. Figures cited here are based on aggregation of the data from individual cities in clusters organised by regions **(Africa, AFR; Australia and New Zealand, ANZ; Eastern Europe, EEU; Latin America, LAM; Middle East, MEA; Western Europe, WEU),** nations **(Canada, CAN; China, CHN; and the USA),** and incomes **(High Income Asia, HIA; and Low Income Asia, LIA)**.

York and Vancouver. Among the 40 “lower income” cities are examples such as Bangkok, Beijing, Sao Paulo, Johannesburg, Prague, Krakow and Cairo. Data for developing cities were generally more difficult to finalise, especially in Latin America. Nevertheless the data assembled represent a reasonable sample of cities in the developing world.

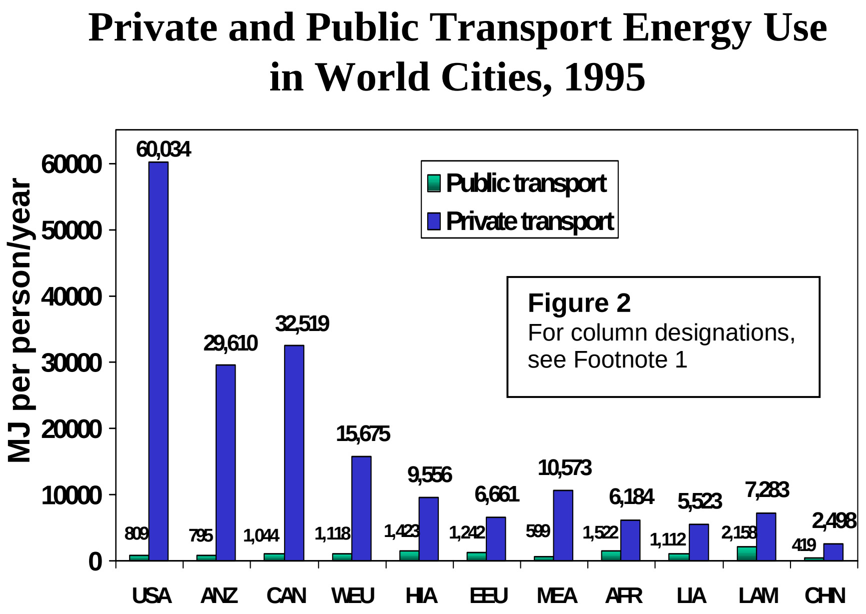

Figure 2
For column designations, see Footnote 1

Data on car use per capita show vast differences in urban car use across the planet, with US cities having extraordinarily high levels compared to all other cities (Figure 1). The developing cities are uniformly low in car use in an international context, in spite of the fact that most streets in poorer cities are saturated with traffic. In other words these lower-income cities may be traffic-saturated but they are not auto-dependent in the way of North American and Oceanian cities.

Not surprisingly, patterns of urban car use largely follow patterns of per capita passenger transport energy use, with again the US cities standing out with astonishingly high levels of oil consumption in urban passenger transport. An average US city of 400,000 people consumes as much oil in passenger transport as a Chinese mega city of 10 million people.

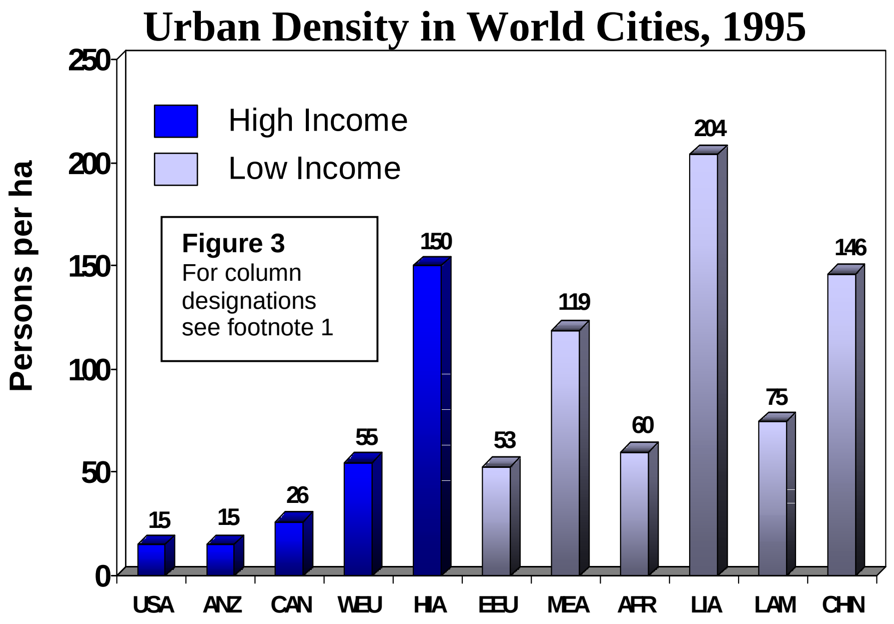

Figure 3
For column designations see footnote 1

Per capita use of energy in urban public transport (Figure 2) is tiny in all groups of cities compared to energy use in private transport, and it does not have the same high level of variability as private transport energy use. This is interesting from an energy conservation perspective because there are vast differences in the use of public transport between regions, as shown later.

It is not difficult to see why the issue of Iraq is so urgent for the United States when the comparative level of energy use in passenger transport in US cities is considered. This is all about keeping the lifeblood of American society flowing without the problems characteristic of the oil shocks of 1973/74 and 1979 when oil prices rose so steeply and people even assaulted and killed one another in 'gas queues'.

In every region of the world, the average use of energy per passenger km is much higher for the car system than for public transport. Only in the USA does the average energy use of public transport per passenger km approach that of cars. This is due to the heavy reliance on bus-based systems in the USA, with low loadings and high service kilometres needed to pick up passengers across low density landscapes and in street systems not well-suited to bus services (eg cul-de-sacs and curvilinear roads).

Figure 4

One of the key factors in understanding the use of cars in cities and the level of transport energy needed to keep them running is urban density (Figure 3). Auto-dependent cities are invariably low density. Asian cities, including Chinese cities are the densest urban environments in the world. Canadian cities sit between the US/Australian cities and the European cities in urban density and represent an interesting and unusual grouping of automobile dependent cities that support relatively high levels of public transport use. Low density cities have the highest use of energy for passenger transport in the global sample.

Typical densities can be portrayed pictorially (Figure 4) to give a sense of the kinds of differences in urban form across the globe. Perth (top left) has very low density, Vancouver (top right) has a moderate density, Prague (bottom left) is medium density and is fairly typical of a European city, while Hong Kong (bottom right) is at the high density end of the spectrum.

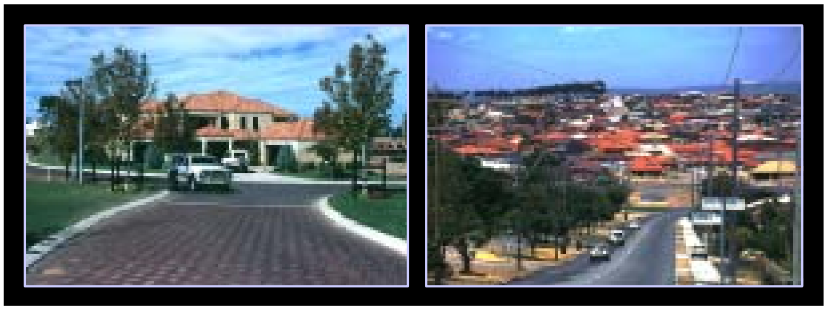

Figure 5 Perth suburbs: Urban sprawl & high-energy lifestyles.

Urban density is a strong explanatory variable in accounting for differences in passenger transport energy use per capita between cities around the world and also within cities – central locations at higher density have much lower energy use than areas far from the city centre and at lower density. This can be seen in New York, for example, with very low levels of energy use for transport in Manhattan and very high levels in fringe suburbs. In the Paris region also, neighbourhoods with low density have much higher energy use in transport compared to high density neighbourhoods. In fact, the correlation is near perfect.

Figure 6

Areas at the high energy consuming end of the spectrum tend to have urban environments akin to Australian suburbs as seen in Perth, for example – with low density, no mixed land use, poor public transport services and nowhere to walk to (Figure 5).

An analysis in Perth[2] supports the idea that location and qualities of the urban form, public transport system, and street design are critical in determining the levels of greenhouse gas emitted as a result of energy use in transport. Centrality, density, mixed land use, transit access and permeability of the urban environment are all critical factors that improve from the fringe towards the centre.

Transport infrastructure is also critical in determining car use and energy use on a metropolitan scale. We have to consider the priorities that we afford to different types of transport infrastructure if we are to understand patterns of transport energy use. Freeways (Figure 6) have been acknowledged for decades as a source of growing dependence on liquid fossil fuels.

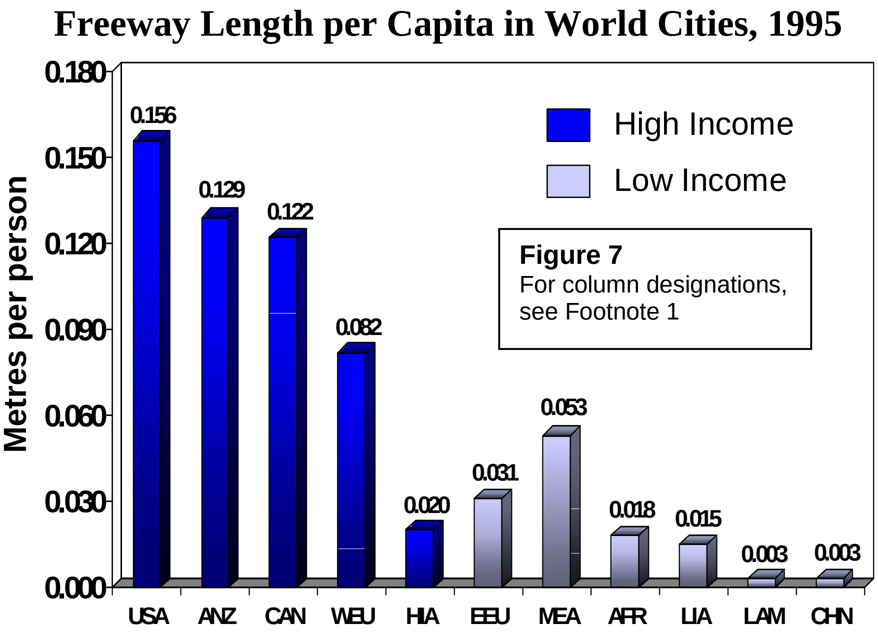

Figure 7
For column designations, see Footnote 1

It is not surprising to find it is the auto-dependent cities that have the highest level of freeway infrastructure in the world (Figure 7). This is notwithstanding high rates of freeway construction in poorer cities where a majority of the population still have no access to private motorised transport, but rather rely on public transport and non-motorised modes.

At the other end of the spectrum to the urban freeway, we have its chief competitor the urban railway. Efficient urban rail lines are the public transport equivalent of the freeway. Both are "premium" forms of transport infrastructure. Whether or not a city has competitive, high-quality public transport infrastructure – such as a strong rail backbone, is critical in determining the city's use of public transport.

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[2] Newman et al. (2001) Study into Greenhouse Gas Emissions from Transport and Urban Land Use Planning. In: Transport Systems and Urban Form. National Taskforce on Integrated Land Use and Transport Planning, National Greenhouse Strategy, Canberra.

Transit Use per Capita in World Cities, 1995

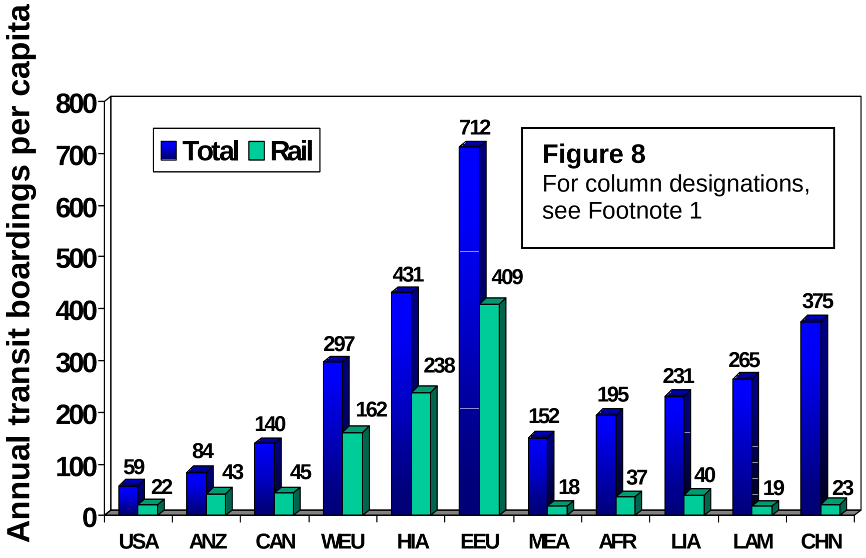


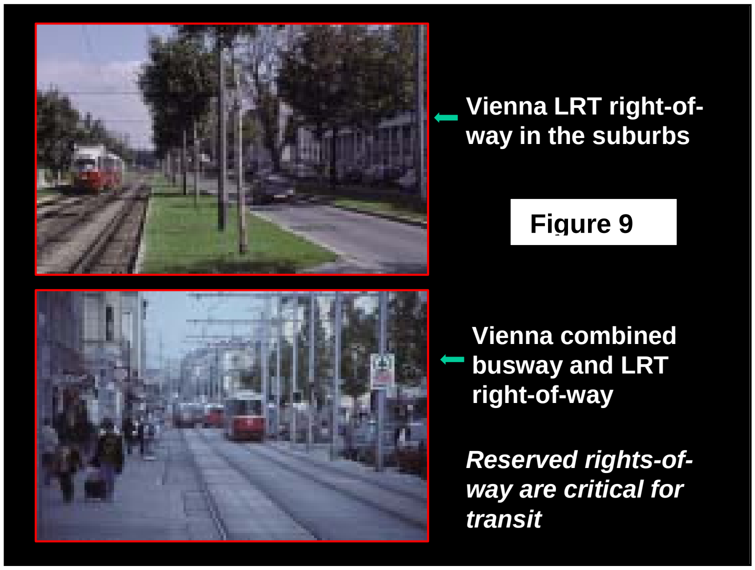
Figure 8
For column designations, see Footnote 1

The data in Figure 8 show that public transport use in the world varies dramatically and is particularly low in US and Australia/New Zealand cities, less so in Canadian cities. The particularly strong cities in public transport use are the western European, high-income Asian, and Eastern European cities. Chinese cities have significant public transport use due primarily to massive captive ridership (since car ownership was still very low in 1995). It is clear that cities with the highest use of public transport tend to have high use of urban rail. Use of public transport in lower income cities is surprisingly low, but can at least be partly explained by their low provision and use of urban rail. The quality of urban public transport is generally low in these cities and riders are easily lost to motor cycles and cars.

The quality of transit services in cities varies enormously and can make a very big difference to levels of usage. Buses stuck in traffic cannot compete with cars, whereas a good urban rail system provides a highly competitive and strongly used service. Bus-only cities tend to languish in public transport ridership.

Reserved rights-of-way are critical for effective transit systems. The key factor in making public transport competitive with cars is speed and reliability (together with a range of other factors such as comfort, image, marketing etc). The critical issue, however, is offering public transport systems with physically separated rights-of-way (Figure 9).

Reserved busways have been effective in Curitiba and a number of other Latin American cities in raising public transport ridership. Ottawa also has an effective busway system. However, cities with successful busways often eventually have to upgrade to rail in order to increase passenger capacity and meet rising expectations of comfort and convenience.



Vienna LRT right-of-way in the suburbs

Figure 9

Vienna combined busway and LRT right-of-way

Reserved rights-of-way are critical for transit

Energy Consumption of Buses and Rail per Passenger km in World Cities, 1995

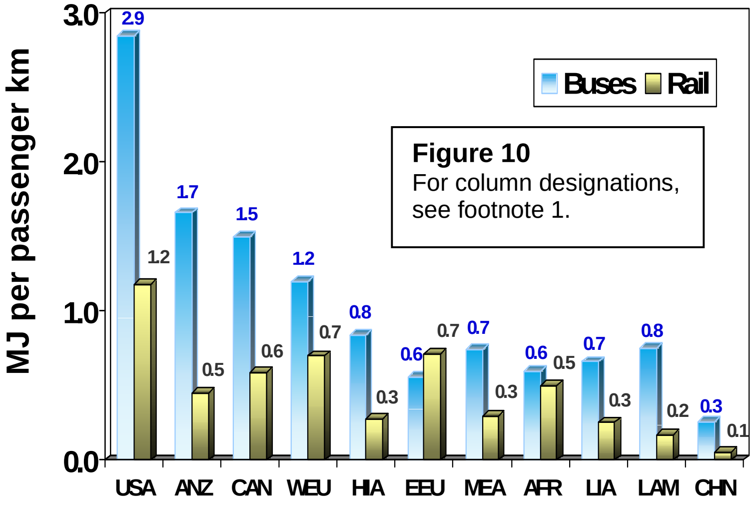


Figure 10
For column designations, see footnote 1.

Data for energy consumption of buses and rail per passenger km (Figure 10) shows that in every group of cities in the world bar one, urban rail is the most energy-efficient mode of public transport. The one exception is the Eastern European cities, which have a considerable quantity of old, heavy, Russian-built railway rolling stock that operators are attempting to make much lighter.

What about the significance of non-motorised modes (NMM) in urban transport? Non-motorised transport uses no fossil fuel energy (except that embodied in making the vehicles such as bicycles). The more urban travel that can be catered for by foot and bicycle, the less energy cities are going to use.

Modal Split for All Trips in World Cities, 1995

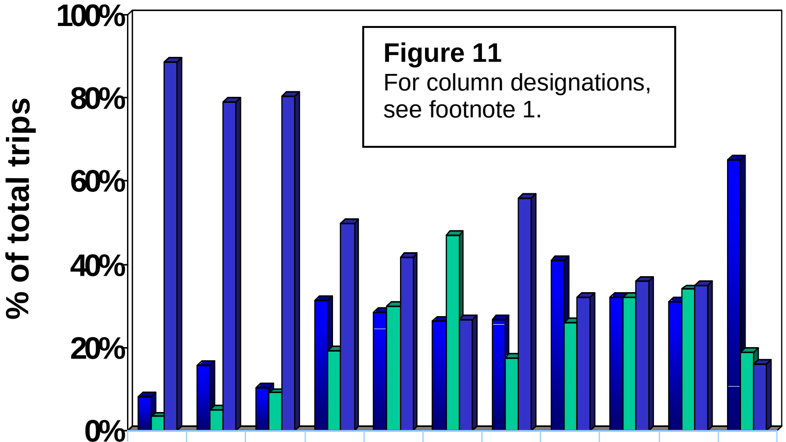


Figure 11
For column designations, see footnote 1.

	USA	ANZ	CAN	WEU	HIA	EEU	MEA	AFR	LIA	LAM	CHN
■ NMM	8%	16%	10%	31%	29%	26%	27%	41%	32%	31%	65%
■ Transit	3%	5%	9%	19%	30%	47%	18%	26%	32%	34%	19%
■ Private	89%	79%	81%	50%	42%	27%	56%	32%	36%	35%	16%

The auto cities clearly have the least amount of total daily trips by foot and bicycle (8% to 16%) (Figure 11). All other groups of cities in the world have substantially more daily trips by these modes (26% to 65%). In fact most other groups of cities have only about one-third to a half of trips by the most energy-intensive private transport modes compared to 80% to 90% in the auto cities.

So what are the transport and planning priorities for reducing transport energy use and confronting the post-petroleum world?

Step 1 – Better public transport.

Clearly a key to reducing energy use in urban transport is to develop better public transport systems, particularly rail-based transport backbones. In Perth, for example, rail use has more than quadrupled since 1991 and average rail speed (50 km/h) now exceeds average road traffic speed (46 km/h). This gap is set to widen with the commitment to building a 74 km rail line from Perth to Mandurah which will have a travel time of only 48 minutes and will greatly increase the attractiveness of public transport in Perth's southern corridor.

A number of cities (e.g., Geneva, Figure 12) have developed quality on-street rail-based public transport systems that are not only a move towards greater energy efficiency through greater public transport use, but also more walking and cycling through an enhanced pedestrian-friendly urban public realm.

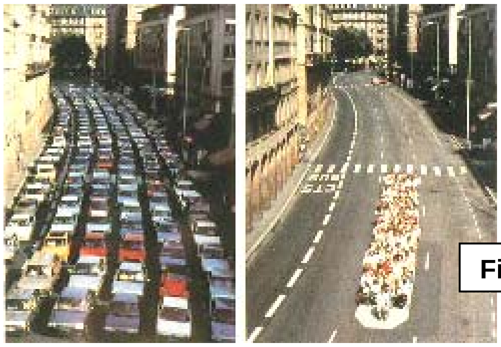


Figure 13

Figure 12

A tramway, or Light Rail Transit (LRT) system, uses as much road space as 177 cars (1.38 person/car occupancy, i.e., 240 people), or 3 standard buses. It is not difficult to see the energy conservation potential of an articulated LRT service, as well as its potential to improve the livability of city streets (Figure 13). Could this be the next step for Perth and other high-energy cities trying to reduce car and energy use?

Figure 14

Many cities are availing themselves of new LRT systems in order to better compete with the car in speed and image terms. For example, Figure 14 shows an on-street LRT in New Orleans, USA, on its own dedicated right of way. Electric rail and LRT systems also have the advantage that they can operate on renewable sources of electrical energy.

Step 2 – More use of non-motorised modes and better conditions for pedestrians and cyclists.

“Pedestrianisation” in selected areas, and area-wide traffic calming schemes can increase the use of walking and cycling, save energy, enhance the livability of the city and be a positive force for urban business. Whole districts can be pedestrianised or traffic calmed to create a walkable public realm (Figure 15 left)

Figure 15 “Pedestrianisation” of (L) neighbourhood streets, (R) arterial road

Traffic calming can also be carried out on main roads to create “environmental boulevardes” where there is a mix of non-motorised and motorised transport. Such schemes can save energy as well as contribute to an overall better urban environment without adversely affecting traffic throughput (Figure 15 right).

Public transport systems, foot and bicycle modes need to be closely integrated and work together to create a virtuous circle of improvements that can compete with the car in attractiveness for many trips (Figure 16).

Figure 16

Step 3 – Compact, mixed use urban planning integrated with public transport.

The critical factor in any city’s efforts to become less dependent on fossil fuels is how it builds extensions and additions to its urban fabric to achieve more energy-efficient urban form and lifestyles. Transport energy conservation can be tackled through non-transport approaches by creating compact, walkable, mixed-use urban environments closely integrated with public transport.

Figure 17

Arabella Park in Munich, for example (Figure 17), is constructed around an U-Bahn station and only has underground parking and roads around its periphery to ensure maximum use of walking, cycling, and public transport; and there are a number of other similar developments in other western European cities. Another example, the mixed use Tiergarten development in Zurich, is built in an old quarry with a LRT and electric trolley bus service at its heart.

Energy-efficient developments integrated around public transport can be attractive from other perspectives, and can enhance opportunities for energy savings in other areas as well. For example, in Reiselfeld, an LRT-based new urban village in Freiburg, Germany, high density, mixed land use involves energy conservation not only for transport, but also within the built environment. Some buildings are equipped with solar photovoltaics and housing is designed to be energy-efficient.


Figure 18

It is not only European cities that are building for greater sustainability and energy-efficiency. Vancouver in Canada has numerous examples of transit-oriented and pedestrian-friendly urban developments that offer low-energy lifestyles. Such developments are proving highly popular for a wide range of lifestyle reasons. False Creek (Figure 18), for example, is a central city neighbourhood where some 15,000 people live in a traffic-free garden environment built for walking and cycling. The development includes a wide range of other uses such as a market, primary school, community centre, supermarkets, restaurants, medical suites, hotel and so on. Frequent bus services, both diesel and trolley are available, and residents can walk to the central city.

As Australia enters the development pathway leading to a post-petroleum world, urban design and transport systems will become major tools for saving energy while enhancing urban lifestyles. In Perth, the new development, Subi-Centro, has been integrated around the Subiaco railway station on old industrial land, and is a good example of more transit-oriented development. The neighbourhood is also planned to be walkable, with the traditional Subiaco centre only a short distance from most of the new houses.

Conclusions

Looking to a future beyond cheap oil, in a more ‘greenhouse-aware’ world, there are some confronting, but ultimately optimistic conclusions:

- The whole problem of automobile dependence and high transport energy use must be tackled systematically through better technologies, better pricing and better urban and transport planning.
- The problems of energy use in transport cannot be solved by technology alone.
- The kind of urban planning principles we use, and the transport infrastructure priorities we have, will significantly determine how we cope with the post-petroleum era.
- Reducing our built-in energy dependence will, however, have enormous positive spin-offs in the overall sustainability and livability of the city.

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