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Title: **Pathways to a more Sustainable Transport Infrastructure**

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Abstract

The imperative to respond to the issues resulting from Peak Oil and Climate Change requires that New Zealand must move from its current high energy use, high resource use, high cost, petroleum dependent, transport infrastructure, to a sustainable one. Because a country's energy profile will increasingly define its economic success, New Zealand needs also to move to a lower energy society to remain competitive with other countries. What will be New Zealand's successful transport energy of the future and how it may be best used are key considerations of our future sustainable transport system. Low energy, low material use and consequently low cost, will be the main criteria.

This paper first identifies our current transport energy usage, and some of the risks of being slow to respond to change. The paper then questions the central tenants of the current New Zealand Land Transport Strategy (2008) that we move to bio-fuels and electric cars because this is not a low energy, low cost pathway. We advocate that instead of just coping with change, New Zealand uses the necessity to change as an opportunity to recast our transport infrastructure to greatly improve the economic success and liveability of our settlements to New Zealand's benefit.

The second part of the paper outlines a transport infrastructure based around electricity, with a heavy emphasis on public transport use, but also with freight much more dependent on electrified rail. This second part discusses: the advantages that NZ has that will facilitate this transition, such as favourable urban forms; the energy needs and energy availability; the benefits and liveability improvements that should accrue; and the need for lead investment which can also be a tool which induces change of settlement form, thereby reinforcing the effectiveness of the new infrastructure; and some of the impediments.

Introduction

The basis for much of our current transport infrastructure lies in the 1950s. This period marked a pronounced shift in our transport infrastructure, so that we became a high energy, high cost society. Aged electric tram systems in 9 cities were scrapped and their road space given over to cars. Diesel powered locomotives entered service rather than electrifying the railways. A road-only bridge across the Auckland harbour helped reinforce Auckland's sprawling car dependant nature. A roll-on roll-off ferry service linked the North and South Islands signalled the demise of coastal shipping. Motor vehicle assembly became the mainstay of industrial growth and employment in Auckland and Wellington. Planning of that era laid out the motorway systems of the major cities and completing these systems still shape the thinking and expenditure of the recent National Infrastructure Plan. (Dravitzki &Lester 2006)

As a consequence of these changes energy use and transport costs are now much higher. Rather than using about 0.5 MJ per passenger kilometre on electric trams we were now using about 2 MJ per passenger kilometre in cars. Expenditure on transport has increased from about 4 to 7 percent of household spending to about 18 percent in the mid 1970's before declining to 14 percent, as at present. (Dravitzki &Lester 2009)

Self sufficiency has declined. NZ shifted from a reliance on domestic capability for transport of our indigenous sources of hydro electricity and coal and local tram and railway workshops and is now importing both our transport energies and the vehicles of transport. Our indigenous contribution to transport is now reduced to supplying the gravels and aggregates for the roadway.

Cars are now central to the lifestyle of almost every New Zealand household. Cars and light vehicles are also a key component of the system by which light goods are moved through our cities. Courier vans deliver internet purchases and the smaller loads of just-in-time restocking are managed with vans and light trucks. Personal vehicles have replaced delivery as the means by which shopping is taken home. Urban form has steadily altered under the influence of cars. Suburban malls and big box retail have moved away from the central business district and away from public transport to locate where it is easy for cars to congregate and where land for parking is cheap.

Current Energy Usage in Transport

Our current transport energy usage in transport of 221 petajoules is 42 percent of the economy wide energy use of 551 petajoules. Almost all transport energy (99 percent) is from petroleum and only 2 petajoules is from electricity which is primarily for the Wellington suburban system, part of the Wellington bus network and the North Island main trunk section between Palmerston North and Hamilton. Table 1 below shows transport energy by mode for the year ending March 2007.

Table 1: Petajoules used as transport energy (EECA, 2009)

		PJ	Percentage of transport
Transport overall		221	100.0
Passenger transport		147	66.7
	Cars and vans	133	60.2
	Buses	3.5	1.6
	Rail	0.5	0.2
	Domestic air	10.3	4.7
Freight transport		74	33.3
	Road	69.4	31.4
	Rail	2.6	1.2
	Coastal shipping	1.5	0.7
Road transport		206	93.3
	Passenger	137	61.8
	Freight	69	31.4

Risks from Peak Oil and Climate Change responses
The two phenomena of Peak Oil and Human-induced Climate Change both together and individually create an imperative for <u>early action</u>, with the need to address Climate Change limiting the range of options that we can use to address peak oil.

Peak oil is often portrayed as a market phenomenon, as a period when demand will exceed supply. Consequently many believe in the market solution: excess demand will raise prices and promote more discoveries and therefore the problem will be self correcting. However peak oil is a geological not a market phenomenon. Debate continues over the nature of peak oil and when it may occur, but there are many indications of its imminence. Most models show that when peak oil occurs production could fall to only 20 percent of the current level within 50 years. A Canterbury University study (Dantas & Krumdieck 2006) predicts a very high probability of onset by 2020 with voluntary restraint as effective for only a few years and thereafter they predict increasingly severe rationing of any available supplies.

This uncertainty as to when Peak Oil will occur therefore places New Zealand in a period of high risk, when the foundations on which our economy depends may quickly become rationed to us both by our own Government and under the energy treaty framework which is in place. A logical risk reduction strategy would be early movement to set an alternate energy pathway in place.

Human induced climate change is now accepted by governments around the world as real and the need for action is now. Although NZ's climate change impact is small, there are several risks for us beyond the actual climate impact. New Zealand could become uncompetitive because we are locked in to high energy paradigms. New Zealand come become an unacceptable trading partner, both of export products and for tourism, because we are perceived as not making an equivalent contribution that other nations have to make.

The New Zealand Land Transport Strategy (2008) identifies a mix of measures to cut Transport GHG contribution, such as walking the many short trips less than 2 kilometres, to cycle more, to buy smaller much more fuel efficient vehicles, to double our use of public transport, to use bio-fuels and to consider purchasing electric vehicles. Freight too is targeted with an intended modest shift from road to rail and coastal shipping.

In times of uncertainty pursuing a mixed strategy, such as the NZLTS, can be seen as a sound approach. But it also can be argued that it is a hesitant high risk approach. The broad approach blurs the priorities for expenditure and action. For the general population, without any clear priorities, it can translate as a general admonition to "live better" which has little impact on the great inertia of the status quo that has become the entrenched way of life since the 1950s. Further risk arises from the implication of the NZLTS that meeting the short term targets would work to ensure that transport is moving in the right direction, but this may not be the case. A Swedish study (Akerman and Hojer, 2006) identifies that changes such as those contained in the NZLTS can make only medium reductions but deep reductions can only occur with a more fundamental change especially with regards to a much more intensive use of public transport and concurrent changes in urban form. It is better then, to embark on the more fundamental changes from the outset.

Early actions therefore greatly lower risk to New Zealand posed of both Peak Oil and Climate change in at least four ways. In contrast the "steady follower" strategy, which is currently being argued as a low risk strategy, is actually a high risk strategy.

Change Via Biofuels and Electric Vehicles

The major thrust of the NZLTS (2008) is to address the fuel use and fuel type so that the operation of the current infrastructure becomes more sustainable. We would still operate a large private car fleet and move heavy goods by road. The two main directions of this pathway are biofuels within conventional cars and electricity within electric cars.

Biofuels

There are many available feedstocks for biofuels. Attention is now moving from food crops to second generation biofuels from residues, waste streams, and biomaterials purpose grown on marginal land. An in-depth analysis lead by Scion (2008 and 2009) identified that New Zealand's maximum yield of liquid fuels from waste streams, effluent, and residues is about 15 Petajoules. This is sufficient for only about 7 percent of the light vehicle fleet. Scion proposed the possibility that all liquid fuels could be replaced by purpose grown forests which can be converted into either ethanol or biodiesel, as chosen. The yield is approximately 1 Petajoule per 10,000 hectares of forest, so the full 300 Petajoules of liquid fuels would require a forest of 3 million hectares, which is twice the current plantation area and would use about half the available marginal land. This forest would take 25 years to mature. Aggregate costs are not clearly identified. $24 billion is tentatively proposed not including a supporting road infrastructure but it is uncertain how much of forest establishment, land purchase and actual conversion plant infrastructure is included. Offsetting carbon credits for the forest would be available as a benefit. The conversion plant technology, beyond the pilot plant scale, is still developing but the commercialisation effort is occurring in many countries.

The Scion analysis of economic viability would require oil to cost US$180 per barrel (exchange rate NZ:US of 0.7) which is 2.2 times the price in August 2010 but only slightly above the high point of July 2008.

Such a pathway is attractive. Existing vehicles could be used with little or no modification, our supply of vehicles could still rely heavily on low cost used imports and a fuel distribution network is in place. The current surge of road building would be of use and the roading and urban infrastructure built up over the last 80 years would still be highly relevant. Almost all the beneficial properties of petroleum liquid fuels are retained. Further gains of a 20% energy reduction are available by using high efficiency vehicles and a further 30% energy saving if vehicles are downsized(de Pont, 2009) but the research shows a very strong reluctance to downsize to a car with less than the capability of the currently owned one. (Walton et al 2009)

There are significant disadvantages in a liquid biofuels pathway to a low cost low energy society, simply because it is not a low energy solution, nor is it likely to be low cost, and there would be threats to its certainty of supply.

The internal combustion engine is a poor user of energy, irrespective of whether the energy is fossil or biofuels. This engine has been viable with cheap and plentiful energy but it is much less viable with expensive manufactured fuels. In addition, about 20 percent of a car's total life energy consumption is embodied in the manufacture as calculated over typical current usage.

Biofuel will not be low cost for many years yet, at best. The production cost estimated may correspond to approximately $3 per litre, taking the forecast by Scion (2008 and 2009), but the consumer price will reflect the price of oil, if oil is more expensive. Biofuel as a liquid fuel can be readily exported so that its selling price will probably be a premium above the equivalent fossil fuel price and both these prices will rise steeply as oil supplies tighten. (This may indeed be the true role for that vision of biofuels from forests, that of a high value export.) In addition, just as food crop biofuels are available in relation to the main use of that food, the availability of biofuels from forest will also depend on the demand for the alternative use as timber. The future demand for plantation timber is also likely to be high.

Production costs are also a risk. The Motonui Synfuel project of the early 1980's, was also an emerging technology, not yet commercialised on a large scale before. Cost rose many times before completion

The long time to establish the forest also puts us on a slow trajectory for achieving greenhouse gas emissions reduction which therefore exposes New Zealand to the risks of slow response identified earlier.

Electric Vehicles

Individual electric vehicles are also advanced as another way to be much more effective at reducing greenhouse gas emissions within more or less the existing infrastructure. The term "electric vehicle" can be used to cover the range of vehicles from the electric recovery of kinetic energy as in the original hybrid car, a plug-in hybrid which has both a large storage battery for the primary electric motor and a small petrol/diesel engine to recharge this battery, through to full electric vehicles. The technology as it existed in 2008 is extensively reviewed in NZTA Research Report 391 (de Pont, 2009).

Full electric vehicles have existed for many years in Europe and Japan, as small light vehicles with limited range, configured for 1 to 2 people, for urban driving only, but do not meet the New Zealand vehicle safety standards. Recent international efforts have been concentrating on making the electric equivalent of the typical family petrol/diesel car. From the literature, (de Pont 2009, Gilbert 2008) it appears the main challenge is the storage battery, so as to give an acceptable range of 200-300 kilometres, and acceptable recharge times. Battery life (number of recharge cycles) is also an issue. Batteries are a very high component of the cost but may need to be replaced about the time of the middle of a normal car's life.

From the New Zealand perspective, to replace all 221 petajoules of liquid fuels used in transport with electric vehicles would require about 60 to 70 petajoules of electric energy, equal to 90 percent of current electricity from renewable sources (hydro, geothermal, and wind). To fuel all the light vehicles would require about 40 petajoules. The New Zealand Land Transport Strategy target of 30 percent light vehicles being electric would require about 13 petajoules, approximately 70 percent of the electricity consumption of the Bluff Aluminium Smelter.

As for the biofuels option, there are issues with electric vehicles. They are likely to be high cost and are unlikely to be readily available at the scale needed for many years. Once again our response to climate change and peak oil would be slow and therefore risky.

At conventional car size, they are an evolving technology. The three issues taking some time to fully solve are cost, battery capacity/travel range, and recharge time. The forecast production dates in the 2005-2006 literature are only now beginning to eventuate and any production is still very limited. For a long period, electric vehicles are likely to be only available as new vehicles and prices will likely be high as commercial logic is that they would be likely to be targeted at a premium above conventional equivalents for some time. New Zealand won't have the same ready supply of used electric vehicles available that we have had for conventional cars.

National impacts

Much of the current transport literature appears focused on technical capabilities and individual behaviour with respect to the uptake of particular technologies. Largely absent from this transport literature is discussion of the impact on national financial accounts of the collective behaviour, though some does occur in the economic literature.

The onset of Peak oil is likely to be accompanied by a period of large price increases, possibly interspersed with cycles of falling prices. Studies point to price increases of two and even four times current prices, that is US$150 to US$250 per barrel compared to today's (August 2009) current price of US$80 per barrel. (Donovan, et al.)

Vehicle prices are also likely to rise because energy costs into production will rise. All countries will be faced with the same challenges as New Zealand of needing to deal with peak oil and respond to climate change treaties and policies, so that high efficiency vehicles, hybrid, or full electric vehicles will be in high demand worldwide. We have benefited in the past from the Japanese premature obsolescence of its used vehicles so that two thirds of our fleet is imported at about 25 to 30 percent of the price which we would pay for the vehicle if new. In the new era, this situation is unlikely to continue but even if it did we would likely face much stronger competition for these desirable fuel efficient or electric vehicles.

Expenditure on transport currently averages at 14 percent of the total household expenditure with about half of this on the purchase costs and half on the operating costs and this split being fairly consistent across the income deciles. This is about the same amount that households spend on food. (Statistics NZ: Household expenditure surveys 1979-2006) This increased cost would be absorbed into individual household expenditure through reprioritisation, although the concept of houses moving into fuel poverty has already been articulated. (Dodson & Snipe 2007) However because we now import our total transport capability, higher fuel prices and higher vehicle costs will also impact heavily on the overall economy.

Table 2 shows the value of transport imports for June-years 2007 to 2010 and the value of some of our key exports. The table shows transport imports, at NZ$9 to NZ$10 billion per annum, are comparable to the export value of dairy products or about 3 times the value of forestry. Transport costs are equivalent to 25 to 30 percent of our total merchandised exports so at a national level we are poorly placed to be able to absorb an oil price rise of 100 to 300 percent or a doubling of vehicle prices.

Table 2: NZ$ millions of transport imports

Year ending June	Transport equipment *BEC521*	Passenger vehicles *BEC51*	Crude oil *BEC313*	Petrol and avgas *BEC321*	Total transport imports
2007	2,037	3,066	2,980	1,145	9,229
2008	1,924	3,187	3,650	1,337	10,098
2009	1,914	2,147	3,816	1,182	9,059
2010	1,051	2,513	3,838	1,287	8,688

NZ$ millions of key exports

Year ending June	Dairy Products[2]	Forestry Products[2]	Total exports
2007	8,383	3,571	34,934
2008	10,787	3,202	40,028
2009	11,429	3,522	43,028
2010	9,939	3,697	40,655

[1] *Statistics New Zealand, 2010*
[2] *Ministry of Agriculture and Forestry, 2010*

This was the situation in the mid-1970s and early 1980s when transport fuel tripled in price in the early 1970s then doubled again in price in the 1980s. The responses of that time, of restricted weekend fuel sales and carless days, were imposed as a form of rationing to assist both the balance of trade and a shortage in supply. The longer term response was known as "Think Big" which aimed for a measure of national self-sufficiency in liquid fuels, including expanding the Marsden Point refinery ($3 billion), the development of the Maui Gas Field, the Synthetic Petrol Plant ($3.5 billion), and the electrification of a section of the North Island Main Trunk railway.

The higher prices for fuel and the high costs of the response impacted across the whole economy for a 20 year period until approximately the early 1990s, a period characterised by rates of inflation of 5 to 12 percent (excluding the effects of GST, goods and services tax).

This experience appears common for the time and likely to continue in the future. A US study (Early and Smith, 2001) tracked oil prices, inflation, and economic growth in the US economy. The study identified the periods of high oil prices, if sustained, were followed by recession and significant rises in the consumer price index as the effect flowed through into secondary inputs across the economy. This study also showed that volatility in prices had a further significant impact on the consumer price index compared to a steady change scenario which is significant for the coming period where high volatility is expected.

An economic modelling of the Malaysian economy using an input-output model identified that a 100 percent rise in the price of oil then coupled with a 100 percent rise in the price of electricity showed price rises flowing across the economy to give an overall impact of a 13 percent price rise, two thirds of which arises from the oil price rise alone.

An alternative pathway to a sustainable transport infrastructure

In responding to the changes in transport initiated by peak oil and human induced climate change responses, we should seek to do much more than using coping strategies which just seek to mitigate the worst impacts of the need to change. Instead we should see how we can use the transition for economic advantage, and to recast our way of living to become a more successful and sustainable society. In deciding our response we should have regard to our natural advantages and not necessarily take lead from those countries where vehicle manufacture is a high component of the economy and so have a vested interest in continuing car dominated lifestyles.

Cars are a resource intensive lifestyle both high in cost and with a significant component of embedded greenhouse gas emissions which we use them for only shorts periods of each day and they fulfil an essential role only a few times each month. We could live quite easily without car ownership and devise other ways of catering for those few trips where they are actually needed.

It is our contention that our goal should be a society in which the major portion of personal transport is by electrified public transport or by active modes and that freight transport is also by electrified railways or by small to medium-sized electric freight vehicles in urban settings with biofuels being used for the residual heavy road freight. In many ways this imitates the transport balance of the 1930s to early1950s but in a much more highly technological way.

New Zealand has numerous advantages for this alternative pathway.

We have a large potential for generating renewable electricity but rather than automatically using this in electric cars we should reflect on what is the best way to use this in transport to deliver highly liveable cities and towns and economic gain.

Most of our cities are small and are well suited to simple public transport systems. Major parts of them evolved in walking and public transport era's and can therefore readily accommodate their re-introduction.

Most of our cities are of a size less than 6 kilometres radius where active modes are highly viable and we have a temperate climate which makes active modes in association with public transport viable and enjoyable year round.

A public transport scenario can be implemented quickly. Whereas second generation biofuels and electric vehicles are emerging technologies with substantial delays, 15 to 30 years, before a full deployment would be possible, we have an existing public transport infrastructure already in place so that we can make an immediate start, then, by channelling our investment into it, public transport can be much improved to deliver the three requirements that make any transport system a success: speed, comfort, and reliability(Litman 2008) An early start puts us into a good competitive position with respect to slow start countries such as Australia which has both a coal sector and motor vehicle sector to protect.

We also have a rail system, part electrified (550 kilometres), that at its height stretched for more than 5,000 kilometres, reasonably comparable to the current 10,000 kilometres of State highway network. Though this rail network is everywhere reduced and rundown, the tracks and rail reserves still connect almost all of the cities and towns of New Zealand to each other and to our export hubs.

The ability to make an immediate start has its challenges. It removes the excuse for procrastination as we wait for the new technologies to develop. It forces us to confront our disjunctive attitudes of landscapes and waterways too precious to spoil with renewable energy generation, but we maintain a high energy fossil-fuelled lifestyle.

There are a number of ways by which a transport system based around electrified public transport enables us to do better particularly with respect to being low cost low energy society. Advantages of electrified public transport over and above those that would accrue from just moving away from imported fuels to biofuels and electricity for cars include:

*Energy use is lower***.** Although the electric car has a much better energy efficiency than petrol cars, at 0.4 to 0.7 Megajoules per person kilometre, electric passenger transport can do even better providing loading is adequate. Even the old tram technology of the early 1900s in New Zealand was providing effective transport of 0.37 to 0.4 Megajoules per person kilometre in cities such as Invercargill, Wellington, and Dunedin. The 9 cities with electric trams had a total population of 0.5 million serviced by these tram systems and their total urban travel was delivered by 49 million kilowatt hours (0.2 Petajoules) in 1928. (New Zealand Yearbooks) Some literature indicates modern passenger transport can achieve 0.2 Megajoules per person kilometre.

*There is a much better investment and use of resources***.** At current expenditure we would over 20 years invest $60 billion in a private car fleet. We have already discussed that this cost could easily double if the source of low cost used vehicles stopped. Yet we use this resource little more than 5 percent of each day, often less, and use cars for those trips that influence our perceived need for a car and a car of a particular size only several times in a month. In contrast passenger transport continues to be useful throughout the day, typically making 30 round trips in an 18 hour day over an 8 to 10 kilometre route, and carrying many hundreds of people to their destinations.

*Household budgets benefit***.** Litman identifies reductions in household expenditure on transport of 30 percent for cities where a quality passenger transport system exists and 50 percent reductions for those living in Transit Oriented Design developments. His analysis includes savings in both fuel and parking charges including offsets in increased taxes to fund the development, and marked decreases in vehicle ownership. As already identified, rising fuel and transport costs will trigger increases across all portions of the household expenditure profile and large transport cost reductions will greatly assist.

A public transport based society in conjunction with active modes provides flexibility for future populations. Statistics New Zealand predicts slow growth in all but the major cities The population median age is also expected to increase by nearly 10 years by 2030. These projections are based around a population of about 5 million by 2040. But projections are highly variable and a population of 6 million is also possible as the high forecast. BERL indicate a linear projection of the last 20 years results in a population of 8 million by 2040. With a well developed passenger transport system much of this increase will tend to be accommodated within existing urban boundaries, this growth pattern already being confirmed in cities that developed high quality passenger transport systems in the 1980s and 1990s. A more dense population based around passenger transport nodes has been shown to promote mixed land use and land value uplift and a net gross domestic product growth over and above what would occur if the same population was spread out at the existing density (Bannister

2007). Studies by Ascari and BERL in association with the Auckland Regional Council have identified the emergence of this same trend in Auckland. In addition many of the immigrant groups, especially those from east and south Asia, are already predisposed to a more dense living style, public transport use and are entrepreneurial in establishing the associated small businesses.

There are economic growth and health benefits associated with use of passenger transport and active modes. Litman's analysis (Litman 2010)of the high quality transport areas points to other sources of benefit. Although the use of passenger transport is much greater in high quality transport areas than for non-quality passenger transport areas, the number of walking trips in the areas of high quality public transport had also risen, and by a much greater extent. What this implies is that the *potential* to use passenger transport, rather than necessarily its actual use, has broken the car dependence cycles and many shorter trips previously made by car are now walked. This higher incidence of walking gives the obvious benefits of a fitter more healthy population with spin-off benefits of reduced health costs but the greatly increased foot traffic sets up the potential for a growth in the service and retail sector with consequent growth in gross domestic product. This is confirmed in New Zealand settings by Ascari and BERL in Auckland studies showing the same trends in gross domestic product growth around passenger transport nodes and by BERL (Norman D & Sanderson K 2010)in Wellington where there is a definite relationships between the quality (as frequency) of the passenger service and the combination of use of passenger transport and active modes.

High value immigrants are attracted. It is well recognised that we need to attract skills into the country in many skill categories. A highly liveable low energy society will attract highly educated and skilled immigrants, as well as provide a point of difference for local high level skills that may otherwise be attracted offshore.

Additional economic gains can occur. High quality passenger transport allows other benefits such as productivity gains. These can occur by working on the passenger transport journey or as a result of being more productive through arriving at work more invigorated by the journey to work.

Progressing the transport infrastructure for a low-cost low-energy society

Progressing this low energy low cost transport infrastructure can be achieved by importantly first addressing the energy supply issue, then concurrently redirecting funding away from roading to increase current service levels of public transport, then expand the networks to better serve the cities, which will in turn initiate changes in urban form around these transport networks so as to reinforce the effectiveness of these new forms

Develop the Energy Supply: The current energy usage of petroleum in transport of 221PJ in 2007, equates to approximately 55 to 60PJ of electricity. In addition to this the target for electricity to be 90 percent from renewable sources requires a further 60PJ of renewable energy. The New Zealand Energy Outlook in its "renewable only" scenario cites the potential resources available as shown in Table 3 where "High" and "high-medium" denote the likelihood of the source being available at a reasonable cost. (8860MW corresponds to approximately160PJ). The likely additional capacity allows more than sufficient for the 120 PJ needed to meet both renewable targets for electricity and an electricity-based transport system. Sequencing and integrating the development of energy infrastructure and transport infrastructure will be critical and it likely to need a much more direct involvement of Government in this lead investment than the current market model.

Table 3: Likely additional renewable electricity sources

Source	High probability	High-medium probability
Hydro	925 MW	1,790 MW
Geothermal	365 MW	435 MW
Wind	2450 MW	4,885 MW
Wave		1,750 MW
	3,730 MW	**8,860 MW**

The Government Policy Statement on land transport funding (2009/2010-2018/2019) plans to spend approximately $30 billion in total, with 42 percent on new roads and 15 percent on road renewal but only 5% on public transport expenditure via the New Zealand Transport Agency. Separate funding of rail projects, primarily the Auckland and Wellington passenger rail improvements, are $3.2 billion by 2013 only about 20 percent of that planned on new roads. While clearly we need to maintain our existing roads there is little need to build new ones to increase capacity. Existing capacity is sufficient given a likely reduction in vehicle ownership of more than 50%. Much of this funding could therefore be redirected towards the alternate transport system.

It has been demonstrated both historically and again in the last 20 years that lead investment in public transport initiates changes in urban form, a trend that will be even stronger in future eras less favourable to car travel. However, this evolution in form, either towards or away from Public transport networks, can take many years (20-40) to evolve, depending on the strength of the economic drivers and political leadership that is provided. If lead investment in passenger transport is to be by technocrats then the tools for economic and social cost-benefit analysis need to be much more accurate. Alternatively we should recognise that the allocation of funding priorities is essentially a political process so we should in a political context, make decisions of how to address this changing future. (Rhema Viathianathan 2009)

An immediate start can be made by first increasing services, then establishing networks and this can be coupled with investment in a new fleet/and or modes.

All major NZ cities, provincial cities, and large towns have an existing public transport system but which is under-deployed. Primarily it is targeted at the weekday peak time travel to and from work and education. Services are greatly reduced on weekends although trip volumes are similar but purposes different. To be an effective mode of travel, timetable frequency needs to be increased both daily and across the 7 days of the week.(Dravitzki and Lester, 2007).

The traditional route structure does not suit the dispersed origins and destinations of car-based systems. New Zealand Transport Agency report 396(Mees et al) *Public Transport Network Planning* shows that effective systems for current city forms can be devised based on the public transport on an intersecting network, multi-ride ticketing, and building up an approach based around directness, clarity of route and stops, comfort, and speed. This can deliver adequate transport until urban form adapts. Expanding the network could be either by road-based vehicles, such as trolley buses, and rail-based lines set in the streets as in modern trams and light rail. There is a developed literature that rail-based systems better signal permanence and encourages both behavioural change and a more public transport orientated urban development about them.

Our streetscape also needs to be altered. To ensure speed and reliability the dedicated space needs to be assigned to the passenger transport system and this will constrain the space available for cars. Their space will be further constrained by increasing the available space for active modes. The street style of the 1970s onwards also needs adjustment where it exists and discontinued for areas of further development. This curvilinear system with few interconnections suits a hierarchical road style and land yield, but is unfavourable for active modes, passenger transport, and energy use because the indirect nature increases journey length.

Freight

Much of the previous discussion has had a focus on passenger transport, in part because the movement of people is that part of transport most prone to impediments that may arise from notions of lifestyle. However one third of the land transport energy (67 PJ) is used by vehicles identified as freight vehicles. This distinction is made because it is suspected that while heavy freight vehicles move a majority of inter and intra regional freight, a major contribution to freight movement within the city is made by light commercial and domestic cars, which collectively move goods from warehouse to retail store, deliver internet purchases, and complete the final leg of the freight journey by moving the goods from store to our homes.

This freight movement, especially the heavy freight component is highly vulnerable to both fossil fuel prices, and to availability of supply, since, as with the passenger transport, the pre-eminence of rail up until the late 1960's been supplanted by a transport mode in which both vehicles and fuel are imported. Low cost freight, with reduced exposure to volatile fuel prices, high fuel prices and fuel availability are critical to the success of export sector. A major shift to an indigenous fuel such as electricity will have much more opportunity for price stability and deliver economy wide benefits to both the internal economy and the export sector. Railway electrification, first mooted almost 100 years ago, is an obvious choice and is reasonably straight-forward. In the 1980s, 410 kilometres of railway were electrified for a cost then of only $250million which included the locomotives and ancillaries.

However a recent study (Cenek et al) has identified another issue which will impede a shift to rail, that of track condition. This study compared to impact on the load of the roughness of the track compared to the impact on the load of the roughness of the road. The comparable ratio of impacts sufficient to cause the container to momentarily lift from the deck of the truck or wagon (an acceleration of 10 metres per second^2) was of the order of 100:1 of rail : to road. This finding highlights that rail is only suitable for bulk goods such as timber, milk, coal and the like that can withstand the rough journey. A major shift to electrified rail would need to be accompanied by a very significant track improvement and increased sections of double tracking to increase capacity.

Electric vehicles are viable for light and medium freight in urban settings. Elsewhere the remaining freight capacity could be delivered by biofuels.

Conclusions

- Peak oil and climate change considerations provide specific imperatives to alter our transport infrastructure because of its heavy reliance on fossil fuels.

- Over the past 60 years, New Zealand has altered its land transport infrastructure to be almost totally dependent on imported energy and vehicles, and we are vulnerable to both increased prices and restrictions in supply, both of which are increasingly likely to occur at the same time.

- Biofuels and electric vehicles are viable options as alternatives to fossil fuelled conventional vehicles on an individual basis, but they are both likely to reflect the increased world price of oil substitution. Collectively at the national level, New Zealand would have difficulty paying for much higher priced energy or the derived vehicles because transport imports are already of an equivalent value to 25 percent of our merchandise exports.

- Entrepreneurs use times of change to improve their position. As an entrepreneurial nation New Zealand should take the opportunity of the necessary changes to build an economically successful, low cost, low energy society and highly liveable towns and cities.

- An alternative pathway is to move resources so as to develop a new infrastructure around electrified passenger transport and an electrified freight capability because such a pathway will deliver highly liveable urban forms and generate economic benefits through lowered transport costs and through gross domestic product growth that arises from the processes of densification and mixed land use. Supporting investment is needed to establish the electrical energy supply based on renewable resources. Sequencing and integrating the development of energy infrastructure and transport infrastructure will be critical and it likely to need a much more direct involvement of Government in this lead investment than the current market model..

- Lead investment is required. It can be justified by progressively developing the methods and economic tools by which the benefits can be assessed and the limitations of the current predict and supply approach need to be recognised. Alternatively a much quicker pathway can be progressed by a more qualitative approach informed by evidence of overseas experience supported by limited New Zealand experience and implemented via the political decision making process.

- There is a substantial body of experience in other countries and starting to emerge in New Zealand that urban form will respond to lead investment in public transport, providing more dense settlement pattern, decreasing car usage and leading to both economic gain and more liveable cities

References

Akerman J, Hojer M, How much transport can the climate stand?- Sweden on a sustainable path in 2050. Energy Policy 34 (2006), pages 1944-1957.

Banister, D. (2007) Quantification of the non-transport benefits resulting from rail investment: Working paper no. 1029. Transport Studies Unit, Oxford University Centre for the Environment: United Kingdom. Available at http://www.tsu.ox.ac.uk/pubs/1029-banister.pdf (accessed August 2010)

Bioenergy Options for New Zealand - Pathways analysis; Energy demand, Pathways evaluation, Economics of purpose grown energy forests, Life cycle analysis of biomass resource to consumer energy. Various Authors, Scion, 2008

Bioenergy Options For New Zealand – Transition analysis – the role of woody biomass from existing forests and drivers for change in energy supply in New Zealand. Various Authors, Scion, 2009

Dantas, A., Krumdieck, S., Page, S. 2006. Energy Risk to Activity Systems as a Function of Urban Form. *Land Transport NZ Research Report 311.* 75pp.
de Pont, JJ (2009) Low-emission fuel-efficient light vehicles. NZ Transport Agency research report 391. 118pp.

Dodson, Jago and Sipe, Neil 2007, Oil Vulnerability in the Australian City: Assessing Socioeconomic Risks from Higher Urban Fuel Prices, Urban Studies, Vol. 44, No. 1, pp. 37.

Donovan S, et al; Managing transport challenges when oil prices rise – Research Report 357, NZTA, 2008

Dravitzki, V. and Lester, T. (2007) Can we live by public transport alone? Transport: The Next 50 Years, 25-27 July, 2007. Christchurch, New Zealand.

Dravitzki, V. &Lester, T. (2009) Some interesting old transport data and where to find it. Paper presented at the 32nd Australasian Transport Research Forum, 29 September - 1 October 2009. Auckland, New Zealand

Dravitzki, V., Lester, T., and Walton, D. (2010) Social/recreational travel and its influence on transport's greenhouse gas emissions. Road and Transport Research: A journal of Australian and New Zealand research and practice, 19(1)

Earley, R. and Smith, K. (2001). Energy Price Impacts on the US Economy (April 2001). Energy Information Administration: United States. Available online http://www.eia.doe.gov/oiaf/economy/energy_price.pdf (accessed August 2010)

EECA (2009) Energy Efficiency and Renewable Energy in New Zealand, Year Six Report: March 2001 to 2007. Monitoring and Technical Group, Energy Efficiency and Conservation Authority: New Zealand. Available at http://www.eeca.govt.nz/sites/all/files/year-6-monitoring-report-01-2010.pdf (accessed August 2010)

Gilbert, R and Perl, A. (2008) *Transport revolutions: Moving people and freight without oil*. Earthscan: United Kingdom

Ministry of Agriculture and Forestry (2010) Situation and Outlook for New Zealand Agriculture and Forestry (June 2010). MAF Policy, Ministry of Agriculture and Forestry: New Zealand. Available at http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2010/2010-sonzaf.pdf (accessed August 2010)

Norman, D. & Sanderson, K. (2010) Relationships between passenger transport use and urban form in New Zealand. (Working paper ref #4756). Wellington: BERL Economics.

Litman, T. (2010) Raise My Taxes, Please! Evaluating Household Savings from High Quality Public Transit Service. Victoria Transport Policy Institute: Canada. Available at http://www.vtpi.org/raisetaxes.pdf (accessed August 2010)

Litman, T. (2008) Build for Comfort, Not Just Speed: Valuing Service Quality Impacts In Transport Planning. Victoria Transport Policy Institute: Canada. Available at http://www.vtpi.org/quality.pdf (accessed August 2010)

Rhema Viathianathan, An economic critique of urban motorways: the case of the wateview connection in Auckland. Road and Transport Research, Vol18 no3 September 2009
Statistics New Zealand (Ongoing) Overseas Merchandise Trade dataset. Statistics New Zealand: New Zealand. Available at http://stats.govt.nz/browse_for_stats/industry_sectors/imports_and_exports/overseas-merchandise-trade.aspx (accessed August 2010)

Stern, N. (2006) The Stern Review. The Economics of Climate Change, Cambridge University Press, Cambridge.

Thomas, J., Cleland, B., and Walton, D. (2004). Working paper: Review of current measures of New Zealand settlement liveability. Opus International Consultants Central Laboratories Report 520951.01

Wallis, I. (2008) Economic Development Benefits of Transport Investment: NZ Transport Agency Research Report 350. NZ Transport Agency: New Zealand. Available at http://www.nzta.govt.nz/resources/research/reports/350/docs/350.pdf (accessed August 2010)

Walton, D., Thomas, J.A., Smith, K., Lamb, S., Murray, S. (2009) Exploring the match between desired vehicle utility and actual use in different vehicle types. *Transportation Research Part A.* (Under review, July 2009).