
Demographic, economic and technological trends and their implications for transportation planning

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Abstract

Transportation is an essential factor in the viability of human communities, but inevitably consumes large amounts of land, energy and other non-renewable resources. Unavoidably, there is a direct conflict between social and economic well-being, and the need for environmental sustainability.

For successful resolution of this conflict, policies need to be based on a clear understanding of demographic, economic and technology trends since 1953. An ageing population, together with trends in household formation, industry and employment, have substantially altered society's transport needs. Recent decades have also seen improvements in technology and a steady strengthening of road transport, particularly the private motor car, as the dominant transport mode. This dominance is perhaps reaching the point where alternative forms of transport are finding it difficult to remain viable.

There is a need to establish an effective role for the various transport modes within the overall transportation system, and to ensure their scope and function are sustainable within the New Zealand context. One means of doing this is to rank each mode in a hierarchy according to cost, efficiency and effectiveness, and using the hierarchy as a basis for policy. Based on the hierarchy, a possible planning response might be to encourage walking and cycling, ensure a safe and serviceable road network, and provide for various forms of public transport as required.

1. Introduction

It is now half a century since passage of the Town and Country Planning Act 1953, fifty years of profound change in society, industry and technology.

Present transportation systems are both a cause and effect of these changes. Better transport has influenced land use patterns at the same time as expanding population and rising affluence has fuelled transport demand.

The intimate relationship between transport, access and land use has made it difficult to separate *beneficial* effects of transport in enabling mobility and



promoting development, from the *adverse* effects of resource consumption, pollution, and environmental degradation. There can be few areas of planning in which the conflict between *social, economic and cultural well-being* and *environmental sustainability* is more sharply defined, or more difficult to resolve.

Nor will solutions be any easier during the next fifty years, constrained as they will be by tight finances, exacting technical requirements, and high expectations for environmental quality. Transportation planners will need a very clear understanding of underlying processes and relationships if they are to keep abreast of change and address the issues with any degree of success.

2. The trends – a review

New Zealand is now a very different place from what it was in 1953. Population has almost exactly doubled, from an estimated 2,048,800 to a figure expected to reach 4,000,000 in May 2003¹. It is also wealthier, with per capita Gross Domestic Product increasing by 64 per cent in real terms.

Despite a high birth rate immediately after World War 2, the population age structure has remained fairly stable for most of the subsequent period, as Table 1 shows.

| Age group | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 (est.) |
|-----------|------|------|------|------|------|-------------|
| 0-19 | 36.2 | 40.8 | 40.9 | 36.4 | 31.3 | 28.5 |
| 20-64 | 54.7 | 50.6 | 50.6 | 53.6 | 57.3 | 59.3 |
| 65+ | 9.2 | 8.6 | 8.5 | 10.0 | 11.3 | 12.2 |

Table 1: Age structure 1951-1996 (%)²

There have been only slow changes in the relative proportions of working and dependent cohorts (youth and elderly), and the predicted aging of the population is only now beginning to gain momentum, with the major impacts still in the future.

More pronounced have been changes in composition of the labour workforce, in particular rapidly increasing involvement by women (Table 2), and a steady rise in the proportion of part-time work (Table 3):

| | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 |
|--------|---------|---------|-----------|-----------|-----------|-----------|
| Male | 566,300 | 670,500 | 785,000 | 870,900 | 917,600 | 1,068,000 |
| Female | 174,000 | 224,800 | 333,900 | 450,700 | 704,400 | 894,800 |
| Total | 740,300 | 895,300 | 1,118,900 | 1,321,600 | 1,622,000 | 1,962,800 |

Table 2: Labour force involvement by sex³



From a situation where men dominated the workforce, New Zealand is now close to the point where the sexes are numerically equal. In absolute terms the effect of women entering the workforce has been even more dramatic, with a fivefold increase in numbers.

Increased participation by women has major transport implications. A second breadwinner in many households provides both the need and the means to purchase a second car, improving mobility for both work and non-work purposes and resulting in a substantial rise in trip generation. New Zealand is now close to the point where 50 per cent of households have two or more cars.⁴

Employment is still dominated by full-time jobs, but part time labour has risen from negligible proportions to being a significant minority of total work, as shown in Table 3.

| | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 |
|------------------|------|------|------|------|------|------|
| Part-time | 3.2 | 5.7 | 10.2 | 14.4 | 18.4 | 21.0 |

Table 3: Proportion of part time jobs (%)⁵

The trend to more flexible employment is also reflected in working hours for full-time employees, and in 2001 32 per cent of the labour force worked more than 40 hours per week. In all, around half the workforce are employed for significantly less or significantly more than the standard 40-hour week. This means that many work start and finish times will be outside the normal commuter peak periods, and will be poorly served by public transport services.

The number of cars on New Zealand roads has burgeoned by a factor of over six, from around 300,000 to nearly 2,000,000. Usage has grown even faster, and since 1979 total car travel has more than doubled during a period when the number of cars increased by only 50 per cent. Use of other vehicles has also grown rapidly, and there are now some 40 billion vehicle kilometres travelled per year. (Refer to Figure 1.) In the same period there have been only minor changes to the extent of the roading network, so traffic densities have roughly doubled in a 20-year period, with the greatest increases in areas of rapid population growth.



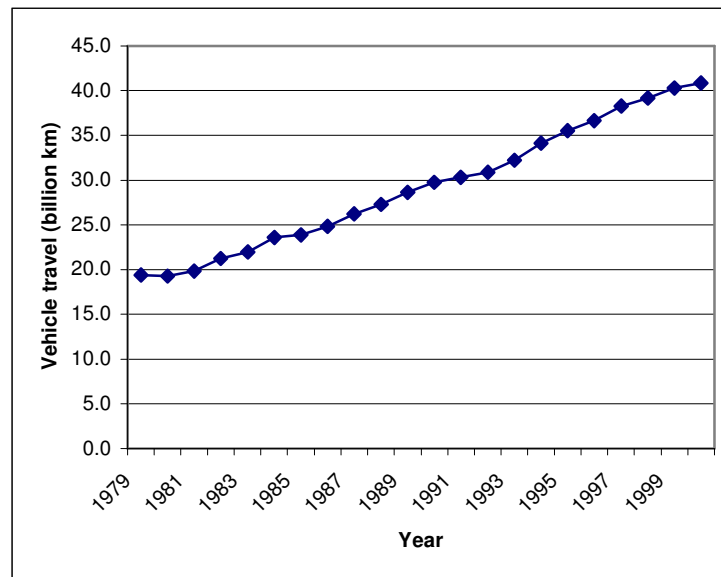


Figure 1: Total vehicle-kilometres travelled (1979-2000) ⁶

In 1953 the rail network was at its greatest extent, with a route mileage of some 5,700 kilometres. It was even then in a state of transition, from a role of universal carrier to one of niche specialist. The process has often been a painful one, with closure of branch lines, withdrawal of services and retrenchment of staff, and the network has now been reduced to a length of 3,900 kilometres. Despite this, freight tonnage has increased from 10 to 14 million tonnes per annum. Average haul distance has also increased, and together with the increased tonnage has resulted in a doubling of the number of tonne-kilometres carried.⁷

Volumes of freight by all modes are now many times those of 1953. The flow of freight is reflected in port cargo volumes, and it is worth remembering that a significant proportion of all freight passes through the country's seaports. In 1953, total cargo traffic amounted to only 7.9 million tonnes. By 1980 this had increased to 31 million tonnes, and today the figure is around 50 million, more than six times the 1953 total.⁸

3. Sustainability: energy efficiency

Transport systems use many different resources, but in an assessment of long-term sustainability a major concern must be in the consumption of energy, particularly non-renewable fossil fuels. As well as the issue of the depletion of world reserves, use of petroleum fuels also correlates with environmental effects such as air pollution and carbon dioxide emissions.

The last 50 years have seen a steady rise in the use of petroleum, from 59 petajoules in 1954 to 220 in 2000, some 85 per cent of it for transport



purposes⁹. Consumption rose rapidly during the 1950s and 1960s but levelled off after 1973 as prices increased sharply. The subsequent period is shown in Figure 2, and it will be seen that since the mid-1980s, fuel prices in real terms have returned to levels similar to those of 1971, prior to the energy crisis of 1973. Cheaper fuels have been accompanied by a resumption in the upward trend in usage.

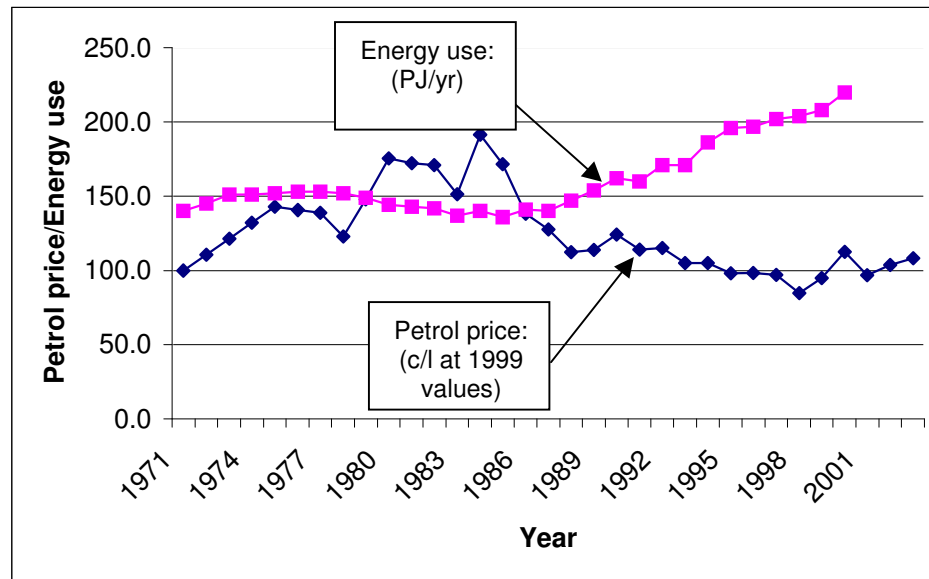


Figure 2: Petrol price trend and petroleum consumption since 1971¹⁰

Comparing fuel usage with total distance travelled as shown in Figure 1 earlier, one finds that high prices and supply disruption in the late 1970s caused no more than a short pause in traffic growth. Rather than limit their travel, it appears motorists of the time acquired more efficient vehicles or switched to alternative fuels. These habits were later abandoned when fuel prices fell in real terms.

Despite this efficiencies overall are improving, and by comparing Figures 1 and 2, it will be seen that since 1979 vehicle distance has more than doubled while total energy consumption has increased by only 50 per cent. For freight transport in particular, fuel efficiency now compares well with rail for long-haul work, for which the two modes most directly compete. In 1998, railways in New Zealand consumed approximately 0.75 megajoules per tonne-km for diesel-hauled freight operation. (One litre of diesel fuel yields approximately 38 MJ of energy.) A large articulated truck can now achieve efficiency in the order of 1.0 MJ/t-km under a range of loading conditions, with consumption as low as 0.75 MJ/t-km when fully-laden. When the two modes are compared on a door-to-door basis (including transport to and from the railheads), rail offers few energy savings for many types of cartage.¹¹



Nor are electric-hauled trains much better in energy terms. For the North Island at least, the marginal kilowatt of energy is produced from thermal power stations, and the thermal efficiency of a power station after transmission losses are taken into account is probably not much different from that of a modern diesel engine.

Road transport efficiency also compares well for the transport of passengers. This is a difficult matter to assess because of wide variations in load factors, vehicles and operating conditions but Table 4 gives typical values. The table is of Australian origin but similar comparisons will apply for New Zealand.

| Mode | Energy consumption (MJ/pass.-km) |
|--------|-------------------------------------|
| Cars | 2.7 |
| Buses | 1.1 |
| Trains | 1.3 |

Table 4: Energy efficiency for passenger modes¹²

These nominal efficiencies should not be compared without taking into account the greater flexibility of car travel. Cars provide direct door-to-door transport without the problems of collecting and distributing passengers faced by trains and buses. Commuter cars can be parked at their destination all day, without the need for repositioning travel or empty back running. Overall efficiencies will be closer than Table 4 indicates.

For both passengers and freight, road-based transport is at least competitive with rail in terms of energy efficiency. Although rail and other modes will have advantages in certain situations, a general transfer between modes is unlikely to result in worthwhile energy savings. Perhaps the most promising avenue for improvement is to promote greater efficiency of road transport, for example with smaller, more efficient vehicles. This could be done with measures such as higher fuel prices or efficiency standards. If past experience is repeated, higher prices will moderate consumption but do little to slow the growth in traffic.

4. A hierarchy of transport modes

Energy use might be an issue of strategic importance in transportation planning, but there are some more immediate concerns to be addressed.

Prominent among these is the desirability of providing mobility for the transport disadvantaged. A major issue in a car-based society is the plight of those who cannot drive because of youth, old age or disability, those who do not own a car or who do not have a car available during the day. This group typically makes up a third or half of the population, and if it is to engage effectively in society suitable transport needs to be available.



Another is cost. In most cases land transport systems require large amounts of public money, not all of which can be recovered from users. Where public subsidies are required, there is a duty both to control the amount of expenditure, and to ensure it is effectively applied.

While energy efficiency might not be decisive in determining which travel modes are to be preferred, this does not mean planners should be indifferent to how modes are used. There are very clear variations in both effectiveness and cost, and these differences provide a platform for policy.

| Mode | Vehicle | Typical cost (\$) |
|------------|------------------------------|-------------------|
| Air travel | Jet airliner (100-300 seats) | 100,000,000 |
| Rail | 148-seat electric unit | 4,000,000 |
| Bus | 40-50 seat suburban bus | 300,000 |
| Car | Small to medium sedan | 30,000 |
| Bicycle | Commuter cycle | 1,000 |
| Walking | Pair of shoes | 100 |

Table 5: Hierarchy of modes

Table 5 shows a hierarchy of passenger transport modes based on level of cost and sophistication. A representative vehicle purchase cost has been used as an indicator in each case, which for most of the modes will correlate with operating cost and the amount of infrastructure (both physical and organisational) required. There is also a relationship with flexibility, and it will be found that the modes low in the table will be more flexible and easier to operate than those higher up.

The important point to note is that each successive level in the hierarchy involves cost an order of magnitude greater than that of the previous level. In most cases the increasing size of vehicle is insufficient to offset the additional cost, resulting in a higher cost per passenger.

It follows that there should be a strong preference for modes low in the hierarchy, and higher modes only used when lower ones become inadequate or ineffective. This means that the first priority should be for developing walking and cycling modes to their full potential, then providing for cars and buses. For most New Zealand cities these modes will be adequate to meet transportation needs, but in large centres there may also be a case for rail services, to supplement the capacity available on the roads.

5. Looking ahead: the next 50 years

Factors behind the present relentless growth in road travel appear likely to continue. Car ownership, already at a high level, can be expected to increase further. Women continue to enter in the work force in increasing numbers, and



it remains to be seen whether the trend will level off once there are more women than men. A flexible and diverse workforce will continue to demand effective personal transport. Aging of the population has yet to have a major impact, but in time will increase the total number of licensed drivers.

Rapid growth in freight movement since 1953 shows no sign of abating, and further substantial growth can be expected.

There may be attempts to restrain travel demand, through tolls, taxes or regulation. Tolling schemes however face an inherent dilemma:

- If the toll *doesn't* influence driver behaviour, then it is no more than a complicated way of raising money.
- Any change in behaviour which *does* occur may well be unhelpful, such as discouraging use of a new road at the expense of existing roads. One can imagine for example the effect if a toll was applied to a road such as the Auckland southern motorway.

For these reasons, tolling may not have wide application in New Zealand, although there may be scope for indirect methods such as the control of commuter parking.

While the private motor car will continue to dominate, it can never meet all requirements. Public transport will need to be available for those without personal transport of their own, or to supplement private transport to destinations such as central business districts.

Given economic, environmental and technical constraints, growth in road traffic is unlikely to be matched by increased road capacity. There will be higher traffic densities on many roads with a need for vigorous traffic management. This means for example a more rigorous separation between through and local traffic, with firm controls on both land use and access along arterial routes.

These issues become particularly acute when roads need to be widened to four lanes. On busy multi-lane roads, minor intersections tend to be unsatisfactory, and need to be replaced by widely-spaced major intersections. In rural areas, long lengths of median barrier creates major problems for property owners, who will be restricted to left-in left-out access. As a result, four-laning should be accompanied by development of a secondary road network to cater for local access, a process which needs to be planned well in advance.

Road safety will continue to be a major issue, although the aging population may mean a shift from speed and alcohol campaigns directed at young drivers, toward measures such as the adoption of more conservative road designs to meet the needs of elderly drivers.



Energy use will be an important issue in the on-going sustainability of transport. For passengers, road-based solutions will in general be the most efficient. For freight, there are unlikely to be large energy savings by a general transfer to rail, although rail will offer advantages in certain types of haulage.

Perhaps the most promising avenue for moderating energy demand lies in improved road transport technology, with the prospect of significant gains through advances such as:

- Better materials and fuels.
- Improved combustion, and better injection and transmission systems.
- More diesel-powered small vehicles.
- Higher weight limits for large trucks.

These developments offer significant gains, and could be readily applied. Further in the future, dramatic improvements in efficiencies are in prospect through emerging technologies such as hybrid engines (petrol-electric or diesel-electric) or fuel cells.

Government intervention may be required to encourage use of new technology, especially in the light vehicle fleet. Measures might include higher fuel prices, or fuel efficiency standards.

6. Conclusions

The last 50 years have seen major changes in society and its transportation needs. Population is now twice the level of 1953, with radical changes particularly in the composition and structure of the work force. A more diverse and versatile labour force has a high need for convenient, flexible personal transport.

Road transport has strengthened its position as the dominant mode for both freight and passengers. The number of cars has increased by a factor of six, with traffic levels doubling in the last 20 years alone despite high fuel prices in the early 1980s.

In New Zealand differences in energy consumption between the various transport modes is relatively small, and there is only modest scope for saving energy by switching to modes such as rail. Continuing technological advances should however offer useful improvements in efficiency.

In considering the roles of different transport modes, it is possible to construct a hierarchy of modes based on their relative cost and sophistication, and



ensure the lowest modes are fully developed before higher levels are provided for.

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NOTES AND REFERENCES

1. Statistics New Zealand estimates.
2. Censuses of Population and Dwellings, as published in annual New Zealand Yearbooks.
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5. Household labour force survey.
6. Car registration data from official sources. Vehicle travel: from National Traffic Database as published on Ministry of Transport website.
7. Freight tonnage from successive Yearbooks, freight travel estimated at 3.4 billion tonne-kilometres from tonnage and freight haul distance.
8. New Zealand Yearbooks.
9. Ministry of Economic Development, as quoted in 2002 *New Zealand Yearbook*.
10. Petrol price is retail price at pump for 96-octane fuel, adjusted to 1999 prices using Consumer Price Index. Energy consumption from Ministry of Development data as quoted in successive Yearbooks.
11. Fuel consumption for rail derived from published consumption figures for 1997-98 (56.6 million litres) and 3.4 billion tonne-kilometres, with an adjustment for electric-hauled trains. Truck consumption based on large articulated truck having a consumption of 50 litres/100 km and a payload of 25 tonnes.
12. Figures in table are from Table A.6 of *Back on Track: Rethinking transport policy in Australia and New Zealand* by Philip Laird, Peter Newman, Mark Bachels and Jeffrey Kenworthy (University of New South Wales Press 2001).

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