PEAK OIL VULNERABILITY
ASSESSMENT FOR DUNEDIN

Prepared for the **Dunedin City Council**
by **Dr Susan Krumdieck and EAST Research**

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EXECUTIVE SUMMARY

Five development objectives to enhance the adaptive capacity and wellbeing of Dunedin:

1. Plan to reduce oil consumption 50% by 2050.
2. Transition Dunedin's urban form to central city lifestyle development and urban villages, accessed by 100km of safe cycleways and pedestrian zones and served by public transport.
3. Build an electric trolley bus system (potentially iconic) using efficient modern technology made in New Zealand.
4. Improve Dunedin's average vehicle fleet efficiency to 5 litres per 100km by 2030.
5. Audit and track Dunedin's residential and business fuel and lead in the development of action plans for fuel shortages.

This report to the Dunedin City Council is a research and engineering-based analysis of Dunedin's vulnerability to Peak Oil. The report identifies how the Council's sustainability framework objectives can be achieved while addressing the issue of declining world oil supply and high fuel price. A strategic analysis process was used together with new modelling capabilities, data analysis and surveys of residents and businesses. The key recommendation is that the city's urban form and transport infrastructure could be enhanced to provide adaptive capacity and resilience in household travel behaviour, while supporting local business and enterprise development.

Personal travel consumes nearly three quarters of the fuel in Dunedin. Freight is vital to the city, but most freight already gets exported or arrives by high efficiency rail and shipping. On-farm, industrial and construction fuel consumption is critical to Dunedin's economy, but the fuel inputs for production have a very high return. For example, it takes less than 9 litres of diesel to produce a tonne of fruit, 70 litres to produce a tonne of milk solids, and less than 80 litres of fuel to produce a tonne of grain. Over the next fifty years, the non-productive and non-critical uses of oil will come under the most pressure to change.

Behaviour is the greatest factor in transport fuel demand. Current travel behaviour is largely determined by past experience. The peak and decline in world oil supply will be a driver for long-term fuel consumption reduction to around 50% of current levels by 2050. The possibility of fuel shocks will be ever present.

This report analyses current travel behaviour in Dunedin and the range of socio-economic issues around vulnerability. It explains how the consequences of Peak Oil will influence people to choose lower energy transport options. Walking, taking the bus, riding a bike and sharing a ride are reported as currently available alternatives to 60% of car trips in Dunedin and the surrounding settlements.

The form of the city also influences travel decisions and the availability of low energy choices. Dunedin's urban form reflects its early history as a tramway and cable-car city with a centralised commercial and industrial zone. More recently, the freedom allowed by private automobiles and good roads to live in the country and work in the city has led to a sizeable commuter population in the surrounding settlements. Private transport consumes about 70% of imported petrol and diesel fuel. Today, 95% of all travel in Dunedin is undertaken by private automobile. This report shows how adaptable the current urban form of Dunedin is to reducing oil consumption. If residents could choose the optimum location for their needs and ages, 90%–100% of all trips could be carried out by walking, biking, or using public transport.

In response to the Peak Oil issues over the next several decades, residents and businesses will begin to adapt their choice of location and transport modes to use less fuel. Local producers will become more competitive. This report shows how this trend can be seen as a growth in demand for low-energy lifestyle options. It provides a vision of how this rising demand for efficiency can be met by development of integrated urban villages that provide a range of shopping, services, cafes, entertainment and weekend markets for local products. If these urban villages have generous pedestrian areas, cycling infrastructure and hubs for public transport connections, they could become valuable amenities, enhancing the lifestyle of the city dwellers. The Council needs to consider taking a leading role in the urban design, planning and facilitation of the development of integrated urban villages.

Analysis of world oil supply showed that 50% reduction is likely by 2050. To achieve this level of oil reduction, transport energy efficiency must improve. Private vehicles will continue to be the dominant transport mode for several decades. The current fleet

efficiency in Dunedin is more than 10 litres per 100 km. Low efficiency vehicles drain money from the Dunedin economy and send it overseas. This report identifies the key role energy efficiency must play in managing the economic impacts of peak oil. The Council should consider its role in encouraging the choice of high efficiency vehicles. The Council should also be prepared for an influx of scooters, and work to ensure that scooters available for sale in Dunedin meet safety, emissions and noise standards.

Increased demand for walking and cycling will be of great benefit to public health, but could be a serious traffic safety issue if proactive measures are not taken. This report describes how the most likely increase in cycling and walking will not be for long-range commuters, but for neighbourhood trips to schools and shops. The traffic engineering to develop cycling and safe crossing infrastructure in the neighbourhoods around each primary and intermediate school would represent roughly 100 km of dedicated bikeways. The Council can provide this infrastructure improvement now with great safety and active transport outcomes long into the future.

This report suggests development of at least 50 km of electric trolley bus routes in Dunedin. Transport surveys conducted in Dunedin and surrounding settlements in August 2010 showed that residents would consider the bus as an alternative to car trips for nearly 30% of travel kilometres. However, the survey also indicated that the people of Dunedin are not happy with the current bus service. The bus is an obvious alternative when fuel price spikes occur, particularly for low income residents. However, diesel buses are exposed to the same price pressures as petrol vehicles. The Council could take a critical leadership role in the transition of a key transport system to sustainable, renewable energy by developing an electric trolley bus system for the city.

This report provides two background and review sections that will help set the context for further Peak Oil planning and risk management. The time frame and nature of the changes in oil supply will be characterised by periodic episodes of sharp fuel price rise and/or shortage, and long-term gradual decline in fuel supply, which can range between 1% and 6 % per year. Battery electric vehicles with a range of more than 100 km and biofuels from New Zealand crops and animals will not be available or affordable in such a way as to mitigate the reduction in oil supply. Dunedin has an opportunity to get past the distraction of promising-sounding alternatives or substitutes and to start working on the transition to a low-energy transport system and urban form. The key measures of merit for these transition projects will be adaptive capacity for low-energy choices with increased local economic development opportunities.

This report finds that Dunedin's industrial, public service, primary production, and business sectors are in a relatively good position with access to the energy efficient shipping and rail systems and relatively short distances to the Port from production centres and business centres. Businesses and organisations should take responsibility for their exposure to fuel shocks and long term fuel price pressure by starting with transport energy audits and action plans.

Peak Oil is an issue external to the city over which the Council has no control. After the research, review and analysis conducted for this report, the conclusion is that there are five things that the Dunedin City Council can do to deal effectively and productively with Peak Oil. The EAST Research consultancy recommends that Dunedin should be working on these five main objectives to enhance adaptive capacity and social, economic and cultural wellbeing now and for future generations.

INFORMATION ON SUSAN KRUMDIECK AND THE PROJECT TEAM

Dr. Susan Krumdieck is Associate Professor of Mechanical Engineering at the University of Canterbury. She has a BS in Mechanical and Aerospace Engineering, a Masters in Energy Engineering, and a PhD in Advanced Materials Processing from the University of Colorado at Boulder. She has undertaken research on wind turbines, solar water heating systems, building energy efficiency, combustion, biofuels and fuel cells in the USA. Since taking the appointment at University of Canterbury in 2000, Susan has focused her energy research on transition to renewable, low impact, and low energy intensity transport systems and built environment. She has undertaken research into geothermal power plant adaptive design, energy system modelling, strategic analysis of complex systems, social and technology dynamics of change, demand response in electricity end use and hybrid renewable-diesel smart power systems for remote islands.

Professor Krumdieck established the Advanced Energy and Material Systems Lab (AEMSLab) at UC. She has supervised 12 PhD theses and nine Masters theses on a wide range of energy and materials-related projects. She has written more than 75 peer-reviewed research papers, several major commissioned reports and invited articles. She has engaged in consulting for government and industry on a range of energy-related subjects. She has been awarded more than $2.5m in research funding. She was appointed to the Royal Society of New Zealand Energy Panel in 2005, and was selected as the Institute of Engineering and Technology Prestige Lecturer for 2010. She is also in high demand as a public speaker on topics of transition, Peak Oil, sustainability, transport and urban planning, having presented more than 70 invited seminars, lectures and keynote addresses in the past four years.

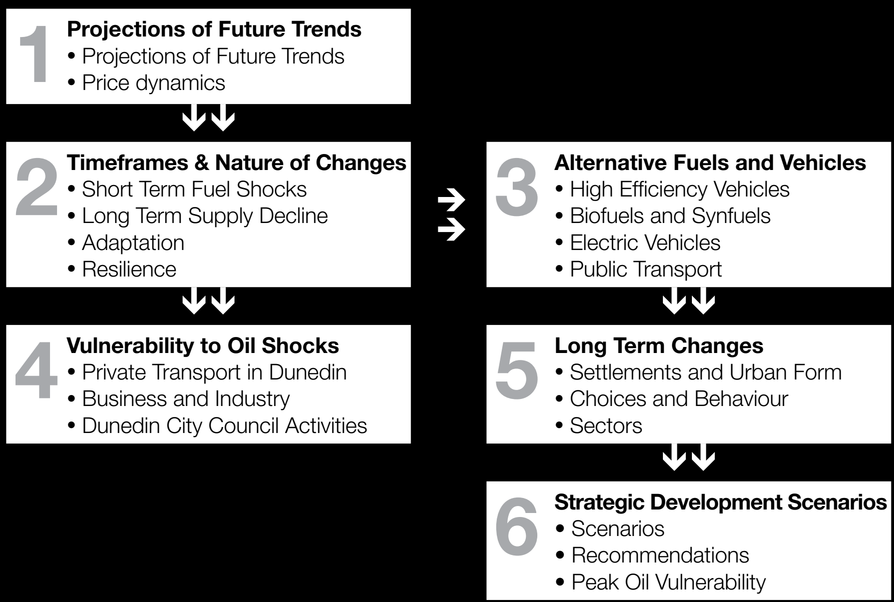
Professor Krumdieck currently holds research contracts with NZTA, FRST, Mighty River Power and NIWA. She is a member of the steering committee of the National Energy Research Institute and the Sustainable Energy Forum. She is a member of the RSNZ and the NZSSES, and she is the current president of the Engineers for Social Responsibility and the convener of the Signs of Change national e-conference on emerging sustainability.

Since first teaming up with transportation researchers in 2003, Professor Krumdieck has developed a unique research area in energy-constrained transport modelling and planning. In 2005, the team produced the LTNZ research report *Peak Oil Risk to Essential Transport Activities as a Function of Urban Form* and the RECATS method to assess the future peak oil risk also was published in the international journal, *Transportation Research Part A*. The team also developed the Transport Adaptive Capacity Assessment (TACA) Survey tool and a Minimum Energy Travel Activity Analysis (METAA) method.

A key member of the AEMSLab research group is Dr. Shannon Page. He has undertaken research in energy system modelling and is the primary software programmer and model builder for the RECATS projects. In 2009, Professor Krumdieck and Dr. Page formed EAST Research Consultants Ltd in order to provide use of the post-peak oil analysis tools to government and industry.
The EAST approach is to accurately characterise the facts, find or gather quality data, analyse the data to understand the dynamics of the energy and activity systems, and then use the Strategic Analysis of Complex Systems (SACS) method to explore development scenarios.

1. INTRODUCTION

Figure 1.1. Oil vulnerability assessment road map used to develop this report.



1.1 Background of this Report

Just five years ago, the price of oil was $30 per barrel and the term 'Peak Oil' was not considered an issue until after 2030 according to the MED.[1] Since then, a spike in oil price of more than $140 USD per barrel has contributed to a world-wide recession. Citizen awareness of the issue of future oil supply has led to increasing pressure on the Council to include Peak Oil vulnerability in planning.

The Dunedin City Council is seeking an assessment of the vulnerability of Council operations, infrastructure, community activities, settlements and business to the supply and price of oil. An assessment of the vulnerability to both short-term oil supply disruptions and long term decline is needed for asset management and long-range planning. The Council needs information about the issue as well as possible mitigation through development and technology scenarios. Council infrastructure and land-use planning decisions will affect the quality of life in Dunedin for decades, even centuries, in the future. Forecast exercises for planning are carried out to identify issues and potential risks as well as to understand drivers for change and innovation. Opportunities are found where risks are mitigated and changes are fruitful.

This report provides information and analysis about the vulnerability of Dunedin to Peak Oil. The Local Government Act 2002 requires councils to consider sustainability issues in Long Term Council Community Plans. The New Zealand Transport Strategy[2] sets objectives of environmental sustainability and economic development. Sustainability is traditionally thought of in conjunction with climate change, pollution and environmental degradation. Resource depletion, and, in particular, fossil fuel supply security are also considered sustainability issues. The Strategic Analysis Scenarios developed in this report provide a framework for identifying development opportunities that reduce Dunedin's vulnerability to both oil shocks and the long-term decline of low cost transportation fuel.

1.2 Scope of this Report

This report provides information from reliable sources and expert analysis of both short and long term transport fuel issues. It aims to give an assessment of Dunedin's current vulnerability to oil supply disruptions and price shocks, and to evaluate the long-term vulnerability trends for different development scenarios. Figure 1.1 shows the oil vulnerability assessment road map for this report.

Section 1 gives a desk research review of petroleum resources and supply. It is clear that there is a very low probability of future growth in world oil supply even with significant new discoveries and new recovery technologies. The oil price in this context of declining supply and strong demand means continued high price with a strong possibility of oil price spikes in the future. Section 2 provides the understanding of how the amount of fuel being used for transportation will decline over time. Section 3 is a technology review of alternative energy sources and vehicle platforms. This section examines the possibilities of technology or fuel substitutions.

The subsequent sections focus on Dunedin and the ways that the future oil supply situation could cause vulnerabilities for Council activities, communities and businesses. Section 4 provides an analysis of the current transport patterns and fuel use in Dunedin and the possible impacts of fuel shocks in the near term. Section 5 explores the long term and presents some possible development scenarios. The final section presents a strategic analysis of how proactive development scenarios could both mitigate the vulnerabilities and achieve outcomes aligned with the Council's long term plan.

1.3 Projected Future Oil Supply and Demand

The development patterns over the next 70 years will be different from the past 70 years. The pace of change will not necessarily be any slower or faster than in the past. However, the nature of the innovations, changes and adaptations in the future will reflect the contraction of fossil fuel supply for personal transportation and the shift to higher value end uses such as production, materials and bulk freight. The following section is a frank and factual assessment of the world oil production situation in the short and long term, and the range of adaptive responses of the world oil demand.

> **"World oil supply is likely to decline every year in the future at a rate between 1% and 6%."**

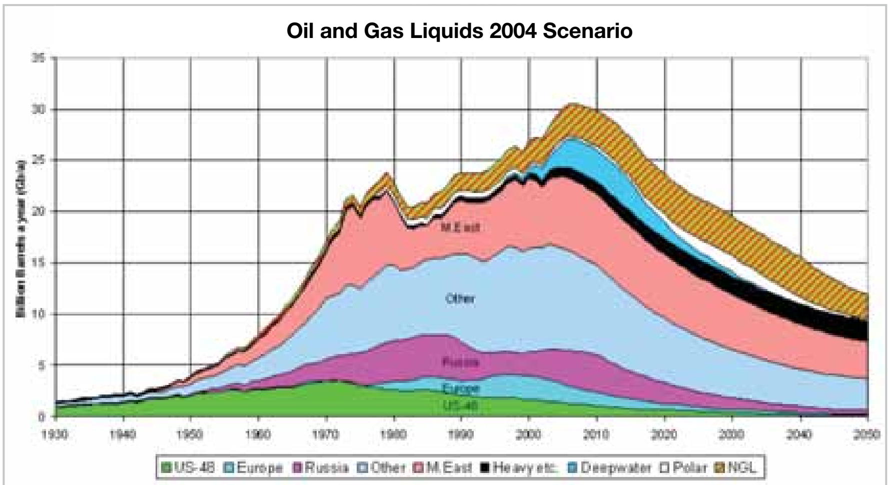


Figure 1.2: Colin Campbell's 2004 calculations of world oil production from each oil producing region.

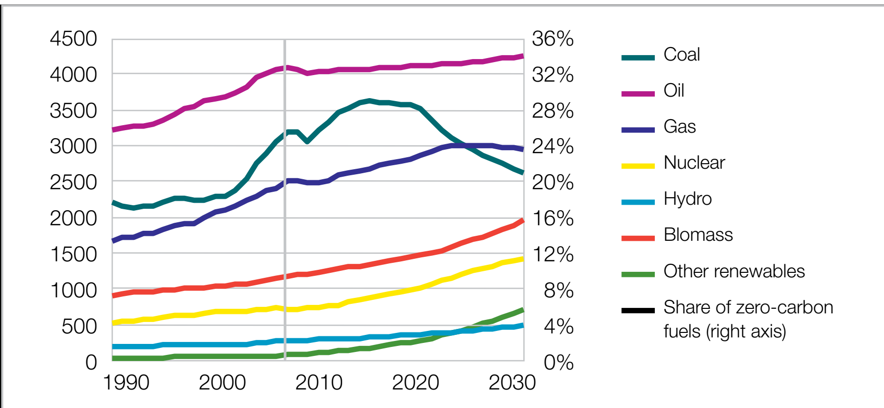


Figure 1.3. IEA analysis of future energy demand by fuel type with carbon price applied to constrain atmospheric CO^2 emissions.

New Zealand's transport fuel supply will follow the same pattern as the rest of the world. Thus, the scope of the review presented in this section is focused on the world oil supply. The conclusion drawn from literature and government reports from around the world is that, unequivocally, transport fuel supply will decline continuously into the future at an annual rate between 1% and 6%. Figure 1.2 shows the once-debated, but now accepted analysis of world oil production by petroleum geology expert, Professor Colin Campbell[3]. The analysis includes a surge in deep water oil recovery, increased use of heavy crude and tar sands, and increased production from the polar regions. While this graph seemed alarming when it was first published, there have been no published research papers or government reports that actually dispute the validity of Campbell's analysis.

The International Energy Agency (IEA) has continued to forecast demand growth, even in the case of a carbon price sufficient to limit global atmospheric CO^2 concentration to 450ppm as shown in Figure 1.3.[4] This is largely due to continued high demand in developed countries and increasing demand in China and India. The IEA anticipates increased production will be brought online from known, but not yet developed, oil fields into the future. However, after 2010, world oil production from known sources will go into permanent decline because the production rate from new fields is smaller than the depletion rate. The new discoveries, non-conventional oil and enhanced oil recovery developed to fill the growing demand-supply gap is questioned by many petroleum geology experts[5] and government reports.[6]

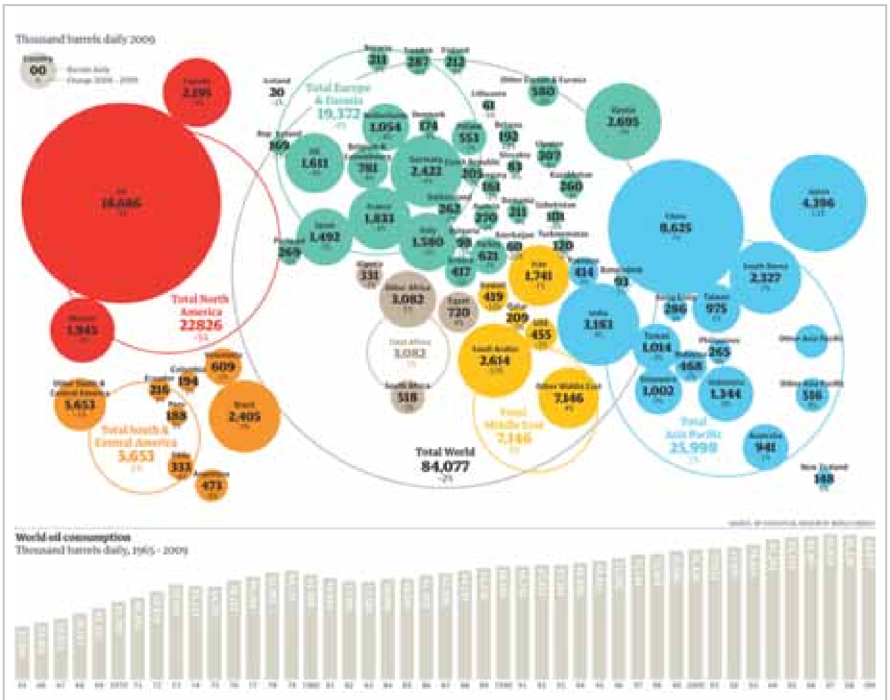


Figure 1.4. World oil demand in 2009 by nation and region together with historical consumption.

Figure 1.4 shows the world oil demand in 2008–2009 with data taken from the BP Statistical Review of World Energy. If the supply is not capable of meeting demand, then prices rise. This price pressure drives some of the marginal consumers out of the market and causes others to use less fuel. The BP data shows that consumption declined by 5% in North America, by 4% in Europe, and by 2% world-wide over 2008–2009.[7] Higher prices would be needed to bring the investment in development of known reserves and refurbishment of refineries to handle the increasing proportion of heavy crude. If the price does not rise, then the supply would decline faster.

1.4 Projected Future Price Dynamics

It is unlikely that demand will decline faster than supply, so future prices are likely to remain historically high. The price of oil is set by traders who can react to any number of possible events. The price of oil is likely to remain volatile unless unprecedented market changes occur. Price shocks as in 2008 can occur again, and will result in demand destruction at the margins and economic damage in the main stream.[8] Figure 1.5 shows the future oil price scenarios from the US Energy Information Agency (EIA).[9] There is a huge range of possible fuel prices depending on many economic factors. Some analysts suggest that the price is most likely to fluctuate periodically and usually quite dramatically between the upper and lower price ranges. What we do know for

> There will be growth in demand for transport options and products that have lower oil intensity.

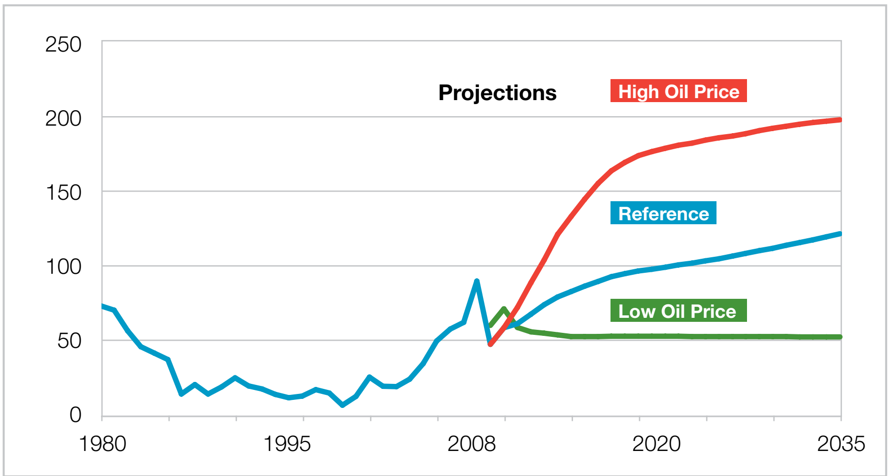


Figure 1.5. EIA future world oil price scenarios showing a range of possible 2030 price from over $200 to $50 per barrel.

sure is that the IEA and the EIA have a track record of predicting future oil prices that has always greatly under-estimated the actual price trend. As described in the background report, many analysts now anticipate cyclical supply and demand crunches that result in severe, but temporary price spikes. The price spike of 2007–2008 and the subsequent demand destruction and price collapse could occur again within the next few years as demand recovers and begins to increase again. These supply and demand crunches could possibly be avoided if the carbon emission reduction measures, fuel efficiency policies and consumer behaviour change to maintain or reduce current demand. On the global scale, however, this is unlikely to occur given the size of the latent demand in Asia and the government support of local car manufacturing industries.

Oil Supply and Price Outlook for New Zealand

New Zealand consumers have been insulated from the world oil price rebound to around $80 USD/barrel because the price increase coincided with a currency exchange rate increase. There are many other circumstances that could make New Zealand's effective oil price and supply different from the world trend. The conclusion of the research and literature review is that New Zealand should prepare for continuous pressure on transport fuel price into the future. This pressure is likely to include episodes of supply uncertainty and price shocks. Ultimately, this pressure results in continued reduction in demand for transport fuel and oil intensive materials and products.

Footnotes

1. MED (2006)
2. MOT (2008)
3. Campbell (2004)
4. IEA (2008)
5. Deffeys (2007)
6. Hirsch (2005)
7. BP (2010)
8. Smith (2010)
9. EIA (2009)

2. TIME FRAMES AND THE NATURE OF CHANGE

2.1 Time Frame for Fuel Supply Decline

World oil production in 2010 to date has averaged 85 million barrels per day (mbpd). The highest monthly production rate on record was 86.7 mbpd in 2007 and the peak in annual average production was 81.995 mbpd in 2008.[10] World oil production declined 1.2–2.6% during 2008–2009. The severe oil price shock and global recession were possibly the result of Peak Oil turns occurring in 2007–2008. There have been a number of reports and papers analysing the petroleum geology and economics of world oil supply. A recently published paper by Krumdieck, Page and Dantas[11] includes a meta analysis of the expert reports and includes new data on decline rates of major oil fields. Published analysis from experts is used to calculate the cumulative probability of the peak and decline rates in world oil production. The result is the future likelihood of various production rates. The 97% probability scenario in Figure 2.1 represents a future fuel supply level that virtually all experts agree will be achievable. None of the experts, even the most optimistic, expect fuel production levels above the 3% probability scenario to be achievable.

All of the petroleum geology experts agree that transport fuel supply of refined petroleum products will decline in the future. However, the most probable 2–6% annual supply decline is not the same as 'running out of oil'. Between 2005 and 2012, there will be a period of adjustment to the peak in supply. This period will be characterised by price volatility and changing priorities as the fuel supply rate plateaus. The near term, from 2010 to 2020, will see consecutive years with declines in global production, even as demand in developing countries pushes upward. The world oil production is likely to remain quite high, between 20–25 billion barrels per year, which is in the range of supply available over the past thirty years. By 2050, fuel supply is most likely to decline to the range last seen in the 1960s. In the long term, beyond 2050, fuel supplies and petrochemical feedstocks will become increasingly problematic. Planning, investment, technology development and management from 2010 forward will change to reflect adaptation to these changing situations.

Adaptation

Dunedin first adapted to the increasing wealth created by local primary production and mining industry by growth in service industries, manufacturing, construction and civic structure. Trams and trolleys were a way to deal with the growing population's booming activity systems. For eighty years, the prosperity and access to activities in Dunedin included public transport. It should be noted that the age of tram and trolley transport in New Zealand coincided with high usage of bicycles.

Beginning in the 1950s, the Council had sufficient income to adapt to the pressures for change from increasing private ownership of cars by building more parking and road infrastructure. Removal of the trams may be understood as an adaptation to the growth in demand for private vehicle transport. The transport engineering information used in past decision-making about road building was basically accurate. Sustained increase in vehicle travel demand put pressure on

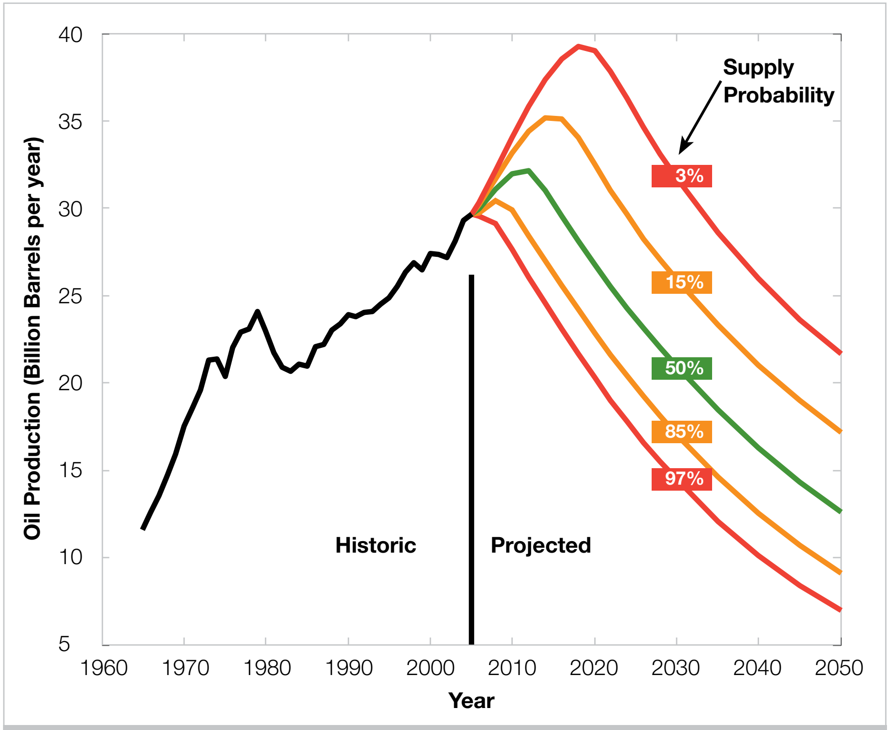


Figure 2.1 Probability distribution of future world oil supply from meta analysis of expert reports from Krumdieck *et al*, 2010.

Table 2.1 World oil production scenarios presented as the probability that at least this level expressed in million barrels per day (mbpd) would be produced on average in the future year.

Probability Scenario	World Oil Production (mbpd)*			
	2020	2030	2040	2050
Unexpected Problems	54	38	27	19
No New Big Oil Fields	60	45	38	26
Most Experts Agree	71	57	44	37
Discovery of Giant Field	85	68	58	48

** For reference: 2008 average daily world oil production was 85 mbpd*

existing road and parking capacity, leading to further expansion of vehicle infrastructure. We now see from history that building more road and parking infrastructure only temporarily decreases congestion and puts negative pressure on active and public transport modes which could also have helped to reduce congestion.

The likelihood of various levels of world oil production over the next forty years from the previous analysis is tabulated for discrete dates in Table 2.1. Each of the different probability scenarios indicates the likelihood that at least this level of world oil production will be available relative to the nominal 85 mbpd in 2008. The three most likely scenarios indicate that the fuel supply in 2050 will be between 50% and 75% less than today. The analysis suggests that there is only a 15% chance that the oil production in 2050 will be half the rate of today, it is more likely that it will be lower. This is a large decrease from current levels, essentially the same fuel usage level as near the end of the 1960s. This reduction happens over a time frame of four decades. From the perspective of year-to-year business, this is an annual reduction of only a few percent. This level of reduction has already been happening since the oil price shock of 2008. The experience of the next forty years will be a continual reduction that is accomplished by aggregate behaviour, technology and land use pattern changes and is driven by high price with episodes of supply disruption and price spikes.

2.2 Nature of the Changes Arising from Peak Oil

There are two ways that the effects of Peak Oil and the resulting reduction of fuel supply will be experienced:

- Short term oil shocks, involving price spikes and possible fuel shortages.
- Long term gradual decline with continuously high fuel price pressure.

Dunedin's Adaptive capacity is key to reducing the vulnerability in both the near and long term. This adaptive capacity is different for private transport, Council activities, business and freight. Adaptive capacity is a concept normally used in natural hazard risk management and in business planning. It is a measure of the available alternatives, but not necessarily an indication of behaviour change unless the issue arises and pressure for change is experienced. For example, the number of dairy farms with onsite generators and the number of deployable generators in the

Adaptation (*noun*):

1. the process or state of changing to fit new circumstances or conditions, or the resulting change
2. something that has been modified for a purpose
3. the development of physical and behavioural characteristics that allow organisms to survive and reproduce in their habitats
4. the diminishing response of a sense organ to a sustained stimulus

Resilience (*noun*)

1. speedy recovery from problems the ability to recover quickly from setbacks
2. ability to react to potential crisis – the ability of government or organisation to identify, assess, and respond to a potentially disruptive situation in order to prevent it from becoming a crisis

Encarta Dictionary

neighbouring towns would be a measure of the adaptive capacity for continuing to milk in the event of a heavy snow storm knocks out power supplies to rural areas. A key for prosperous development in the future will be to find ways to assess adaptive capacity for all transport activity systems, and tools to bring adaptation planning into household thinking, transport engineering, business management and urban design.

Adaptive Capacity

Current travel behaviour and freight movement patterns reflect the historical availability of low cost fuel, vehicles and infrastructure. The transportation system has always changed as people and businesses decide how to take advantage of evolving technology and new opportunities. Decisions and ideas are the greatest source of nearly unlimited adaptive capacity. Using less fuel to carry out desired activities and business is not destructive, and in fact has numerous positive benefits. Decisions to use less fuel can be made very quickly in households, but will usually take more time in business and council organisations. Panic, economic breakdown and civil disintegration are destructive to this decision-based adaptive capacity.

The adaptive capacity in personal travel behaviour can be enhanced if people have experience with alternatives. For example, people who have previously taken a bus to the shops or have ridden a bike to work are aware of these travel alternatives to a much greater degree than people who have never tried an alternative to the private car.

Dunedin does not have any control over the world oil supply, the world oil price, or the prices set by oil retailers. Dunedin does not have any influence on the fuel efficiency of the vehicle fleet, the condition of the national rail system or the arrival of cruise ships. However, Dunedin can decide what to do with its public transport, development of the urban form and transport infrastructure. The Dunedin City Council may be able to help citizens and businesses explore their alternatives and develop their adaptive capacity.

2.3 Resilience to Short Term Oil Shocks

The adaptive capacity, together with risk management and preparation of action plans, will determine Dunedin's resilience to short term oil shocks. Resilience is determined by the 'four Rs':

- *Readiness:* the degree of forward planning, design and preparation.
- *Reduction:* the degree to which exposure to the impacts of the risks have been reduced.
- *Response:* the ability of government, businesses and citizens to change behaviour quickly to continue activities during the crisis.
- *Recovery:* a measure of the time needed to return to normal operation after the crisis has ended.

It is possible that another price shock with petrol price above $2.50 – $3.00 per litre will occur in the next decade. It is also possible, and increasingly so in the future, that there could be a fuel shortage. Events of this nature in the past have been short lived but, like natural disasters, have a high impact on social confidence, economic damage and disruptions.

The 2008 price shock resulted in demand reduction and economic contraction. There is evidence that patronage of public transport increased in New Zealand during the price shock. However, as the bus companies are subjected to the same high fuel price as vehicle drivers, rising bus fares may dampen the mode shift capacity during a future price shock. Public transport may have a high priority during a fuel shortage, but during past events, such as the tax protest strike actions in the UK, bus services were also disrupted by lack of fuel.

Sharing rides, trip-chaining, working from home and using more efficient vehicles if available are adaptive measures within the context of the existing vehicle transport system. There is not much evidence that these measures were widely used either in New Zealand during the 2008 price shock or during fuel shortages in the UK. It is possible that being able to take advantage of these measures would be enhanced if forward planning were done via travel planning programmes. A public education programme and access to transport auditing tools could be used to encourage households to make a fuel reduction plan just like they are encouraged to make fire and natural disaster family plans.

Shifting to active mode (e.g. walking or cycling) is the most direct and effective way to reduce fuel consumption during a short-term oil disruption. Dunedin residents should have a reasonable ability to walk or bike to some proportion of their destinations, given that most Dunedin residences are within 6 km of the city centre. Figure 2.2 shows a map of Dunedin colour-coded with the population for each census mesh block. Residents in the newer suburbs and outlying settlements have longer distances to travel to the activity centres of the university, central business district, Port and industrial park. The higher density residential areas of urban Dunedin are all within 6 km of the main destinations in the central city area. This pattern of urban form should be more resilient than a low density or 'sprawled' city, if the other conditions of resilience are met. We will explore Dunedin's resilience in later sections.

2.4 Adaptation to Long Term World Oil Production Decline

Vulnerability to the long-term effects of Peak Oil is related to adaptive capacity. Adaptable systems have the ability to adjust more easily

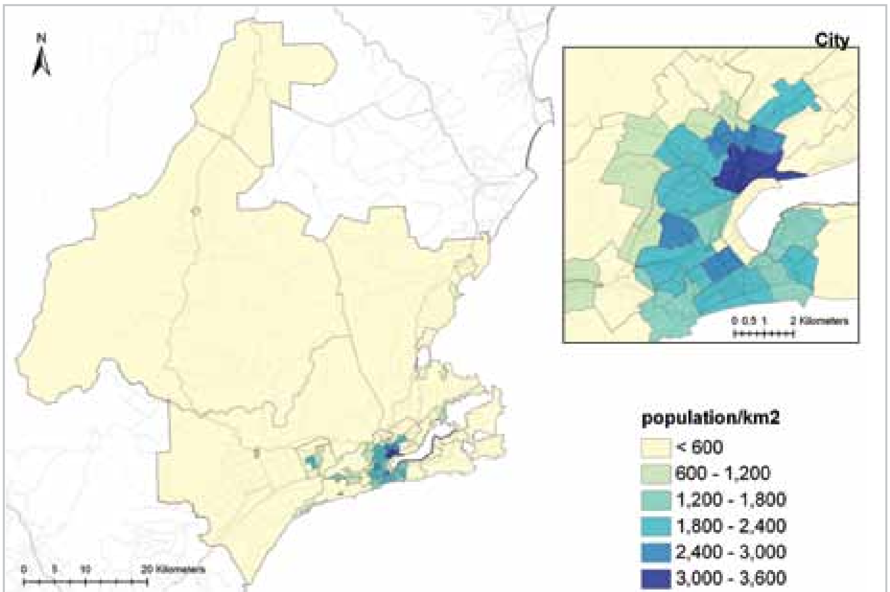


Figure 2.2: The population of Dunedin is concentrated in the historical city neighbourhoods and suburbs, but there are a significant number of people residing in coastal settlements and along the highway corridors.

to changes and new conditions. Adaptation always takes time. Adaptation will mean changes to use less oil. However, adaptation also means growth where new opportunities and demands are present. It should be noted that adaptation occurs at vastly different rates throughout the population. The 2–3% fuel demand reduction over the past two years is indicative of a small proportion of households making major changes, a small proportion making moderate changes, a large proportion making no change, and a small proportion having growing fuel use. There was a contraction in overall car sales, but not a general rush to uptake fuel-efficient vehicles.

The long-term adaptive capacity for 1–6% fuel demand decline in a given year will depend explicitly on the options open to the particular individuals who decide to reduce the fuel intensity of their lifestyles. The key metrics for adaptive capacity will include availability of housing in all price ranges near all work and education facilities, as well as bike and walking access between residential areas and amenities, market places and public transport networks. Walk and bike access is a measure of the ease with which people could get themselves to their activities rather than driving.

Dunedin's location and geography can't be changed. The built environment, including transport networks, buildings and factories, are rebuilt every 30–75 years. Removal of a household to another residential location can be done in a matter of days. Certain investments and policies in the near term can make future systems more adaptable.

The Next Ten Years

In the near term, the main change in fuel supply will be the inability of world oil suppliers to increase production. This has already been the case from 2005 to 2010, and will continue for the next five years. As discussed in the first section of the report, this period will likely have a relatively low decline rate as high prices cause rapid development of smaller and more marginal fields.

The most profound change in the near term will be the end of growth in car travel demand. Supplies of fuel will remain sufficient for normal access to activities to continue without interruption. Congestion will not worsen, particularly on arterials from outer suburbs. Growth in the use of public transport and bikes will be noticeable, but not dramatic.

The sustained high price for transport fuel and the impact of oil price instability on world economies will cause the end of growth in goods movement for many types of products. The near term is too short for improved rail and sea infrastructure to facilitate a large shift in freight volumes from road. Established freight logistics take some time to adjust. However, rail and sea freight that is cost-competitive with road will see increased demand.

Ten to Thirty Years in the Future

From 2020, oil supply will be sufficient for individuals and households to carry out their normal activities with primarily mode and location adaptations. Petrol and diesel cars will continue to be available in the market, and people will increasingly choose more efficient vehicles. However, most people are not likely to accelerate their purchase of a new vehicle primarily in order to get higher fuel economy. Indeed, people will be likely to forgo the expense of a new vehicle and choose to adapt their travel behaviour to reduce fuel use. People will also increasingly choose to locate in areas with amenities accessible without using transport fuel.

The medium-term times frame of twenty to thirty years is ample time to redevelop many parts of urban areas into active mode-accessible, amenity integrated areas, and the demand for housing and business locations in these low-energy areas will be high. Demand for passenger rail seats will also grow as tourists and family travellers find the train becomes cost-competitive with driving vehicles long distances. In the medium term, some form of management of fuel purchasing may be required during fuel shocks that involve fuel shortages.

Medium term pressure on fuel supplies will start to cause adaptation in freight and goods movement. Twenty to thirty years is ample time to redevelop rail networks between primary production centres, urban centres and export ports. As the freight sector develops new logistical patterns to deal with high fuel prices, the demand for lower cost freight will grow. Part of this new demand will be due to adaptation in the retail fuel market. Although the world oil price will remain within certain bounds, local competition for fuel will drive development of allocation market systems. Freight companies will need to bid for fuel deliveries in competition with primary production, construction and other uses. Thus, the price of fuel in a given country will increase dramatically at times as re-organisation of production–processing–hauling–distribution–retail chains is likely to be accomplished in steps and jolts rather than a smooth, incremental fashion.

Thirty Years in the Future and Beyond

The long-term timeframe for Peak Oil is beyond thirty years in the future. Beyond 2050, world oil production drops below half of the peak value. Of course, in this timeframe, citizens and businesses still experience incremental fuel supply decline year-to-year. Over the ensuing thirty to forty years, however, transport fuel supply for private vehicles will become severely constrained in Dunedin.

In the long term, it is unlikely that oil will continue to be a commodity with un-controlled distribution managed by price alone. Oil will have become recognised as a very valuable resource with a finite quantity. Governments may take over the distribution of transport fuel and will likely be allocating on the basis of maximum utility for primary production and essential services rather than for the convenience of private citizens.

Footnotes

10. BP (2010)
11. Krumdieck, Page and Dantas (2010)

3. TECHNOLOGY REVIEW OF SUBSTITUTIONS AND ALTERNATIVES

A lot of people consider alternative vehicles and fuels to be possible substitutions for automobiles and fossil fuel. Other people reason that a lot of fuel could be saved through behaviour change. National data sets, surveys and analysis have been used to assess the degree to which the main alternative technologies could mitigate a short-term fuel emergency in the near term, and the likelihood of availability and market growth of the alternatives to 2050. The results clearly show that the oil reduction of 50% by 2050 can be accommodated in private transport without losing any access to activities in Dunedin by voluntary behaviour change such as shifting lifestyle to require shorter trips, choosing lower energy modes and more efficient vehicles and sharing rides. The technology review findings indicate that it is nearly impossible for electric cars or biofuels to replace a significant proportion of current transport energy at any time in the future.

Substitution Analysis

What is the likelihood that a new vehicle technology, alternative fuel or behaviour change could substitute for reduced oil supply in the future? The likelihood of substitution is assessed on the same basic criteria for each fuel or vehicle technology.[12]

- Technical Feasibility.
- Market Viability.
- System Integration.
- Resource Availability.

Figure 3.1 gives an overview of the results of the technology review and substitution analysis within the time frame of the next 50 years. The figure shows the mode share percentage of travel to activities. Historical data is estimated from national trends as research resources are scarce. In the 1930s personal vehicles were present in Dunedin but people were as likely to walk or take the tram to their activities as they were to drive a private car. By the 1950s, the tram system was removed and by the 1970s, personal vehicles were used by most households for a majority of trips. The low-cost import boom of the 1980s resulted in the doubling of the number of vehicles per household, and the current dominance of automobiles for transport mode choice. From 2005 to 2009, the number of registered scooters increased 45% compared to less than 5% increase in number of cars.

In the future, car trips do not disappear by any means. However, the percentage of trips carried out by large, low fuel efficiency vehicles will reduce as people adapt to high fuel price and availability pressures. In the long term we see a trend to walking and biking for short, convenient trips by a continuously increasing, although modest, percentage of households. The uptake of scooters for trips under 5 km will probably continue, and eventually represent about 15% of all vehicle trips by 2050. The city makes a major investment in improving the public transport system which sees increased patronage. The maximum contribution for New Zealand produced biofuels and imported electric vehicles other than scooters and carts, is calculated to be no more than 8% by 2050.

Hydrogen and fuel cells for transport vehicles will not be assessed in this Peak Oil vulnerability assessment. A recent review of hydrogen as an energy carrier has been published by the EAST researchers[13] with the conclusion that system level energy efficiency is so low for hydrogen systems that they will not be developed commercially.

3.1 High Efficiency Vehicles, Scooters and Motorcycles

The fuel efficiency of an internal combustion engine (ICE) is directly related to the engine size (e.g. cylinder volume in litres or cc), vehicle weight, and average speed. Smaller, lighter vehicles use less fuel per 100 km. The average fuel efficiency of the New Zealand vehicle fleet is 10 litres/100km.[14] High efficiency petrol vehicles (HEVs)

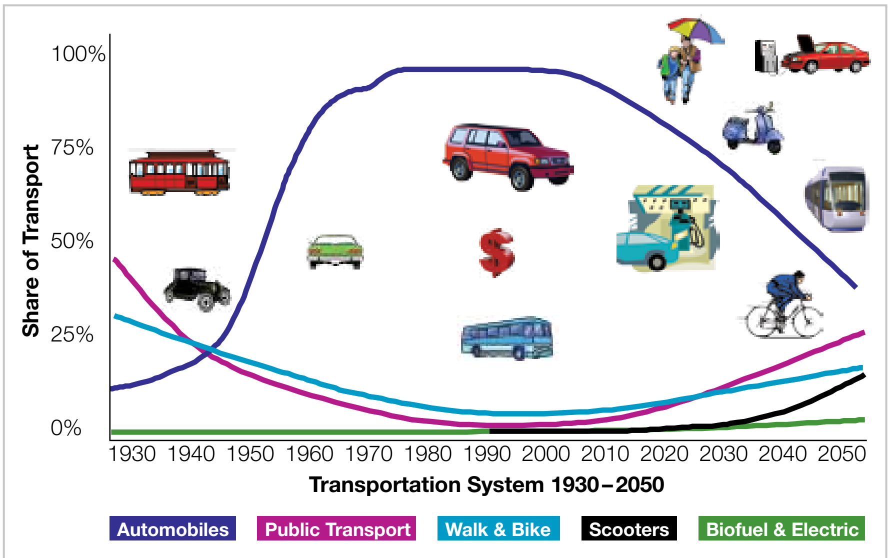


Figure 3.1 Probability distribution of future world oil supply from meta analysis of expert reports from (Krumdieck *et al*, 2010).

Vehicle Make	Engine Size (litres)	Fuel Efficiency (1/100km)
Daelim Scooter	0.05	2
Honda Jazz	1.3	4.5
Holden Commodore	3.6	11
Ford Explorer	4.6	17

Table 3.1 Reference values of engine size and fuel efficiency for a range of motor vehicles.

currently available in Dunedin, such as 1.3 – 1.5 litre Honda Jazz and Toyota Yaris, have fuel efficiency of 4.5 – 5 litres/100km. These vehicles are available new or used and are affordable, with prices in the range $10,000 – $27,000. Modern diesel vehicles and hybrid vehicles can achieve fuel efficiency below 4 litres/100km. Motorcycles that are large and powerful have basically the same fuel efficiency as a small car. Smaller motorcycles and scooters with small engines (40 cc – 150 cc) can use less than 2 litres/100km and are available at low cost, $2000 – $10,000. Table 3.1 gives reference fuel efficiency values for a range of common New Zealand vehicles.

- *Technical Feasibility* – currently manufactured.
- *Market Viability* – currently affordable.
- *System Integration* – sufficient numbers available, uses existing infrastructure.
- *Resource Availability* – requires no novel or rare materials or manufacturing.

The likelihood of reduction in total Dunedin fuel supply being substituted by uptake of high efficiency personal vehicles is low in the near term, but increasing in the long term. Within ten years, a fuel demand reduction of 10% – 20% could be realised by penetration of HEVs representing a 20% increase of market share and 30% kilometres driven. HEVs are assumed to be used for both long and short distance trips. Every 100 kilometres driven in a Jazz rather than Commodore or an Explorer represents a fuel demand reduction. In the long term, the HEV penetration could not realistically exceed 70% of the personal vehicle and light commercial fleet.

In order to achieve greater fuel demand reduction in the long term, replacement of vehicles with scooters for the majority of urban social, work, school and shopping trips would be required. Vans and trucks can be upgraded with more efficient or hybrid versions, but it is impossible to reduce total fuel demand to more than half of the current level while maintaining the same number of kilometres travelled in private transport.

3.2 Battery Electric Vehicles

Using an electric car would reduce the fuel demand by 100% for each trip. The technology for electric vehicles is relatively mature and used in many instances such as golf courses, airports, large resorts, and warehouses. 'Golf cart' electric vehicles are currently available in New Zealand. The number of electric scooters rose from 144 to 394 in the past five years.

The main technical issues for electric cars are range, size and on-board services. The

range of an electric car is determined by the number and quality of batteries. More than 50 car batteries are required in a small vehicle for a range of 70km at highway speed. New battery technologies are aimed at reducing the on-board weight and the charging time. Hills, high speed and strong winds reduce the range. Most of the population of Dunedin currently has travel distances within the range of electric vehicles. Vans and delivery vehicles have been constructed with electric propulsion, but are currently not available in the market. Technology development at the moment is focused on small, 2–4 seat vehicles. Ancillary on-board services include lights, radio, fans, signals, air conditioning, and most importantly for Dunedin, heating and defrost. The batteries and controllers function better when they are warm. Some electricity from the battery can be used to warm the controls and batteries, but there is not nearly enough power available from the batteries to heat air for anti-fogging or for heating the passenger compartment. One research study has estimated that this fact will limit the range of battery electric vehicles (BEVs)quite severely in the USA, Canada and Europe.

Cost is a serious issue for uptake of BEVs in Dunedin, as is availability. There are no BEVs currently available in the market. The Chevrolet Volt, Nissan Leaf or Mitsubishi MiEV are not yet available for purchase. One of these cars and the charging station upgrade is likely to cost more than $50,000 in Dunedin and, unlike cell phones, the cost will not go down as more are manufactured. The cost of new cars doesn't go down as more are made. Better batteries are more expensive because the materials and manufacturing are more expensive.

- *Technical Feasibility* – currently possible, but not manufactured.
- *Market Viability* – very poor affordability for initial purchase of passenger cars, however, scooters, bikes and golf carts are currently affordable.
- *System Integration* – Dunedin range possible, climate too cold.
- *Resource Availability* – market competition for lithium and nickel means low production volumes.

3.3 Biofuels and Synfuels

The possibility for replacing part of New Zealand's current consumption of 23.53 million litres per day of oil with biomass derived liquid fuel depends on biomass capacity and production efficiency. The energy return on the energy invested (EROI) in producing and refining the biomass is highest for vegetable oils and lowest for fermented alcohols. Ethanol has a lower energy value than the petrol it replaces. Ethanol is currently processed from dairy by-products in the South Island. Studies during the 1970s showed that sugar-beet ethanol had a very marginal energy return. International research indicates that ethanol production from sugar cane has a positive energy return, but other feedstocks have an EROI near, or below, one. Ethanol can be used directly in specially designed engines, but most markets currently use blends. In Dunedin, a blend of more than 10% ethanol (E-10) is not anticipated within ten years as vehicle technology will not be compatible with higher blends.

Biodiesel is currently made from tallow and Solid Energy has established a company to produce biodiesel from rapeseed. The current production facility can produce one million litres per year. Plans for a filling station to supply 20% blend diesel fuel in Dunedin have been announced. There have been some issues identified with rapeseed aggressively cross-pollinating valuable food and seed crops, which will limit the growing range. Because of the tendency of biodiesel to form small crystals at low temperatures, biodiesel blends of more than 20% are not anticipated in Dunedin. Competition for land with food and fibre production is a major issue for ultimate biofuel production capacity, as is water and energy use in processing.

The main limitation of biofuel is the production rate. Solid Energy states a production target of 70 million litres per year at some point in the future, which would provide about three days of oil consumption in New Zealand. One cow carcass returns less than 40kg of tallow, or less than one half tank of fuel. Rapeseed's bio-oil yield is 400–550 litres per acre per year, or less than ten tanks of fuel for a Honda Accord. Numerous studies have calculated that even aggressive conversion of land to biofuel cropping would produce less than 10% of current demand. Advocates of wood-derived ethanol propose massive conversion of marginal land to coppiced Salix willow could produce surplus ethanol. However, the processing methods for converting wood cellulose to ethanol are not currently technically or economically viable.

- *Technical Feasibility* – currently possible from known biomass materials.
- *Market Viability* – no great price difference anticipated.
- *System Integration* – low percentage blends due to cold and older vehicle fleet, conversion of agricultural production to biofuel economically inefficient.
- *Resource Availability* – more than 10% total substitution ultimately impossible.

3.4 Public Transport

Conventional 30–40 passenger buses have fuel efficiency of 25–50 litres/100km, so the greatest improvement in efficiency is gained by carrying more passengers. Increasing patronage, and thus removing a car trip, directly reduces fuel demand. It is likely that demand for public transport will increase in the future. However, this analysis only looks at the reduced diesel demand possible from technology substitutions for the current level of patronage.

Hybrid buses are available, but the fuel consumption is similar to conventional vehicles. The hybrid bus uses the electrical motor to accelerate from stops, thus reducing soot production in low-speed, high-load operation of the diesel. Technology development in buses has been focused on reducing emissions as a new clean air standard for diesel vehicles is coming into force in the USA. The emissions improvements have resulted in reduced fuel economy.

Smaller 12–20 passenger buses have much better fuel efficiency of 10 – 20 litres/100km. Other small cities, like Boulder, Colorado, have developed bus routes based on small buses that have increased frequency during peak times. Half the fuel on a route with low patronage could be saved by substituting small buses.

Electric trolleys, trams and buses are well known technology available in the market. Conversion to electric buses or trolleys would provide direct fuel demand reduction. It would be possible to replace all of the city buses with overhead electric vehicles, but the regional lines may be better substituted with light rail. Electric buses become more affordable as fuel prices rise, but require some new capital investment in vehicles and overhead wires. We assume in computing the fuel savings that a re-organised and well-run electric bus and trolley system would have the very high patronage indicated in the TACA Survey where 25% of current car trips could be done by bus.

Pool vehicle systems have been established internationally and in New Zealand. Car-pooling, van pools, vehicle-sharing and hitch-hiking increase occupancy of vehicles, thus reducing fuel demand as a vehicle trip is eliminated. There has not been any research to estimate the maximum degree of vehicle sharing possible.

- *Technical Feasibility* – currently available.
- *Market Viability* – no great price difference anticipated and lower costs in general.
- *System Integration* – dependent on patronage and occupancy.
- *Resource Availability* – resources available.

Solid Energy has announced a long-range production target of seventy million litres per year and the 2011 production target is four million litres from rapeseed crops.

New Zealand's 2008 – 2009 oil consumption averaged 23.53 million litres per day.

Footnotes

12. Further details available in Appendix 2
13. Page and Krumdieck (2009)
14. MOT (2009)

4. VULNERABILITY TO OIL SHOCKS

The recent Parliamentary report highlights the probability in the near future of another oil shock in the form of a price spike in world oil price, and the fact that New Zealand is completely exposed to the world oil price and supply.[15] The driver for fuel price shocks is demand being higher than supply capacity. Price shocks can only be avoided if the world demand decreases at least at the same rate as the supply. The probability is very low that world fuel demand will reduce fast enough to avoid fuel price shocks. The current strike action in France (November 2010) has caused a substantial fuel supply disruption. The French situation illustrates the fact that fuel shortages occur for a range of reasons, and that the panic buying and impact on the transport system seem to occur regardless of the reason for the fuel shortage. In this section, we will explore the vulnerability and resilience of the different sectors of the Dunedin economy and the Council that rely the most on low-cost transport fuel.

4.1 Dunedin's Current Demand

Private Transport

The residents of Dunedin engage in just over 15 trips to activities per week. More than 50% of trips are social visits, recreation or to accompany someone. About 30% of trips are for work and education.[16] The dominant transport mode in Dunedin is private vehicle, representing 95% of all trips. The majority of trips are relatively short, 50% are under 6 km. Figure 4.1 shows the average yearly travel in kilometres per household. The data was extracted from Ministry of Transport registrations and Warrants of Fitness.[17] People who live in the CBD travel the least, while people in the outlying suburbs and settlements, like Port Chalmers, drive the most.

Light Commercial

Vans, trucks and utility vehicles are used by tradespeople and for deliveries around the city. Light commercial activity is estimated to represent less than 15% of total transport energy use in Dunedin. A national study estimated that, as with personal transport, improved maintenance of vehicles, proper tyre inflation pressure, driving within the speed limit and gentle acceleration and braking could reduce fuel demand by 2–7%.[18] Newer vehicles are available, including hybrids, which have improved fuel efficiency, so over time, the fleet efficiency may improve. Some deliveries could be substituted with smaller vehicles, but the current approach to trades and commercial transport do not have great potential for energy intensity reduction. The opportunities for reducing fuel demand may come from unexpected new forms of business arrangements. For example, plumber's co-ops may arise that make tools and materials available at franchise locations all around the city so that plumbers can pick up only what is needed for a particular job locally and the trade vehicle could be a motorcycle and side car. There is no research in this area, but it is not hard to imagine that tradespeople will adjust with innovation in order to carry out their business while reducing exposure to fuel issues and costs.

Regional Freight

Currently, road freight uses about 30% of all transport energy nationally. There are some possible efficiency improvements in logistics and utilisation, e.g. how full a truck is loaded. However, improved efficiency through driver behaviour, full loading, and optimal logistics for current truck freight is estimated to be less than 10%, based on research from the UK. The key opportunity for reduced freight fuel demand is in reorganisation of business structures and decision-making so that more freight moves by rail and coastal shipping. Moving a tonne of freight by rail uses half the energy required for a road truck.

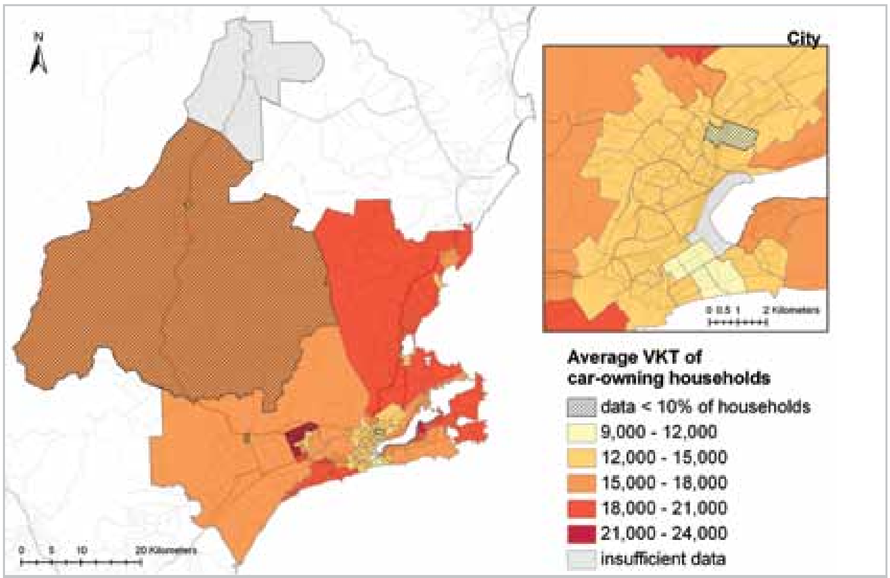


Figure 4.1. Average annual household kilometres travelled by residents in various suburbs and settlements in Dunedin.

Innovations and developments in rail security are key opportunities. Reduced demand for shipping of retail goods can be realised to a certain degree through local development of processing, manufacturing and marketing. Research in this area is limited, but it seems a natural area of business development in response to high transport prices for road freight, and smaller-scale, local production and marketing will become more competitive.

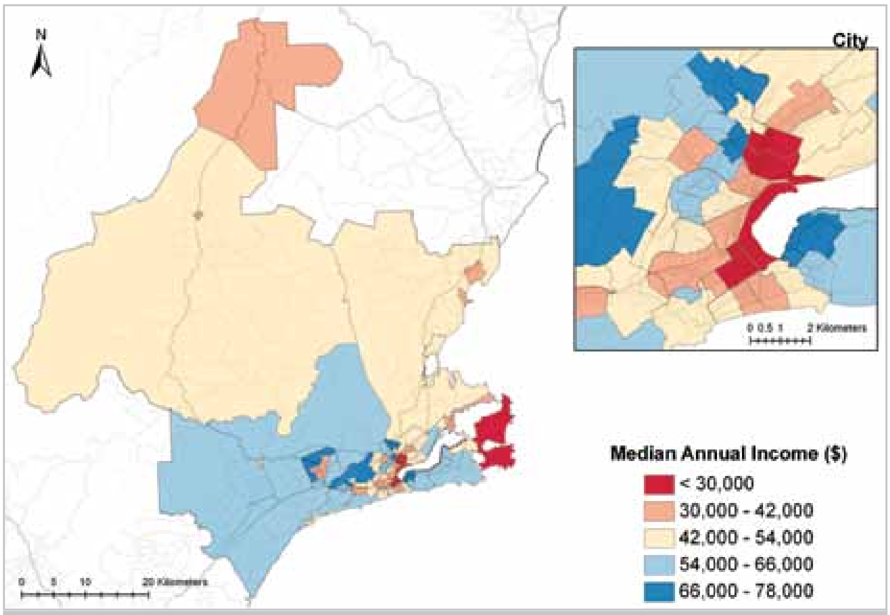


Figure 4.2. Average household income for Dunedin suburbs and settlement areas showing pattern of higher income residential areas in the outlying areas.

4.2 Private Transport Resilience

Households are vulnerable to a rapid rise in fuel price if they would not be able to adjust spending in other areas enough to continue with fuel purchases. This largely puts low-income households at the greatest disadvantage, and households that rely heavily on vehicle use for essential transport activities like access to work would be most impacted.

Figure 4.2 shows the general distribution of household income levels plotted for suburbs using data from the New Zealand Census. The dark blue areas show the highest income areas are in the new outer suburbs and in the seaside and lifestyle areas. Figure 4.3 shows an economic vulnerability analysis for the city of Dunedin. This is a straightforward analysis that uses the New Zealand Census data for household income and New Zealand Household Travel Survey data for vehicle usage for a work trip. A relative vulnerability score for households in a census mesh block is calculated by the product of average income and mode share of vehicle use for work.[19] Figure 4.3 shows that, unlike most major cities, the lower income residents are not necessarily segregated to out-lying areas. In Dunedin, lower income groups include university students who tend to live near the University and do not report using a car for a work trip. People living in the suburbs and coastal settlements around the city have a high percentage of work trips using a car, but also have higher incomes. The integration of residential locations for different income levels could provide for the diversity of housing stock near a variety of destinations that increases household ability to find lower-cost transport to crucial activities like work.

Personal travel would be resilient to a fuel shortage if the normal travel demand could be changed quickly in response to a fuel supply problem or price shock. An assessment of the travel demand adaptability for Dunedin was carried out as part of this Peak Oil Vulnerability Assessment. The TACA (Travel Adaptive Capacity Assessment) survey tool[20] was used and a sample of 220 Dunedin residents participated during August. The TACA survey prompts participants to think through a normal week of activities like going to work, school, band practice, and visiting Nana. In a weekly diary, participants report the origin, destination, route, purpose, and mode for each trip. They also rank how important the trip is to them. If the trip was done by private car, they are asked “Do you have another way to get to this activity?” The answers to this question provide a measure of the adaptive capacity of the household activity system.

Figure 4.4 shows the travel demand pattern for the survey cohort in Dunedin and surrounding settlements, which agrees with data extracted from the New Zealand Household Travel Survey. Survey participants reported very rarely using the city’s bus system. Participants expressed a high level of dissatisfaction with the bus service, schedule and cost. However, the bus did feature as an alternative to vehicle travel, particularly for longer distance trips.

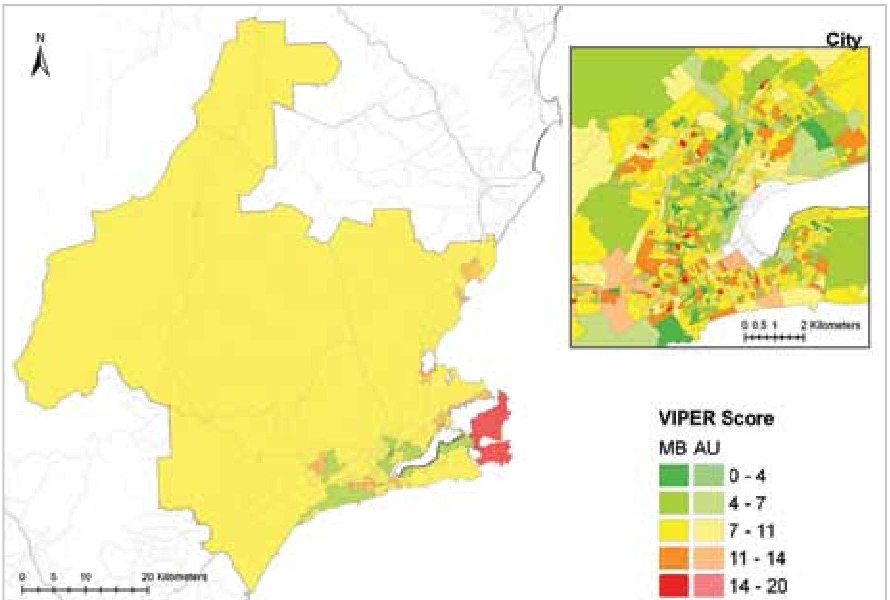


Figure 4.3. Analysis of the economic vulnerability with total score assigned to mesh blocks in Dunedin using scores derived from the household income and vehicle use for work trip.

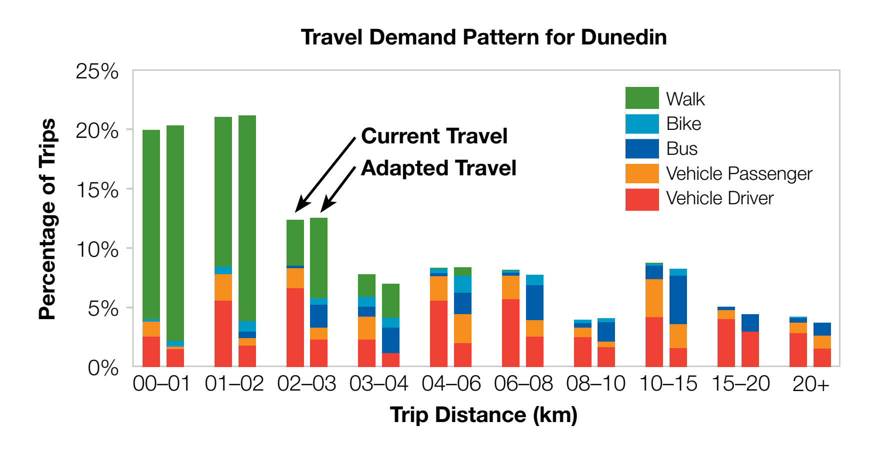


Figure 4.4. Current travel demand pattern for Dunedin and the adapted travel demand pattern with all reported alternatives to individual driver of a private vehicle.

The TACA survey asks participants to supply up to three 'alternative' ways to travel for each activity. These are alternatives that participants currently have for their normal trips. More than 60% of the trips currently carried out by an individual in a private vehicle in Dunedin have at least one alternative involving public transport, walking, biking or car-pooling. Less than 1% of activities could be carried out without travelling. It is important to note that the survey does not ask why or if participants would choose the alternative, it simply asks if they have another way to get to the activity. Figure 4.5 shows the private vehicle travel and the first selection of alternative mode. Although bus patronage in Dunedin is low at present, the current bus system provides adaptive capacity of 30% of car trips overall.

The adaptive capacity of Dunedin's urban form, transport system, and activity system is substantial. An energy reduction of roughly 40% in private transport would result from the adapted travel behaviour.[21] The lower bar graph in Figure 4.45 shows the amount of fuel saved as calculated from the trip distance and type of car reported by participants. The walking and cycling alternatives save all of the fuel, sharing a ride saves half of the fuel, and riding a bus uses quarter of the fuel used by the private car. The alternative walking and biking trips are shorter distance than the bus and car-pool trips. Travel behaviour change in private transport could easily respond to a major fuel crisis without disrupting social or economic activities, as long as the bus system could continue to function. As a reference, conservative driving is estimated to potentially reduce fuel demand by 2%.[22]

What if the price of petrol spiked to $3.00 a litre?
Resilience means the ability to react to a situation without it becoming a crisis. The TACA survey results indicate that Dunedin's urban form and population should be quite resilient to both fuel price shocks and fuel shortages. However, resilience depends on behaviour of individuals and organisations. In the case of the 2008 price spike, residents reported riding the bus, but then the fares increased substantially so people went back to private vehicles.

Figure 4.6 shows the average vehicle kilometres per year for vehicles registered to addresses in the settlements and Dunedin city urban areas.[23] The suburbs are listed by approximate distance from the city centre. Residences in the urban neighbourhoods travelled in the range 10,000–13,000 km per year. The rural towns have 15%–20% lower km per year than lifestyle commuter areas. The differences between settlements indicate that Port Chalmers, Portobello, Ravensbourne and Broad Bay are currently commuter suburbs. The people living in the lifestyle areas of Brighton, Company Bay and Sawyers Bay have few local destinations and appear to drive a great deal. New immigrants from the UK or North America generally do not consider a commute of more than 15 km each way to be long by any means.

During the TACA survey a number of retired lifestyle participants who live in outlying settlements registered very high weekly driving to shops, restaurants and social visits in Dunedin and other areas. The survey identified several families with children in satellite settlements who were making multiple trips to town, including after school and weekend activities for the children, shopping and social visits.

Given the travel demand and income patterns of the settlements shown in Figures 4.1 and 4.2, the resilience to a fuel price spike is probably reasonable for high income commuters, as fuel at $2.00 per litre would still not constitute a major household spend. However, a fuel shortage could pose a serious problem for people wanting to switch to the bus. The bus service to suburbs and settlements is poor and expensive. In particular, residents thought the hours of operation needed to be extended, transfers between bus routes need to be available, and fares need to be rationalised.

What if there was a fuel shortage?
People rely on fuel to a varying degree depending on a range of lifestyle factors. A person who already walks to most activities would be resilient during a fuel crisis. A person who commutes 25 km each way to work and school in a Ford Explorer and has no alternatives would

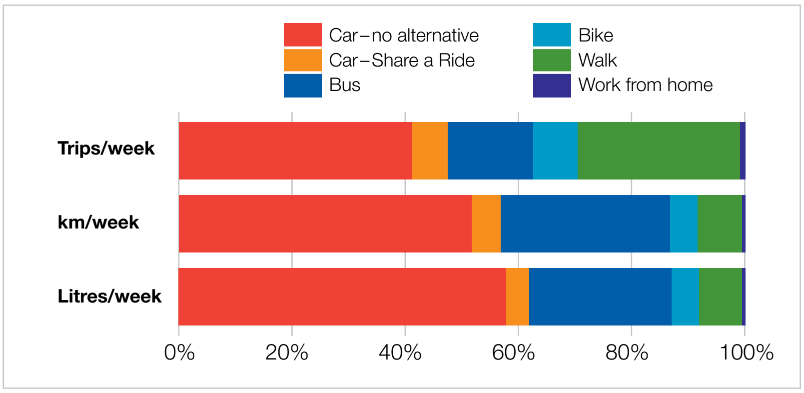


Figure 4.5. Alternatives to weekly private car trips, and the resulting distance shifted to other modes and fuel saved.

Dr Shannon Page helps a TACA survey participant to complete the personal transport audit in the Dunedin Public Art Gallery, August 2010.

not be very resilient during a fuel shortage. The TACA survey data can be used to provide some measures of resilience to a fuel shortage. Firstly, we need to know the *fuel dependence* of a person's lifestyle, so we compare the number of trips to the total fuel used. Next, we want to know the degree to which a person's activity schedule would be disrupted, so we calculate the *trip adaptability* based on the percentage of trips that had a fuel-saving alternative. Finally, we look at the total *fuel reduction capacity* calculated from all of the fuel saving alternatives reported.

A measure of *fuel shortage resilience* is calculated using the normal fuel dependence and the percentage of fuel use reduction resulting from alternatives to car trips for each participant. A fuel shortage resilience score of 0 would indicate no resilience, while a score of 1 would mean that all car trips have lower energy alternatives, or that the person can access all activities without using fuel. The higher the score, the more resilient the participant's lifestyle.

In general, the resilience of Dunedin residents is a factor of age and income. Table 4.1 gives the measures of resilience for different demographic groups. Students have the lowest income, the lowest energy use, and are the most resilient. University students also tend to live near the University. Council workers have high income, high fuel dependence, and low resilience. They also tend to have longer travel distances and live in outer suburbs and lifestyle areas. There were some high-income people who had low energy demand, but overall the fuel reduction resilience of professionals and workers in Dunedin is low enough to indicate that a panic situation is likely and business could be adversely affected.

How vulnerable are Dunedin residents to an oil shock?

Resilience is related to residential location to a certain degree. Figure 4.8 shows the resilience scores of participants in the TACA survey plotted on the city map according to their residence location. The interesting thing to note in looking at this figure is that the ability to reduce fuel use is not strictly related to the location of the residence. This pattern has been observed in other cities and in other research. The ability and readiness to have a low fuel dependence lifestyle, or to change in order to save fuel is much more dependent on internal factors than on external conditions. Households and individuals will prepare for reducing fuel use according to their own particular circumstances. If people are not prepared for a fuel shock, then they are much more

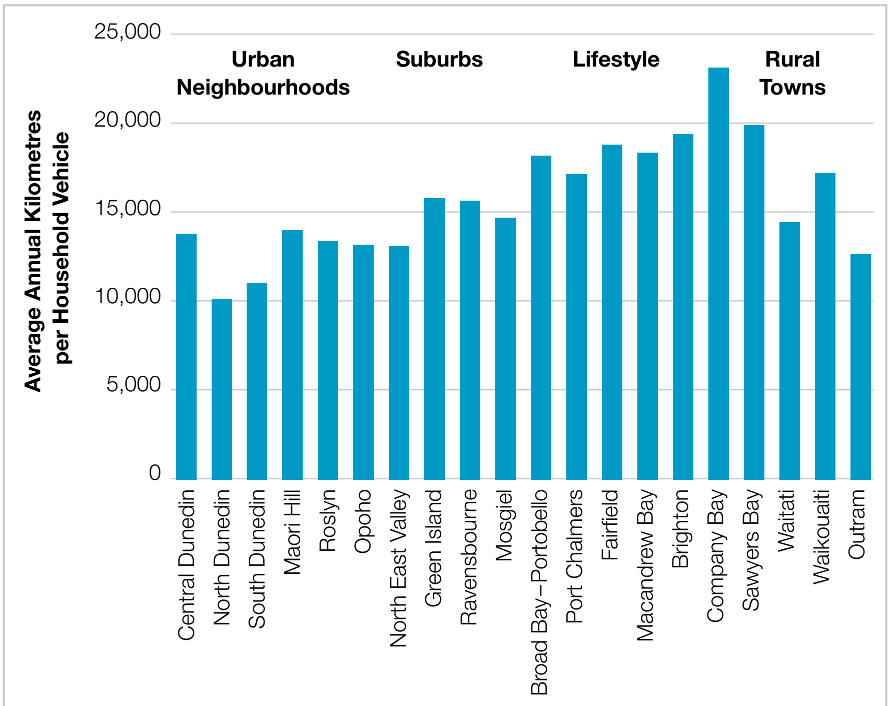


Figure 4.6. Average annual kilometres travelled per vehicle registered in Dunedin city suburbs and settlements. Data from Ministry of Transport Warrant of Fitness Records 2007–2009.

likely to panic and engage in behaviours that are destructive to the management of a fuel shortage. People can panic even if they do not rely heavily on fuel. We recommend that the Council encourage residents to make a fuel saving plan, in much the same way families are encouraged to think about fire escape and natural disaster preparedness. Working through the TACA survey to audit the normal travel activities could be a useful part of fuel shortage resilience.

The ability to recover from a fuel price spike or a fuel shortage is of course not a problem, as people simply go back to their higher usage behaviour patterns. However, if the fuel shock contributes to an economic recession, which reduces tourism, demand for products made in Dunedin, or retail activity, then the recovery will be more of an economic issue than a transport issue. Dunedin may be able to recover more quickly if plans were developed to switch to domestic market tourism and to have measures in place that eliminate panic behaviour in Dunedin.

4.2 Dunedin Businesses and Industry

Resilience in businesses and industry has two main components: private transport and freight. The resilience of workers to quickly adapt and continue to get to work, and the ability of customers to continue shopping trips are key to reducing the effects of a fuel disruption on normal business. Nearly all businesses require materials and goods that arrive through the freight movement system. Manufacturers and farmers must also be able to get their products into the freight system and to markets. Thus, the adaptive capacity of the freight and urban goods movement systems are paramount for business.

The readiness of businesses, manufacturers and primary producers depends on transport energy auditing and forward analysis. Reduction of the exposure to fuel shocks, response and recovery to normal business after the crisis are primarily achieved by investigating options and developing action plans. How many of Dunedin's foundation businesses have an action plan for fuel price spikes or temporary shortage events?

The fuel shock resilience of Dunedin's businesses was assessed by interviews with managers and directors in key foundation companies. The key elements of resilience were assessed. The companies are not explicitly identified in this report. The current resilience in the different business and industry sectors in Dunedin is not high. Even though a serious fuel price spike has already been experienced, the forward planning of business is limited to purchasing hedge contracts on diesel fuel. All of the industrialists acknowledged that their businesses and their supply chains depend on transport and thus on the fuel supply. However, none of the companies had conducted a transport fuel audit of any kind, there were no personnel assigned to forward planning to reduce fuel use, and there were no assessments of any kind relating to customer or worker travel resilience.

International tourism from America and Europe is a foundation of the Dunedin tourism trade, particularly via cruise ship arrivals. Americans and Europeans were reported to spend much more than Australian or Asian tourists. Vulnerability of this sector of the industry to fuel shocks was acknowledged as a serious issue. However, no measures or plans to mitigate the impacts of reduced long-haul visitors were identified.

Manufacturing, engineering and service industries reported being largely unaffected by the 2008 oil price shock, or even the global recession. Interest rates, availability of capital, international exchange rates and skills shortages were seen as some of the much more pressing business issues. These major employers were not concerned with the ability of their workers to get to work in the event of a fuel shortage. Some industrialists mentioned that lower cost transport of goods to market via rail would be desirable, but that it was outside their control.

Participants	Fuel Dependence (litres/trips)	Trip Adaptability	Fuel Reduction Capacity	Fuel Shortage Resilience
Age				
Under 20	0.165	0.92	34%	0.88
20–29	0.410	0.80	45%	0.74
30–39	0.469	0.69	35%	0.63
40–49	0.464	0.63	37%	0.57
Over 50	0.692	0.58	28%	0.55
Income				
Under $10,000	0.278	0.90	36%	0.83
$10,000–$20,000	0.210	0.71	29%	0.70
$20,000–$30,000	0.462	0.56	30%	0.50
$30,000–$50,000	0.516	0.65	32%	0.60
Over $50,000	0.611	0.61	40%	0.57
* TACA survey conducted August 2010 with 167 participants, at least 30 randomly selected in each group				

Table 4.1. Measures of resilience to oil shocks for Dunedin participants in the TACA Survey where a low score for fuel dependence, high score for trip adaptability, high percentage of fuel reduction capacity and high resilience score mean lower vulnerability to fuel shortage impacts.

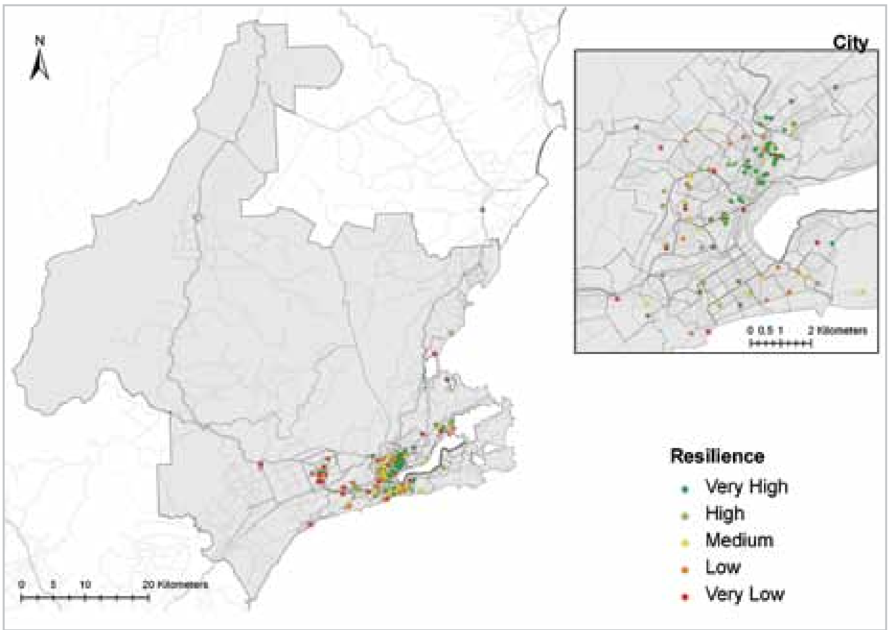


Figure 4.7. Fuel shortage vulnerability for all TACA survey participants plotted on a map of Dunedin at the residential location.

Primary production currently relies almost exclusively on road transport to move produce such as logs to processing facilities then to port for export. Company managers acknowledged their reliance on transport fuel, but were explicit about the ability of the economy and new technology to continue to provide transport fuel into the distant future, thus making transport fuel a non-issue. Further in-depth discussion regarding freight transport options again brought up a demand for rail transport that was not being met by investment in infrastructure. Several managers said they would prefer rail and that it made much more sense in the long run, but their advice and preferences were not currently sufficient to sway decision making in favour of investment in rail infrastructure.

The managers were clear that they were not motivated by Peak Oil or carbon emissions reduction in their preference for rail, but rather considered rail to be a lower-cost option which was not currently available to the degree they would like in Dunedin due to degradation of infrastructure.

There is very clearly a less than analytical attitude in the business sector toward the forward planning of transport resilience. Without exception, business managers and industrialists exhibited a hostile attitude toward ‘Peak Oil’. Future oil supply, rather than being one of a number of valid planning issues, is seen as a theory that is being espoused by certain types of irrational individuals with an anti-business

“Dunedin private transport sector currently has an adaptive capacity for 40% fuel demand reduction.”

Dunedin Private Transport Oil Shock Resilience Score Card

Resilience	Grade	Comments
Readiness	Fail	No forward planning, design or preparation, so panic is likely
Reduction	C	Exposure to impacts reduced by urban form and income distribution, but problematic for commuters from lifestyle settlements in case of oil shortage and poor bus service increases exposure to high impacts
Response	C	Some urban residents can change behaviour quickly to continue activities, but poor bus service limits response
Recovery	A	Resumption of consumption easily achieved when crisis is ended

“We have a long list of issues we worry about; interest rate, exchange rate etc. and Peak Oil is not one of them.”

agenda. Upon further discussion, all of those interviewed acknowledged that fuel price and supply is a major issue, and that low cost oil supplies will peak and then decline. However, all interviewees were adamant that oil supply is not a ‘doomsday’ issue, oil is just a commodity. When oil gets scarce, the market will bring in alternatives and new technologies will become available. When asked what the alternatives and new technologies might be, and if they expected the price to be higher than oil, the interviewees agreed that any alternatives to oil would be more expensive, so oil is likely to be the fuel used into the future. Rail and bus services were again seen as important options to have for the city, but that major deterioration problems exist with infrastructure and operation.

Freight and Goods Movements

All of the companies that rely on freight and goods movement in Dunedin acknowledged the vulnerability of road freight to fuel price. There were also concerns voiced about bitumen costs and road maintenance costs incurred by local councils. The freight movements in Dunedin and surrounding areas have a local pattern of flow to and from the city and the Port. Rail provided a major share of the freight movement during the development phase of Dunedin’s history, and coastal shipping provided a link to the rest of the country and the international markets. The shift of freight to road in Dunedin has not brought about the same degree of savings in time and warehousing that have driven that sector in other countries. The run-down of key rail lines and shipping infrastructure, for example to move logs, could present constraints on future growth and competitiveness.

4.3 Dunedin City Council Activities and Assets

Interviews with DCC staff were conducted in mid-2010. Records and data related to fuel use for city services were limited and not available for in-depth analysis. There are several staff at the DCC who have concerns about fuel supply and the long-term implications of Peak Oil. There has been community concern expressed about Peak Oil. The interviews with staff indicated a general concern about the issue, but difficulty in determining appropriate planning procedures or measures to take. There was also an opinion expressed that the Council was bowing to a radical element, and the interviewee expressed resentment that the Council was spending funds on commissioning a Peak Oil Vulnerability assessment.

It is not surprising that DCC staff find it difficult to find a standard or best practice approach to defining the issue or developing action plans. Since 2006, numerous cities overseas have initiated a range of actions on climate change and Peak Oil. Most of the actions involve council resolutions recognising the issue, setting up of a task force, and budgeting for a risk management assessment and development of a Peak Oil strategy. In Australia, the Queensland Environmental Protection Agency is developing an Oil Vulnerability Mitigation Strategy and Action Plan, and Brisbane’s task force produced a report with recommendations. An example from the UK is the 2008 Bristol Peak Oil Task Force which produced a report looking at the facts, assessing the impacts, discussing risks and opportunities

Dunedin Business Oil Shock Resilience Score Card

Resilience	Grade	Comments
Readiness	Fail	No auditing of current transport fuel use, forward planning, design or preparation.
Reduction	C	Exposure to impacts reduced by proximity of production and tourism destinations to the city and the port. Vulnerability of road freight sector and perishable produce. High Exposure to loss of international tourism.
Response	Fail	No ability to change quickly due to lack of rail infrastructure.
Recovery	C	High risk of failure of road freight companies. Tourism operations like cruise ships can take longer to recover.

Footnotes

15. Smith (2010)
16. NZTA (2010)
17. MOT WOF data 2000–2010
18. Denne *et al* (2005)
19. Method related to VIPER analysis www.griffith.edu.au (2008)
20. Watcharasukarn, Krumdieck, Dantas and Green (2009)
21. Carpool = 5 litres / 100km, Bus = 2 litres / 100km
22. Denne *et al* (2005)
23. Extracted from MOT Warrant of Fitness Data 2000–2008

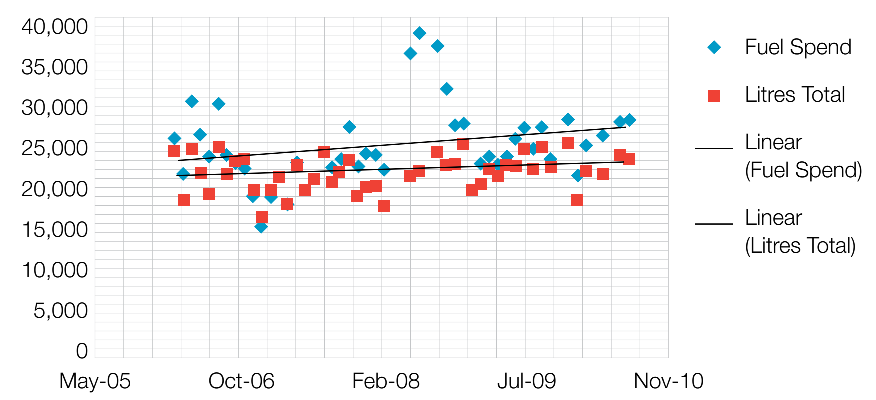


Figure 4.9. Citifleet fuel use and expenditure over the past five years indicating more than 2% annual growth in fuel use.

and making recommendations for action. Cities and towns across the USA have passed resolutions recognising oil supply as a challenge and setting up groups to develop action plans. The city of Bloomington, Indiana has a population similar to Dunedin. The city passed a resolution in 2006 recognising the issue, supporting adoption of an oil depletion protocol, and urging the federal and state governments to take action. Bloomington has also established a Peak Oil Task Force. A common task force recommendation is for public awareness to be increased so that individuals and households can increase their own resilience. Another common recommendation is for all councils to include fossil energy decline in future planning and modeling, including decisions about the need for new roads and road expansions.

The Dunedin City Council currently uses around 22,000 litres of fuel per month to carry out a wide range of activities and provide services. Nearly all of the transport for council staff is done in Citifleet vehicles. The Citifleet managers are conscious of fuel efficiency and carbon emissions. However, interviews with DCC staff found a lack of awareness of, or concern for, the amount of fuel used in Council activities. Indeed, some staff expressed a desire to use the large city vehicles even if the task did not require it as driving the utility vehicle is more fun. The charge system for vehicles is based on time out rather than on fuel use or kilometres travelled. There was not a sense that staff were aware of the cost of fuel to the Council. Figure 4.9 shows the monthly fuel purchase and the monthly spend over the past five years. The 2008 price spike is clearly evident; from an average monthly spend of $22,000 to a high of $37,000. This type of increase of 50% over budget is difficult for organisations.

5. LONG TERM CHANGES IN DUNEDIN COMMUNITIES AND SECTORS

5.1 Dunedin City Urban Development Scenarios

Current Urban Form

Urban form refers to the land use patterns and the transportation networks, but does not infer any particular travel behaviour. In a particular urban form, the range of options for activity destinations and the travel distances will be different. Research from around the country and the world shows that the number of return trips per week for households is always in the same range, with some variation for household make-up but little dependence on urban form. The number of trips per household would not be expected to change in the future. As oil supplies become increasingly restricted, the major changes will be in choices of where in the urban form to live, what destinations to choose, and what transport mode to use for the trips. The range of choices for distances travelled and the modes available depend strongly on the urban form.

The basic geography of Dunedin city is a result of its history. The urban form of the city reflects the historical and continued importance of the rail and Port connections to Dunedin's economy. The pattern of the trolley and cable car infrastructure can still be found in the locations of the urban residential suburbs and alignment of major streets. Figure 5.1 shows the extent and routes of the city cable car and trolley system. Urban residential areas are within 4 km to the west, 5 km to the north, 6 km to the south, and 4 km along either side of the Harbour. There are shopping areas and destinations along the main north-south axis of the city, as well as along the old tram routes.

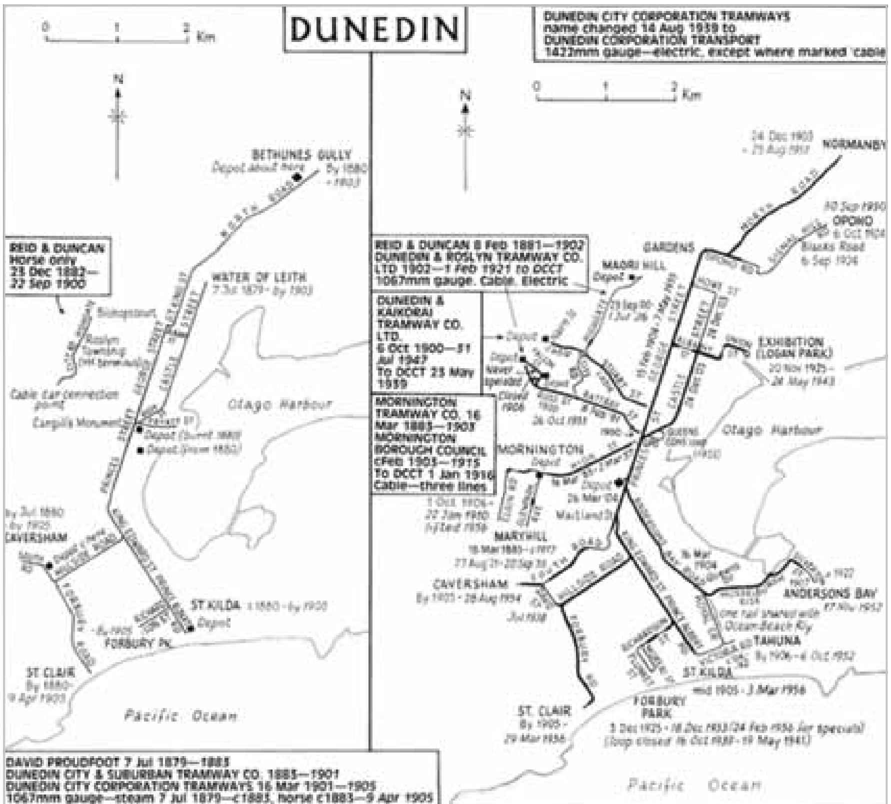


Figure 5.1. The historical extent and alignment of the tram lines shaped the city of Dunedin

Dunedin city's vulnerability to long term oil supply decline is tempered by the adaptive capacity inherent in the historical form of the city. The main destinations are all accessible to the urban housing areas within 6km. The current walkability of the city is degraded by the vehicle traffic, parking and congestion. However, long term congestion decline means that the city could become more amenable to pedestrian and bike traffic. Figure 5.2 (a) is a map of Dunedin with the land use designated by different colours.

High Density Urban Development Scenario

High Density Urban form has a high number of households and high number of destinations per square kilometre. As shopping trips comprise the highest number of trips per week, the average distance to shopping should be lower for a high density urban form. In Dunedin, the shopping density is already quite high in the central city area. There is an opportunity to increase housing density in the central city area and along the waterfront with apartment buildings and with development of loft apartments in existing and historic buildings. Many cities around the world have had successful redevelopment of the central urban areas for high-amenity living. Apartment developments that cater to a range of income levels are most desirable.

Many of the work and shopping destinations are in the central business district, so adding high density housing within the CBD would facilitate reduced fuel demand. The growth of high density urban housing will depend on the market for urban, amenity-accessible lifestyles. Figure 5.2 (b) shows a land use map of the Dunedin region and city with population reduction in the low-density residential areas, and increased high-density residential areas within the CBD. The change in transport mode share is due to the relocation of 20% of residents of the most distant lifestyle residential areas into the city.

Redevelopment of high density housing in urban city centres is a lucrative and attractive market. Loft apartments are created in re-modelled historical buildings and urban amenities such as restaurants, dry cleaners and shops fill the street level store fronts.

Urban villages are created in existing urban forms, firstly by turning the public space of a road or parking lot over to people and their activities. Everywhere that urban villages have been established, business has increased. Weekend farmer's markets and seasonal festivals are other high–value activities that need urban village space in order to thrive.

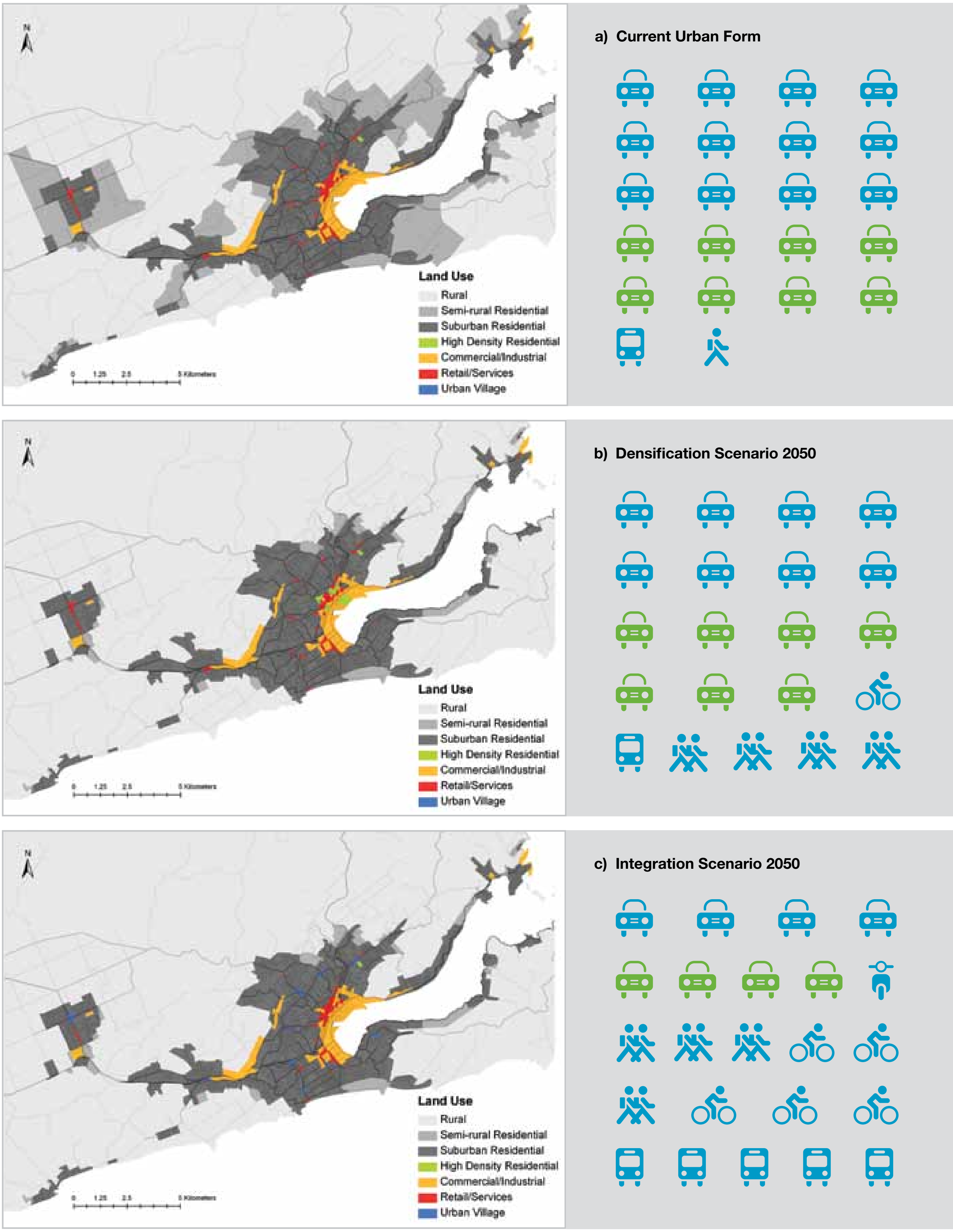


Figure 5.2. Urban form scenarios with the current (a) and modelled (b and c) travel behaviour indicated. (b) Densification is achieved with a shift from semi-rural to high-density residential housing in the central city. (c) Integration is achieved with a shift from semi-rural to suburban residential housing and the growth of urban villages in the suburbs that act as shopping and public transport nodes. The green cars indicate the percentage of car trips that are adaptable to bus, walking or bike according to the TACA survey results.

Integrated Urban Village Development Scenario

Integrated Land Use implies no higher density than today, but key activity destinations are located within residential areas. To a certain degree, this is the historical pattern of suburban development in New Zealand where small shopping strip malls are present in older suburbs. The recent trend to large box warehouse retail stores, large supermarkets, and outlying commuter settlements increases the shopping travel distance on the whole. In the TACA survey we found that people accessed the large stores in the city more often than the local neighbourhood stores. The development of well-designed, highly attractive and amenable integrated shopping, education, service and medical facilities within the suburbs could create urban village centres surrounded by feeder residential areas within biking and walking distance or on bus routes. The growth of village market centres will depend on a demand for local amenities that can compete with the convenience and prices of large box stores and supermarkets. In the long term, the increased transport costs and awareness of oil supply decline will likely lead to renewed appeal of village centres.

Figure 5.2 (c) shows the future land use pattern for Dunedin with integrated neighbourhood village centres. A much lower vehicle demand could be accommodated by an integrated urban form. The integrated development pattern is also highly amenable to public service routes which connect up the urban villages. The integrated travel pattern was calculated by substituting the travel demand pattern for South Dunedin, which is currently a relatively integrated neighbourhood, for the other urban suburbs and settlements. The residents of the very low density residential areas were also moved into a medium density area.

5.2 Active Mode Infrastructure – 100km of Bike Path

Active Mode Infrastructure implies that precedence in the transport network is given to active modes. The design of 'car interference-controlled' bicycle and walking paths, bike storage facilities, walking spaces, etc are well known to improve and enhance

Traffic engineers in Dunedin carve out space in the transport network for 100 km of bike-dedicated infrastructure to service local neighbourhood activities, primarily children.

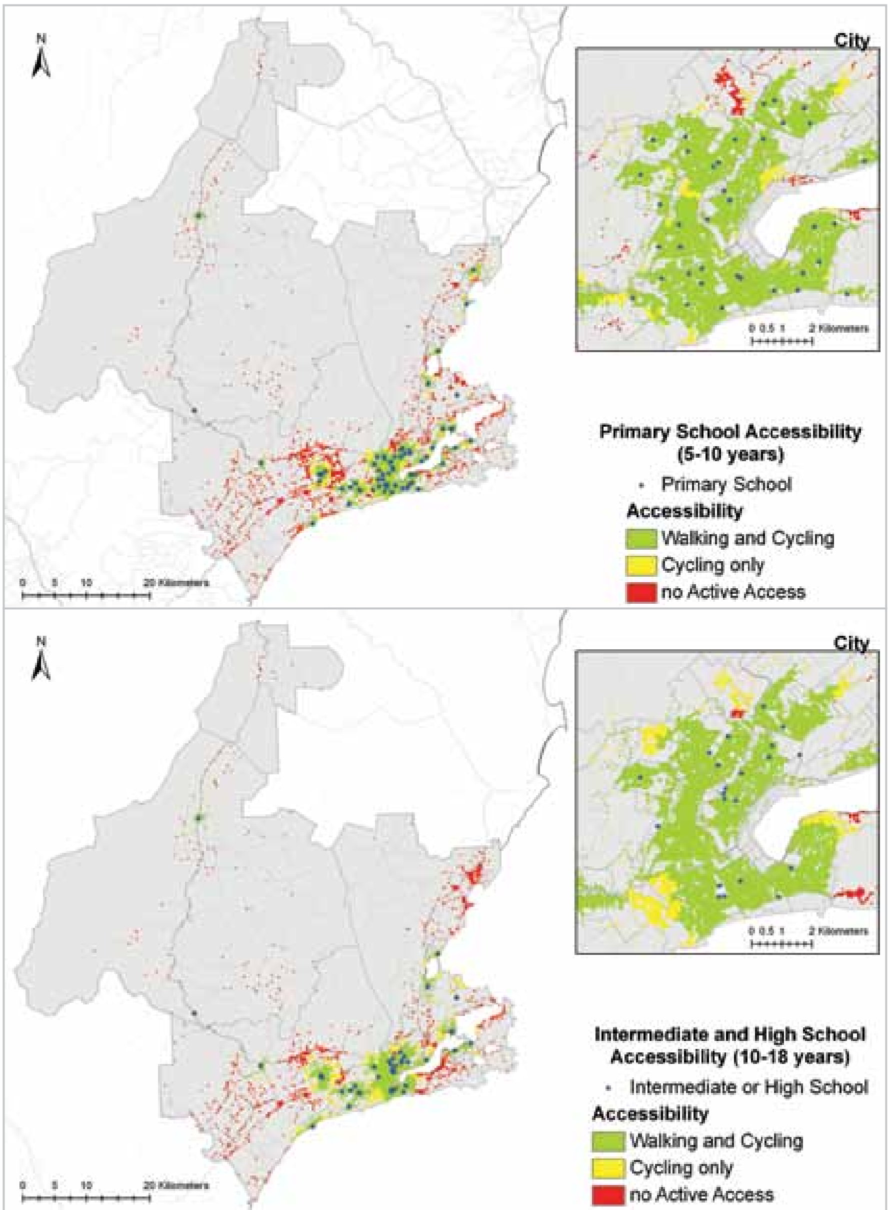


Figure 5.3. Accessibility to educational facilities (blue dots) is indicated by a green dot on residences within a walkable distance to a school and a yellow dot to indicate a cyclable distance.

the adaptation to active modes. In Dunedin, the historical urban development pattern has primary and intermediate schools within walking and biking distance of the feeder neighbourhoods and the public transport lines. Active mode development over the long term would make the most sense to facilitate access to local schools, shops and recreation. In the long term, congestion reduction will improve the cycling experience along major roads. However, demand for short trips without traffic interaction is higher than for cycling with traffic. We have estimated that building 100km of dedicated cycleways that connect residential areas to local schools, recreation destinations and shops could reduce short car trips by 20%. The potential for this adaptation is born out by the high percentage of short trips indicated by the NZTA Transport Survey and the local TACA survey. Substitution of short trips with active mode will not result in major fuel demand reduction but would have many ancillary benefits in health, safety and community. In fact, a recent report has found that designing New Zealand urban areas for active mode was the most important measure for improving public health.[24]

Figure 5.3 shows the results of a new kind of analysis being developed at Canterbury University to help understand the active mode accessibility of a residential area with respect to a range of activities. This figure has a coloured dot placed at each residential address denoting the distance along the existing streets to a particular type of destination, depending upon the modes by which the destination can be accessed.

A vast majority of the homes in the urban and suburban areas of Dunedin are within walking distance of schools. There are only a few residences outside of cycling distance of a school. In Figure 5.3, the walking and cycling distance has been adjusted to fit the age of the children and the school. For example, the maximum walking distance for primary school age children is 1.4 km and for high school age students is 2.3 km.

Figure 5.4 shows the accessibility analysis for food shopping. The supermarkets are marked with blue dots. As is the case with schools, most homes in the urban areas and the main suburbs, Mosgiel and

Port Chalmers are within 6.3 km of a food market. The locations of supermarkets are the locations used in the integrated urban form scenario as urban village centres. The urban villages could be developed by re-design of the supermarkets, parking lots, and some surrounding roads and properties into pedestrian malls. This sort of project could be accomplished as a public-private partnership with property developers and local businesses. Many of these areas have some historical architectural elements, and they were stopping points on the old tram lines. However, much of the amenity value of the supermarket areas has been lost due to the dominance of public space by automobiles.

5.3 Transportation Long-Range Developments

The compactness and relatively high density of the urban form have actually made converting Dunedin to car-dominated transport networks problematic in several ways. The space for parking is difficult to carve out of a pre-car urban form without damaging the urban feel of the city. The continuously increasing demand for vehicle transport has challenged transport engineers, and led to carving up of neighbourhoods with highways and thoroughfares. The noise and congestion of vehicles on narrow streets, and the hazards vehicular traffic pose to pedestrians and cyclists has led to a marked decrease in walking and cycling over the past fifty years.

Scooters

A 1 km walk can be achieved in around 20 minutes by a moderately healthy person. A 4 km bike ride on a flat path would also take about twenty minutes. The challenge for active mode transport in Dunedin is the steep hills. The convenience of access to residential areas on the hills afforded by a private vehicle can still be achieved with motorcycles and scooters while realising large fuel savings. If most transport around the city continues to be individual, then the greatest adaptive capacity is in the uptake of scooters and motorcycles. Fuel demand reduction of 30% from the private transport sector could be achieved by mode shift to two-wheeled vehicles with fuel consumption of less than 2 litres/100 km (usually a 50cc engine size). Scooters are currently available and affordable. The uptake of scooters has been high in other cities where fuel is expensive.

There is a problem with a shift to scooters as a way to reduce fuel demand: it is not ideal for quality of life. Anyone who has travelled to Taiwan or Italy where scooters are widely used can testify that there are serious issues. Noise and pollution are the key problems. These could be solved by technology improvement, but only if governments require emissions and noise-reduction equipment before the scooters enter the market. The future of Dunedin as a scooter city is not the most desirable possibility unless scooter technology develops further and traffic engineering can manage the safety issues.

Electric Trolley Buses

Public transport is another mode that will experience demand growth in the future. The TACA survey showed that there is a large potential demand for a high quality bus system. However, Peak Oil means that the fuel for buses is declining at the same rate as the fuel for cars, and thus it will be difficult to maintain affordable ticket prices and services. If the historic electric tram and cable car system were in place, the adaptive capacity for Dunedin city would be much higher than any other city in New Zealand. Perhaps it is time to think about a revival of an electric public transport system?

Electric light rail is expensive. However, electric trolley buses powered by overhead lines are currently manufactured in New Zealand and have reasonable capital cost. We envision a unique opportunity for Dunedin to explore:

- Local manufacturer Designline could design electric buses that have a look similar to the historic trams. The city with historic trams would have high appeal for tourists.
- The current bus system requires a major re-organisation and public relations boost. Building an electric trolley bus system could be a way to accomplish this.

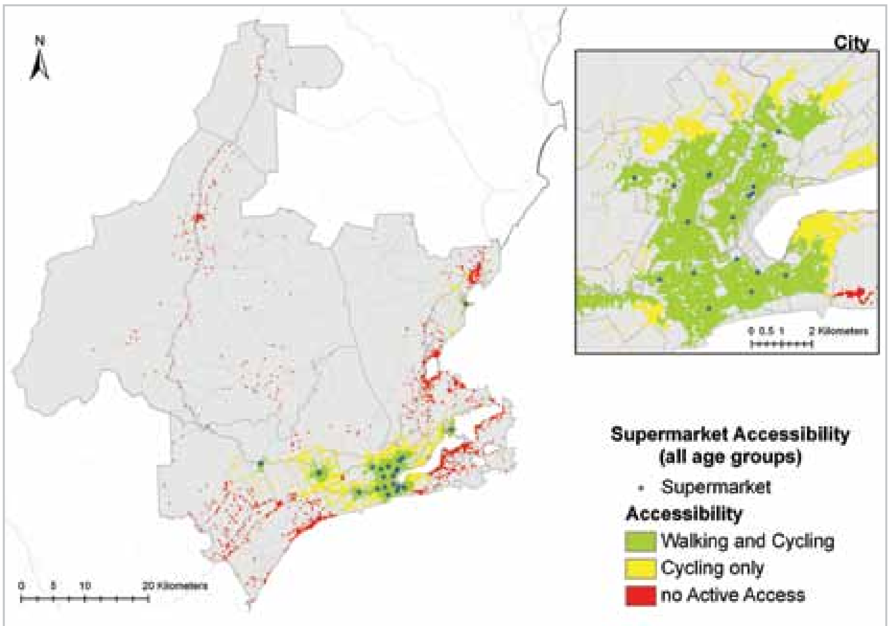


Figure 5.4. Accessibility to supermarkets and food markets (blue dots) is indicated by a green dot on residences within a walkable distance, a yellow dot for a cyclable distance, and red for homes further than 6.3 km.

The next forty years could see significant renovation, replacement and relocation of housing stock in Dunedin. Future development trends will be influenced by many factors, including a growing demand for low-fuel use travel options.

Flexibility and ingenuity are traditions of Otago agriculture as exemplified by Flagstaff Alpacas.

Escea and Farra Engineering are examples of versatile Dunedin industry.

- Electric public transport would be insulated from future Peak Oil vulnerability.
- The electric tram route design could be part of a master plan for village centres and active mode infrastructure. The routes could also be designed to connect lower-cost housing areas with the University and employment centres, thus increasing the resilience of low income workers to fuel price spikes.

5.4 Settlements

Greater Dunedin includes the central city plus settlements along the Harbour, along the coast, and into the interior. Over the past 15–20 years, these settlements have been slowly changing character with increased numbers of retirement and commuter lifestyle residents. In the context of continuing high prices and gradually reducing fuel supplies, lifestylers in the settlements may eventually choose to relocate within the city or the suburbs. At $2.00/litre price for fuel, the average household in Sawyers Bay would spend $1600 more per year on petrol than a household in Māori Hill for the same 10 litre/100km vehicle.

The trend of relocating to the city could be accelerated with the innovation of new 'urban lifestyle' neighbourhood redevelopments that capitalise on the desirability of walkable, safe, and amenable areas with easy access to culture, education, recreation, services and work places. Given the age and non-standard condition of much of Dunedin's current housing stock, an urban re-development project that renovated quality character homes and replaced end-of-life pioneer housing with modern, high-efficiency, clean heat housing would be a huge benefit for the well being of residents, particularly retirees. If the development trend is for workers to move into the city, then the property values and prospects for the settlements as lifestyle residences could be degraded. However, if local food growing and processing became more competitive with imported goods, the settlement areas could see redevelopment as production areas.

Another trend that could occur would be development of amenities, schools and shops in the settlements. If 50% of current non-work trips could be shifted to local destinations, and if van pools could increase passenger density from one person per vehicle to eight, then the settlements could adapt to the predicted fuel reductions of the next twenty years.

5.5 Behaviour: The Low Carbon Lifestyle

An extensive travel behaviour adaptability survey was conducted in Dunedin at the end of August using the TACA survey method.[25] The TACA survey is an activity-based method that records the weekly travel pattern and the mode alternatives.

The TACA survey can be analysed to gain some idea about the long-term adaptive potential of the city of Dunedin. Of the more than 200 participants, 15% currently do not use a car and do not use any fuel. Our research in Christchurch has found the same percentage of people reporting this type of 'low energy lifestyle' as well. Analysis of the annual household kilometres for Dunedin registered vehicles agrees with this finding, as 20% of registered vehicles travel less than 3000 km per year. When the TACA survey data is geo-coded and plotted on a map of the city, there is no correlation found between the residential location and low energy lifestyle. Organisation of activities and travel behaviour for a 'low carbon lifestyle' is possible for a wide range of people in Dunedin with residences in nearly all of the settlements and suburbs of the city.

Table 5.1 gives examples of four Dunedin residents who participated in the TACA survey and who currently have a low carbon lifestyle. The 19-year-old full time student walks everywhere, but still normally makes 33 trips per week and covers 60.89 km. The 37-year-old professional woman walks most places but reported being able to walk all of the trips she currently uses the car for. She must live quite close to her destinations as her longest trip is 1.7 km. The 74-year-old retired man walked or drove but reported walking or the bus as an option for all trips. The 51-year-old man with full time employment biked all trips in town, and only used his car for weekend recreation. He reported not having any alternative for the weekend driving.

Long-term fuel demand reduction could be realised by uptake of the lower energy alternatives, for example an increase of 120% in kilometres travelled by bus was indicated by participants, using the existing public transport system. A 160% increase in bike kilometres was indicated as an alternative to current car trips. Walking alternatives totalled 20% of travel distance as opposed to the current 4%. The 40% energy reduction associated with all of the lower-energy alternatives that residents of Dunedin currently have simply through behaviour choice, would be highly affordable as it would actually reduce spending on fuel. Of course, behaviour change is also technically feasible, as long as the public transport system is available and as long as the walking and bike trips are safe journeys.

There are two other main sources of energy savings which arise from lifestyle change. One is uptake of lower-energy travel behaviour patterns by a greater percentage of residents, and the other is re-organisation of residential location to reduce travel distances. The TACA survey shows that walking is a lower energy alternative for short trips under 2 km for about 40% of participants.

5.6 Sectors

The long-term impact of a reduction in transport fuel use on sectors depends on the ability to adapt while maintaining function and economic viability. Flexibility and the ability to envision new opportunities will be key to prosperous change. Action plans to

Wenita Forest Products is a local radiata pine producer.

Cruise ship tourists totalled 11,000 in 2009.

Dunedin ICU ward.

help employees cope with travel demand change, and long range planning which includes some consideration of ways to improve fuel efficiency in the business will be useful in reducing Peak Oil vulnerability.

Industry

One of the hallmarks of Dunedin's industrial sector is its diversity and flexibility. Many of the manufacturers have high versatility and are not tied to a particular mass-produced item for export. Much of the manufacturing in Dunedin involves custom engineering and tooling, and is capable of satisfying local and domestic markets. The industry in Dunedin has access to skilled labour and a good range of materials. Local industry also has the capability to process food, brew beer, mill forest products and wool, and produce textiles and clothing. Peak Oil may mean a long term reduction in imported goods, but this could have a revitalising effect on local manufacturers. High oil prices may cause a slow-down in fishing, but this could actually have a beneficial effect as fish stocks may be able to recover, meaning less fuel is needed to find fish.

The conditions for industry have been good since before the oil boom. Local industries will need to adjust to market conditions in the future as they have in the past. As long as industry does not get committed to ventures that can only be carried out with low-cost transport then its resilience should be reasonable. Industries should include some long-term thinking in their regular business planning. The most vulnerable industries are those that refuse to adapt, and those which have made no provisions for dealing with high priced fuel.

Agriculture

The agricultural base in the Otago area is more than sufficient to meet local needs and provide surplus for export, even with reduced oil use. However, on-farm fuel use is a very small share of current oil use. There is no evidence that a crisis is looming for farmers from Peak Oil. Agricultural productivity has increased with the use of fuel for farm machinery, but the return to society of farm fuel use is so high that the small share of farm fuel use will always be a priority. Most farmers have become reliant on oil-based chemicals and other farm inputs. However, there are numerous examples of farmers who have reduced these inputs and actually improved their soil condition, biodiversity and biological resilience. Reduced on-farm fuel use may lead to reduced range for sheep and cattle. This in turn may lead to regeneration of bush on erosion-prone hills and thus provide ecological services for local climate control, water quality and slope stability which may actually improve the resilience of the rural areas. Agriculture will adapt to conditions in the future as it has in the past, but there will be sufficient fuel supply for support of primary production for at least then next forty years.

Forestry

The local wood supply from Otago forests is sufficient to sustainably supply home heating, lumber, pulp, and other needs into the distant future with surplus to export. Forestry depends on heavy vehicles and equipment to produce lumber in the current radiata pine plantation model. This particular model of forestry is not inherently versatile, flexible or adaptable. Future adaptation may be found in the methods of producing valuable wood products from the land in the region. Other models of truly sustainable forestry are numerous from other areas around the world with environments similar to Otago. These models use integrated and multi-purpose aspects of more natural forests to increase biological diversity, soil and water quality and resilience of the forests. The sustainable forest model recognises local values and has also been shown to reduce susceptibility to pests, disease, and importantly, to fire. It is entirely possible that reduced fuel consumption in forestry operations could be part of a system-level move to more sustainable forestry models. Logs and forest products must be moved to the mill and on to the market. Rail is obviously a possible lower-energy alternative to log trucks on roads. Building of rail infrastructure to handle logs, dairy, wool and other primary produce would require an integrated approach to land use planning with a long-term view.

Tourism

There is no question that Dunedin's $20 million international tourism industry is highly vulnerable to Peak Oil. In the long term, it is likely that the number of international tourists will decrease. The number of cruise ships around the world has grown with the increase in middle class consumption of holiday products and with low-cost fuel providing no

Profile	Age	Income Range	Sex	Travel [km/week]
Otago University Student	19	Under $5,000	F	60.89
Retired	74	$30,000–$40,000	F	25
Professional	37	$40,000–$50,000	F	33.25
Work Full Time	51	$70,000–$100,000	M	55.8

Table 5.1. Low carbon lifestyle residents of Dunedin are found in all age and income ranges. They use very little fuel for their normal trips or could adapt nearly all of their car trips to walking or the bus.

University of Otago graduation ceremony.

New Zealand Link operated by Air New Zealand

Historic Dunedin Rail Station

barrier to delivering the product. In the long-term, uses for oil other than holiday-making will have much higher priority and the long-haul tourist boom will become a bust.

As with the other sectors, the changes in the future that emerge from oil supply decline are not necessarily doom and gloom scenarios. For example, the first overseas tourists to disappear will be the backpackers with lower incomes and spending power. New Zealand should still be able to compete for the higher income travellers if high quality travel expenses, which come with higher price tags, can be provided. As the numbers of overseas tourists decline, so too does the number of New Zealanders who travel off-shore for holidays. Long-range planning for Dunedin should include development of attractions for local tourists. For example, a Scottish Highlands festival and games seems like an obvious tourist attraction for Dunedin with at least a comparable appeal as the West Coast Wild Food Festival. There are many opportunities for connecting with the rest of the country to provide for the domestic family holiday market. In the long term, local destinations are likely to be able to compete with the overseas holiday if creative and innovative holiday experiences like the Taieri Gorge Railway are put on offer.

Commercial and Business

The Dunedin Public Hospital is one of the major employers in the city, as is the Dunedin City Council. Commercial and business organisations will have to adapt to the long-term changes from Peak Oil through evaluation of their services and customer needs, and delivering their services while being more efficient and conservative with transport fuel. Businesses can work with their employees to help them make travel plans and encourage active mode choices by providing facilities and incentives. In the long term, businesses will develop preferentially near public transport hubs and in urban village settings. It is likely that the retail model of large supermarkets with large parking lots and large discount box stores that rely on bulk sales of low-cost imported goods will decline in the future. This means that local goods and services and smaller shops will be able to compete and may find a favourable position in the post-Peak Oil business environment.

New Zealand's current estimated cost of road crashes is $4 billion. In the long term, reduced vehicle kilometres driven, slower speeds and more conservative driving in response to oil supply reduction will have a sizeable social benefit. The Dunedin Public Hospital can look to have reduced need for costly ICU services due to fewer accidents. Similarly, the local spend on new road projects and road maintenance is likely to decline in the future.

University of Otago

The University of Otago is an anchor for the city of Dunedin which provides a large number of high salary jobs and attracts students and visitors. The country will continue to need the graduates of the University as oil supplies decline, and thus the University will continue into the future. However, the university facilities, operations, and in particular, the travel patterns of the staff and students will adapt to consume less fuel. This could have interesting implications. For example, students may increasingly stay in Dunedin during holiday breaks rather than returning to homes around the country. Teleconferencing technology at the University could become a hub of activity for staff and for local businesses and local government as increasingly communication is done via technology rather than a quick flight. As with the other sectors, auditing of current fuel-consuming activities and long range planning which includes oil demand reduction will improve adaptability.

Dunedin International Airport

There is no question that the current level of air travel in New Zealand is at, or near, the peak in number of flights and number of kilometres. In the long term, the high level of service provided by air travel will mean it will continue to have an important share of the transport market. However, it is certain that air fares will creep upwards and that people will start to limit air travel to more important trips and either curtail less important trips or double up on trip purpose when using airlines. Air New Zealand has taken measures to improve fuel efficiency in response to the fuel price spike of 2008. It is reasonable to think that travellers will also take efficiency measures in the future.

Freight and Goods Movements

The adaptive capacity for shipping freight and moving goods around the city is high for Dunedin for the same reasons stated for private transport. The ocean port and the rail line give access to external markets via very low energy transport modes. The compactness of the city and the proximity to the regional transport hubs and local production facilities means that freight will continue to move into and out of Dunedin as a regional hub. Long term priorities would obviously be on maintaining and enhancing the rail and port infrastructure.

A freight matrix for Dunedin and the Otago region has been produced opposite to provide some indications of the freight movements in and out of Dunedin.[26]

Footnotes

24. Public Health Advisory Committee Report (2010)
25. Watcharasukarn *et al* (2010)
26. Richard Paling Consulting (2008)

Table 4.1. Freight Matrix for Dunedin and the Otago Region through Port Otago

Freight Category	Produced or Exported from Dunedin (tonne)	Imported to Dunedin (tonne)	Notes and Comparison with New Zealand
Phosphate Fertiliser		37,900	3.54% of NZ total Fertiliser is also produced at Ravensbourne but unknown destination
Limestone	241,000		4.77% of NZ total Limestone quarry in Otago
Concrete	526,000		5.88% of NZ total Concrete also imported but quantity unknown
Aggregate	5,393		Rock and sand produced and used locally for buildings and roads
Coal	57,000,000		1.2% of NZ total Produced from open cast mine, not known how much used locally or exported
Petroleum Products	1,300	255,400	3.8% of NZ total From Marsden Point except for 14,300 t
Scrap Iron and Steel	11,000	8,000	3.6% of NZ total exports 2.0% of NZ total imports
Horticultural Products and Grain	60,800	5,700	4.1% of NZ total exports 0.6% of NZ total imports
Fruit and Vegetables	102,000		2.42% of NZ total 204 t of production consumed locally
Otago Meat Production	Lamb 41,000 Beef 14,300 Sheep 10,800		11.7% of NZ lamb 3.2% of NZ beef 13.7% of NZ sheep meat
Port Otago Meat	219,200		25% of NZ total meat export
Milk Production	721,000		4.63% of NZ milk production
Port Otago Dairy Perishable Non-Perishable	Milk 1,300 Dairy 172,300 Dairy 272,400		1.6% of NZ fresh milk 20.7% of NZ perishable dairy 23.8% of NZ non-perishable
Port Otago Forestry	Wood Chips 58,000 Logs 335,000 Sawn Timber 61,000 Products 54,000 Pulp & Paper 15.1		10.3% of NZ total 18.8% of NZ total 19.5% of NZ total 6.5% of NZ total 1% of NZ total

6. PRIORITISATION AND RECOMMENDATIONS

EAST Research was asked to assess the vulnerabilities of the Dunedin City Council and the community to Peak Oil. Peak Oil websites, books and videos focus on vulnerability to declining world oil supply. Public concern is an understandable response to these messages. However, the Transition Engineering approach pioneered by Associate Professor Krumdieck, founder of EAST Research, is based on evaluating drivers for change in complex systems and developing strategic development scenarios that explore policy options, manage vulnerability, meet quality of life requirements, and achieve desired sustainable development outcomes.[27]

Figure 6.1 shows the Strategic Scenarios Analysis results for Dunedin's development opportunities over the next forty years. This chart is essentially a summary of all the previous discussion, and the calculation of private transport adaptation to 50% fuel reduction by 2050. The analysis also includes cost and technical feasibility. Clearly, behaviour change in conjunction with any combination of urban form adaptations provides the most promising opportunities for adaptation.

6.1 Strategic Analysis Scenarios

Strategic Analysis Scenario Method

Two sets of strategic scenarios were developed. Urban Form Scenarios reflect land use patterns and urban development strategies that are recognised as reducing the need to travel. The scenarios are developed specifically for Dunedin. Transport Scenarios reflect developments in vehicle technology platforms, fuels and travel behaviour.

Each scenario is evaluated for the probability of being able to achieve a 50% fuel reduction from 2010. This evaluation uses the RECATS fuel energy constraint modeling method.[28] The RECATS analysis provides an indication of the level of risk that the combination of urban form and transport technology or behaviour will be able to achieve the 50% fuel energy constraint. The RECATS model has two parts: fleet energy efficiency, and adaptive capacity for each of the following – mode, destination, and distance characteristics of the travel demand pattern. Adaptation models were developed for each scenario using literature review and the results of the Dunedin TACA survey.

Each scenario was then evaluated for technical feasibility and future availability. This analysis draws on the technology reviews presented in Section 3 and the long term changes discussed in Section 5. A relative score of highly likely, likely, not likely, highly unlikely is given depending on whether the technology is currently available in the market on one extreme, or has serious development issues with no predictions of availability within the next forty years. Finally, each scenario is evaluated for cost based on the literature review and specific conditions in Dunedin. A relative score of very affordable, affordable, not affordable, and highly unaffordable is assigned to each scenario. Finally, a composite score is generated from the RECATS, feasibility, and cost analysis. The best score is presented as green, and the worst score is red. Green indicates a scenario that is possible right now, which would achieve the 50% fuel reduction over the next forty years and is affordable. Red indicates a scenario that does not meet the energy target, is not feasible, or is prohibitively expensive.

Fuel, Vehicle, Behaviour Adaptations	Urban Form Adaptations: Active Infrastructure 100km Cycleways	Dense City Centre	Integrated Urban Villages	Current
3 L/100km Fleet Efficiency	Possible	Possible	Possible	Unlikely
50% Biofuels Synfuels	No	No	No	No
50% Electric Vehicles	No	No	Unlikely (*golf carts only*)	No
50km Electric Trolleys	Possible	Possible	Possible	Unlikely
Low Carbon Lifestyle	Yes	Yes	Yes	Possible

Figure 6.1. Strategic Scenarios Analysis of the opportunities for future developments in urban planning, transportation networks, technologies, and behaviour adaptation in the 50% petroleum fuel reduction scenario. The results reflect a combination of transport analyses for fuel reduction, implementation cost, market availability, and technical feasibility.

SCENARIOS

Accessible Urban Form Scenario: 100 km of Cycleways

A bike-oriented urban form is a city containing a network of safe cycleways, which results in increased cycling as a primary transportation mode. These cycleways are purposely designed to make travel from residential areas to activity centres and amenities feasible, safe and convenient. Residents feel safe cycling and therefore have higher adaptive capacity for riding a bicycle to carry out their activities than those living in the current urban form. In Dunedin, a strategic step towards development of cycleways would be to start with the car trip to primary and intermediate school to drop off children. In this scenario, the traffic engineers focus on neighbourhoods around schools and construct dedicated cycleways which can give 95% of children in a school zone car-free access to their local school. The next project is to connect residential areas with local amenity areas of shopping and recreation by construction of dedicated cycleways. Finally, dedicated cycleways are built along stream and open space corridors, again out of the road traffic, to connect residential areas with the city employment centres. Creating 100km of cycleways is a target goal designed to deliver ancillary benefits of increasing community contact and health as the population becomes more active.

The adaptability to bike transport can provide about half of the target. All trips under 2 km, 70% of trips 2–5 km, 50% of trips 5–10 km and 10% of trips 10–15 km are adapted to active mode. Bicycles and bicycle infrastructure are feasible and available now. The cost of engineering and building cycleways is low relative to any of the urban form development options.

Urban Form Scenario: Dense Urban Centre

Densification of Dunedin city centre moves large numbers of residents from the surrounding low-density housing areas into the centre of the city, where much of the activity occurs. This greatly reduces and sometimes eliminates the need for a personal vehicle. Public transportation and active modes, such as cycling and walking, become the primary transport modes. With residents living near the activity centre, the travel distance decreases significantly. Major development and investment in new apartments and housing areas in the central part of the city are in demand. In addition, current lifestyle block living declines and the land is returned to production in small farms. Apartments can be developed in existing buildings and new mixed-income apartment complexes can be developed.

The adaptability to active modes and shorter distances provides about 60% fuel reduction for the residents who move into the centre. This results in a 25% overall fuel demand reduction for Dunedin if 80% of the people who currently live 10–30 km from town, but work in town, move into the city. The densified urban form is definitely feasible as it is well known in Europe and planned cities like Canberra. We assign moderate cost to this scenario, as the development of housing in desirable areas is normally taken as generating wealth.

Urban Form Scenario: Integrated Urban Villages

In the integrated Dunedin city, at least half of non-work activities can be carried out in the immediate neighbourhood within walking distance. The hallmark of the integrated city is the development of new urban villages around existing market areas. Activity destinations, including small businesses and services, are found in the urban village. The urban village has a pedestrian centre with room for weekend markets for local foods, goods, and entertainment. Active modes, such as cycling and walking, are the predominant transport modes to access these local destinations. Urban villages are spaced roughly 4km apart, so that the longest distance from a residence to a centre is 2.5 km (Figure 5.2(C)). Due to the short travel distances, a city designed in this manner can support the use of lightweight and economical battery electric vehicles similar to golf carts. Public transport is highly efficient in this urban form even though there is a relatively low density of residential housing. The urban villages form hubs where people can wait for and meet the bus in a friendly and multi-purpose environment. This kind of transport network and market integration has been very successful in other cities.

The adaptation to shorter distances and active modes for 50% of shopping and entertainment provides about 25% of the fuel reduction target. Public transport replaces the car for 30% of the trips to the city centre. The integrated urban form is clearly feasible, and is a traditional New Zealand urban form with small shopping centres common in suburban developments until the last few decades. We assign moderate cost to this scenario as the development of shops, services and businesses is normally considered positive for the economy.

SCENARIOS

Technology Scenario: 3 litre/100 km Vehicle Fleet Efficiency

The personal transport sector does not include farm vehicles, construction, freight, public transport vehicles, or light duty delivery vehicles. This scenario assumes that the current VKT level is maintained, while still achieving a 50% fossil fuel reduction. The current vehicle fleet efficiency for New Zealand is 10 litre/100 km. Achieving a fleet efficiency of 3 litre/100 km would mean a wholesale shift in how vehicles are perceived and valued. In this scenario, vehicles lose their social status connotations. They are thought of purely as a transport tool, a way to get from point A to point B in the circumstances that none of the normal transport modes are available. Some people currently think of vehicles this way, but they are a minority at 15–20%. Most of the vehicle fleet is not capable of speeds over 100 km/hr and rarely travels long journeys on open roads. More than half of vehicles are scooters or light-duty motorcycles. The vast majority of cars are under 1000 cc engine size. For reference, the 2-seater Smart Car has a 600 cc engine. Clearly, the technology, materials and manufacturing to produce this fleet of cars is currently available so it is highly likely that it could be feasible. These smaller, more efficient vehicles are also economical, both in cost of purchase and running, and in material and energy footprint. The main barrier for this scenario is not function, technology or cost, but rather advertising. The gap between the current fleet and the high efficiency fleet is very large, but it is mostly in the minds of the citizens. The post-Peak Oil era will see many large-scale changes, and primary among them will be attitudes about consumer goods and their value to human wellbeing. A society that does not see a novelty or status value in their mode of transport is a society with very high adaptive capacity to reduced fuel supply.

Alternative Fuel Scenario: 50% Biofuel or Synfuel

The current travel demand levels could be maintained, while reducing oil-derived fuel consumption by 50%, if alternative fuels which do not require oil for manufacture are substituted. Vehicles can be designed and built to use biofuel and biofuel blends, so the way the 50% substitution is achieved could be any combination of vehicles and fuels. Synfuel is a coal-derived diesel fuel. Biofuel cars would have a similar range to current cars.

The availability of ethanol and bio-diesel from agricultural crops and wastes has been studied specifically for New Zealand, and found to be a maximum of 8% of 2004 petroleum fuel consumption. At roughly 1000 litres/ha per year of rapeseed oil, about 330 ha of land would be required to run the DCC fleet on biodiesel. Even with generous assumptions about the proportion of current agriculture production that could be converted to fuel, the plausible quantity of biofuels available for substitution is not anywhere near the 50% range. The costs of biofuels are no lower than petroleum fuels. Wood ethanol production has not been demonstrated, and the production rate is still a matter of speculation, thus the likelihood of substitution is low.

Alternative Fuel and Vehicles Scenario: 50% Battery Electric Vehicles

Replacing 50% of the petrol vehicle fleet with battery electric vehicles (BEVs) would reduce the fuel demand by 50% for the same travel demand. BEVs do not currently, and are very unlikely to ever, have comparable range to liquid fuel vehicles. Thus, the ability to reduce fuel demand by substitution of BEVs is restricted to shorter trips. BEVs are not currently available in the market other than some scooters and by special order. Batteries have been the subject of intense R&D for more than fifty years. Batteries are the critical cost issue for electric vehicles. Batteries have material supply chain issues, as the materials for the highest performing batteries are relatively rare. The cost of BEVs will continue to be prohibitive. Normally, we think that things will get cheaper as they build market share, are mass produced and more suppliers enter the market. This is not the case for batteries. Batteries are currently used in countless devices, and have been in mass production for nearly 100 years. The battery technology has improved–lighter, higher energy density, safer, but it has also become more expensive. Better batteries cost more because they use more expensive materials and manufacturing processes.

Hybrid vehicles entered the market in 2000. They increased sales every year thereafter, but have not been able to come near 5% market penetration despite aggressive marketing, a growing number of vehicle model choices, and subsidies. The main draw-backs of the hybrid are size, cost and the batteries.

It is very unlikely that BEVs, other than golf carts, will be available in the world market at a market share of 50% of current vehicle numbers within the time frame of the scenario. That said, electric golf carts are very useful vehicles. In the integrated urban village scenario, they can easily be used by people for grocery shopping, transporting young children or by those with a mobility impairment. Electric golf carts also use the lower cost lead acid batteries.

SCENARIOS

Technology Scenario: Public Transport, 50 km of Electric Bus Network

A city with an improved public transport system makes it easier for residents to shift trips from their current mode of transport to public transport, resulting in increased patronage. This improvement can be accomplished through various methods, including improving route layout and directness, making destinations more accessible by public transport, and selecting appropriate technology. Bus circuits of the central city for example, could use less powerful but more efficient vehicles where low maximum speeds and acceleration are required. A 50% reduction of diesel fuel demand for public transport cannot be accomplished unless electric trolley buses or trams are used.

Electric trolley buses that use existing roads and an overhead power line are currently used in Wellington. Trams and light rail technology is currently used in major cities for longer distance routes. The cost of building an electric light rail system to Mosgiel or along the coast is considered too high for the number of passengers served, so is not included here. In this scenario, electric trolley buses are developed for 50 km of public transport routes in Dunedin. Electric trolley buses are reasonable in cost and have route flexibility as the urban form changes. The new electric trolley bus system would run essentially along the historical tram corridors. In the integrated urban villages scenario, the network connects the village centres with each other and with the central city. In this case, nearly all households in Dunedin would be within walking or biking distance of a major bus hub.

This scenario also envisions bicycle parking available at the urban village bus hub, and nearby cafes and shops in a pedestrian zone around the hub. Local goods movement is not included in the calculation, but it could also be possible to use the late night runs of the electric trolley buses to move goods to the vendors in the urban villages from the ports in the platform areas of the buses normally reserved for prams and wheelchairs. It does not affect the fuel reduction calculation, but we envision bespoke trolley buses could be designed for Dunedin that have a particular style that evokes the historical tram. Modern buses are much more efficient and safer than the old trams. There is no reason to try to ‘bring back the trams’ but there are good reasons to celebrate local heritage and possibly even have a public transport system that is part of the attraction of the city.

Behaviour Scenario: Low Carbon Lifestyle

A city of any form can become a very low energy city if the residents organise the location of their homes, their transport modes, and the locations of their destinations to minimise fuel consumption. The TACA survey shows that about 20% of participants already have very low transport energy lifestyles. The adaptive capacity right now is for 60% of residents to adjust to at least 50% fuel reduction. It is clear from the geographical data from the TACA survey that low carbon lifestyle or adaptability is not necessarily dependent on residential location.

It is very likely that the residents of Dunedin could reduce their fuel use by 50% without affecting their activity systems if they chose to. There are large cost benefits to reducing fuel use. Virtually no new technologies or materials are required.

RECOMMENDATIONS

6.2 Recommendations

Community Planning

The Dunedin City Council is implementing a Sustainability Framework and is developing strategies to comply with the Local Government Act 2002, which requires a 'sustainable development approach'. The decision making process is required to consider sustainability, investigate reasonable options, and take account of community views. The key sustainability factors are:

- Consideration of the social, economic, and cultural well-being of communities.
- Recognition of the need to maintain and enhance the quality of the environment.
- Accounting for the reasonably foreseeable needs of future generations.

Sustainable development does not mean sustaining recent development trends. Rather, sustainable development means decision-making that is informed by scientific measures of wellbeing, that is precautionary rather than reactionary, and that is participatory. A perfect state of sustainability with a zero environmental footprint and zero energy or resource consumption is not possible. Adapting existing infrastructure, technology and systems to be more sustainable and more resilient is possible.

Peak Oil presents pressures for change that are not a matter of choice. Sustainable development is thought of by many as an alternative option to business-as-usual decisions, as long as the costs are acceptable. Peak Oil will change what is thought of as business-as-usual. Thus, we see adaptive capacity objectives that can combine the push of Peak Oil with the pull of sustainable development as the best approach for the Dunedin City Council.

Adaptive Capacity Development Objectives

The following recommendations are specifically targeted at achieving the increased resilience and adaptive capacity needed for Dunedin to have low vulnerability to both oil shocks and the long-term oil supply reduction associated with Peak Oil.

1. **We must plan to reduce oil consumption in private transport 50% by 2050**

   World oil supply will decline by around 50% in the next forty years. If we do not take any actions, we will achieve this reduction through struggle and sacrifice. If we take action now, we can benefit from the investments we make long before they are fully utilised for fuel savings. We must start investing in ways not to use cars rather than in places to drive and park them.

2. **We want to transform into a low-energy, healthy and prosperous city by focusing on three urban form developments**

   Integrated urban villages should be developed strategically around the city. The urban village is a shopping and activity centre where local producers can participate in weekend markets, families can go for a meal, people can get groceries for dinner, friends can watch the rugby, the children can catch the bus into town and senior citizens can see a GP, all without getting in a car.

   CBD central city living should be developed to provide luxury city loft apartments as well as modest flats in a dense urban centre with numerous work opportunities and urban lifestyle amenities within walking distance.

   100 km of cycleways should be developed in the neighbourhoods throughout Dunedin to connect residential areas to the local school, village centre, public transport hub and parks. The cycleways are specifically engineered to manage the safety of cyclists and pedestrians through preference over car traffic.

3. **We want a quality public transport system that runs on renewable energy**

   An electric trolley bus system with 50 km of overhead electric lines could be designed to reflect Dunedin's character, connect the urban village centres to the Central city and industrial areas, and provide a huge degree of Peak Oil adaptability to the city. The city could choose to develop local renewable resources to help power the trolleybus system.

4. **We want to be energy efficient**

   High efficiency vehicles are available, affordable and will reduce fuel demand. We must encourage adoption of high efficiency vehicles now, not wait for biofuels or electric cars. We can aim for a fleet efficiency average of 5 litre/100km for vehicles and scooters by 2030.

5. **We need to measure and plan – audit and track fuel use, identify fuel savings and develop contingency plans**

   We cannot manage what we cannot measure. Households, businesses and organisations in Dunedin must understand how they use oil in transportation, how that supports economic activity, and where the most beneficial fuel savings could be gained. We must also have basic contingency plans for fuel shocks in the same way we have management plans for epidemics or earthquakes.

CONCLUSION

6.3 Conclusion

Peak Oil has been hyped by some and ignored by many. Peak Oil is a real phenomenon that will cause change in expectations, the economy, and historical patterns of growth. Dunedin is vulnerable to Peak Oil as is the rest of the world. Peak Oil does not mean 'running out of oil'. It means a boom and bust cycle of development for a useful resource. As with other mineral booms, there is a growth phase when wealth is generated and the patterns of prosperity from the new wealth come to be seen as normal. The investments in civic buildings and amenities from Dunedin's gold boom days are an example. During the growth phase, people have a hard time contemplating an end to the growth, not to mention a period of irreversible contraction. The boom phase is now nearing an end. The growth in road building, increased spending on private vehicles, and the culture surrounding cheap and abundant oil is beginning to contract.

Vulnerability to Peak Oil arises not so much in the fact that transport energy supply is declining, as in the lack of options. The contracting world oil supply will force adaptation. The way that the adaptation occurs, and the ability to prosper while using less fuel, will depend on the adaptability of the city and region. Dunedin has no choice about whether or not to reduce transport energy consumption. However, there are good decisions and investments to be made in increasing Dunedin's adaptive capacity in ways that also increase economic activity and quality of life. The critical element of Peak Oil adaptation is improvement of efficiency. There is no possibility that the maintenance of historical fuel consumption growth, or even of current levels of fuel use, can be achieved by encouraging biofuels or electric vehicles. If citizens, the media and councils continue to focus on these alternatives to efficiency, they will increase the risk exposure to the negative impacts of Peak Oil.

Personal transport consumes 70% of the oil imported at the world price. The other 30% of oil is used to produce products, move goods, extract minerals, grow food, fibres and wood, catch fish, and construct buildings and infrastructure. Personal transport provides access to work, services, markets and leisure activities. However, household use of fuel is at best 40% efficient and does not drive the nation's economy. Rather it drains our household finances and is responsible for a dangerously negative balance of payments. The adaptation to Peak Oil must be seen as an opportunity to improve efficiency in the personal transport sector, reducing fuel demand for driving private cars, while maintaining the productive and service sector's access to fuel. This report has focused on identifying the opportunities for personal transport fuel demand reduction by at least 50% by 2050.

Dunedin's adaptive capacity is relatively good as the city is compact and the urban form was laid out around public transport routes and walking. The drivers for personal transport behaviour change should be leveraged to support new growth and development of strategically planned urban village activity centres, a new electric bus network, and CBD development of urban lifestyle loft apartments. The urban villages will include market places for local produce and goods, access to services and will have integrated public transport connections with cycling infrastructure. In the residential areas around the urban village centres, 100 km of cycling infrastructure where people have preference over cars will increase active transport, increase safety and improve public health.

The primary production, businesses and industry sectors are in a good position with the proximity to the Port and rail line. The local water and food supply are sufficient to meet the needs of the current population with capacity for export. There is room to develop local markets for local products, and the new urban village centres would provide a low-cost and interesting market place.

Dunedin citizens, Council and businesses are not prepared for another oil shock. Resilience could be improved greatly through a small amount of forward planning. We recommend conducting transport energy audits and developing basic oil shock action plans.

There is no question that the next seventy years will involve a large degree of economic adjustment to Peak Oil. However, rather than be pessimistic, Dunedin has the opportunity to plan for adaptation and resilience.

Footnotes

27. Krumdieck and Hamm (2009)
28. Krumdieck, Page and Dantas (2010)

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