Energy Demand Of Light Vehicles Relative To Residential Location: Case Study Greater Christchurch, New Zealand

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Abstract: Smart growth and Transit Orientated Development (TOD) are seen world-wide as driving factors in policy development relating to urban and transport planning. New Zealand is still an exception, relying on property developers and the market to heavily influence the location of new housing developments. The focus of this research was to develop a tool that would provide support to decision-makers by being able to identify the annual VKT (vehicle kilometre travelled) and thus the annual energy demand of private (non-commercial) vehicles relative to residential location. This led to the development of VEDAS; Vehicle Energy Demand Analysis Software. VEDAS is a tool which allows authorities to analyse the past or current VKT / energy demand situation, enabling them to understand the potential energy demand of new subdivisions relative to their location.

Keywords: Vehicle Kilometres Travelled, Light Vehicle Energy Demand, Residential Location and Fuel Consumption

1. INTRODUCTION

Around 86% of New Zealand's oil consumption (44% of the nation’s total energy usage) is used in the transport sector (Energy Efficiency and Conservation Authority, 2012). Furthermore, over the next 25 years the forecast under *business as usual* models, is for transport energy demand to increase by approximately 1.4% per annum (Ministry of Transport, 2010). Whilst there has been a great deal of focus on reducing energy demand in areas such as residential and commercial buildings, the issue of reducing energy demand for passenger transport has only recently started to gain attention from the New Zealand Government.The energy demand of passenger transport and the potential contribution of urban planning in reducing demand is an area of research which is becoming increasingly important as efforts to reduce demand intensify.

Due to the uncertainty of energy availability, it is crucial for the New Zealand Government to understand the fundamental relationship between land use and transport energy demand, including the energy demand of commuting and non-commuting residents located in outlying residential subdivision and commuter towns. The design and layout of New Zealand cities and towns has traditionally embraced the quarter acre section due to the availability of land and small population, causing residential expansion to occur on the edge of the urban boundary. Such development does not allow for cost effective public transport systems and increases dependence on the private motor vehicle. Despite this, there is a continued drive towards residential development in these areas, increasing commuting distances to access employment and services such as schools and supermarkets. The establishment of new residential areas geographically distant from such destinations will not be viable if transport energy costs increase to levels predicted by industry experts and the academic community.

New Zealand's current urban environment planning regime still assumes the constant availability and affordability of energy. So far there has not been much thought in New Zealand about the future or long-term demand of fuel for commuter purposes. This may have serious implications as fuel shocks and long term fuel price increases will have a detrimental effect with regard to accessibility and mobility such as witnessed in 1979-1980, when the Government introduced carless days (Taylor and Francis, 2007). It may be necessary for New Zealanders to make changes to their use of transport energy as has already been witnessed in Europe. However, due to the design and layout of New Zealand's urban environment, there is a limit as to how far the public can adapt. The issues need to be urgently addressed so as to allow for a period of steady behavioural change which will help reduce demand. The major impact on mitigating the situation is that New Zealanders have a love affair with cars and the politicians are concerned to dictate the location of urban growth by emphasizing on reducing the VKT demand and prefer leaving it to the market to decide. This is very short-term thinking.

2. RESEARCH OBJECTIVES AND STRUCTURE

The aim of this research was to analyse the impact of residential location on light passenger vehicle energy demand. This research is applicable to all New Zealand but focuses on selected commuter towns within Greater Christchurch (South Island – New Zealand) and includes an overview of energy demand for Christchurch City (See Appendix 1 for Greater Christchurch Research Area). It aimed to highlight the importance of residential location on light passenger vehicle energy demand and provide local authorities and Government with an improved understanding, allowing for the development and implementation of solutions to manage and reduce demand and as a result ensure a sustainable approach with regard to land development. The desired outcome would be for the necessary authorities to address such issues and prepare for future oil price increases.

The impact of residential location on light passenger vehicle energy demand was identified through the analysis of vehicle kilometres travelled (VKT)and the energy demand (fuel consumption). In addition, a number of scenarios were analysed to assess the impact of residential location and transportation demand management principles on light passenger energy demand. After the preceding introductory chapter, Chapter Three discusses the application used to undertake this research, Chapter Four presents the findings and the final Chapter provides the conclusion and recommendations.

3. VEHICLE ENERGY DEMAND ANALYSIS SOFTWARE

In order to gain an understanding of vehicle energy demand relative to residential location, it was required to firstly identify the annual distance travelled, secondly the type of vehicle undertaking the travel (e.g. cc-rating and age) and relate the afore mentioned information to a residential (Geo-tagged) address. The vehicle data were provided by the NZ Government (NZ Transport Agency). Unfortunately, the dataset contained a considerable amount of manual entry data. Eight data processing applications were developed to correct and process this data (Figure 1). Whilst it would have been possible to combine the eight individual applications, the use of multiple applications allowed the logic and code to be separated into smaller sections, decreasing the chance of bugs and errors. The need for several of the data processing applications would be removed had the address information in the vehicle kilometer travelled dataset been correct and geo-tagged. Furthermore, this would have removed the most complex and time consuming data processing applications.

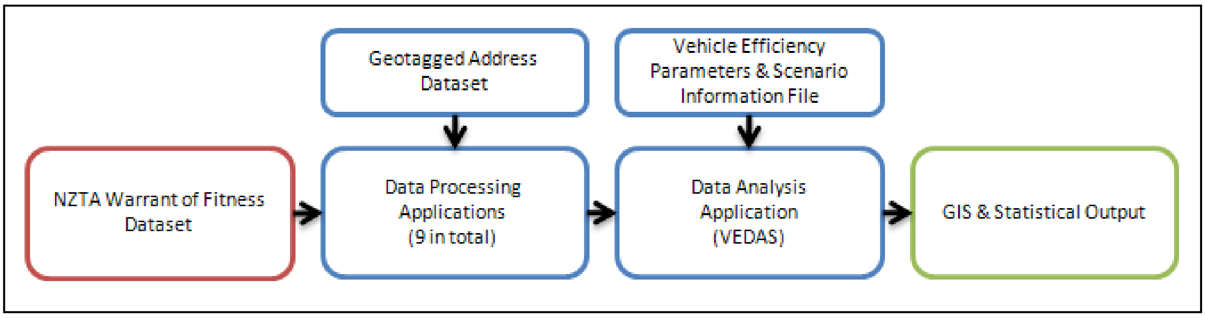
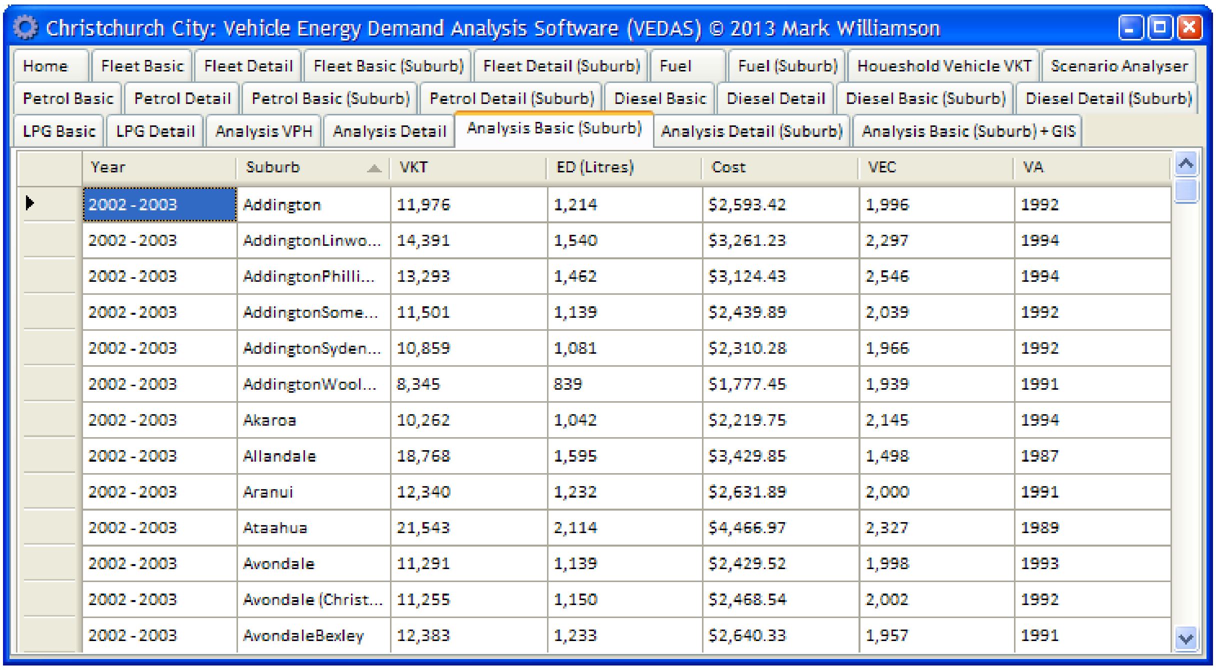


Figure 1. Schematic Diagram for the programmes and datasets used in the research

In addition to the data processing applications another application was developed to calculate vehicle kilometres travelled (VKT) and energy demand as well as model various scenarios using data provided by the New Zealand Government. The result was a specifically designed data analysis application; Vehicle Energy Demand Analysis Software (VEDAS). The data from VEDAS may be exported and used in tables, graphs and Geographical Information Systems.



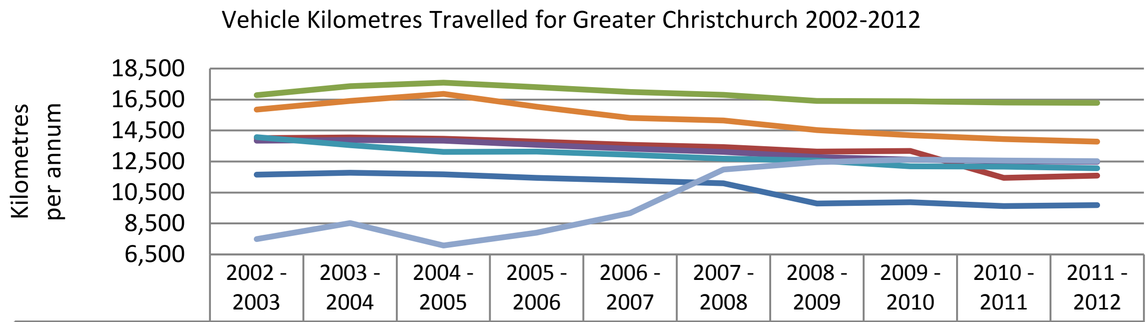
Year	Suburb	VKT	ED (Litres)	Cost	VEC	VA
2002 - 2003	Addington	11,976	1,214	$2,593.42	1,996	1992
2002 - 2003	AddingtonLinwo...	14,391	1,540	$3,261.23	2,297	1994
2002 - 2003	AddingtonPhilli...	13,293	1,462	$3,124.43	2,546	1994
2002 - 2003	AddingtonSome...	11,501	1,139	$2,439.89	2,039	1992
2002 - 2003	AddingtonSyden...	10,859	1,081	$2,310.28	1,966	1992
2002 - 2003	AddingtonWool...	8,345	839	$1,777.45	1,939	1991
2002 - 2003	Akaroa	10,262	1,042	$2,219.75	2,145	1994
2002 - 2003	Allandale	18,768	1,595	$3,429.85	1,498	1987
2002 - 2003	Aranui	12,340	1,232	$2,631.89	2,000	1991
2002 - 2003	Ataahua	21,543	2,114	$4,466.97	2,327	1989
2002 - 2003	Avondale	11,291	1,139	$2,429.52	1,998	1993
2002 - 2003	Avondale (Christ...	11,255	1,150	$2,468.54	2,002	1992
2002 - 2003	AvondaleBexley	12,383	1,233	$2,640.33	1,957	1991

Figure 2.Screenshot of Vehicle Energy Demand Analysis Software

4. OUTCOME

4.1. Vehicle Kilometres Travelled

Over the previous decade there was a reduction in annual VKT of 15% in Greater Christchurch (excluding Lincoln) (Table 1). In addition, over the previous decade residents in Christchurch City travelled on average approximately 2800 kilometres less than their Greater Christchurch counterparts (Figure 3).



	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
Christchurch	11,653	11,776	11,671	11,437	11,273	11,090	9,790	9,873	9,611	9,680
Rangiora	14,019	14,048	13,974	13,782	13,580	13,440	13,138	13,184	11,446	11,589
Oxford	16,782	17,362	17,599	17,311	16,985	16,799	16,423	16,385	16,318	16,285
Kaiapoi	13,854	13,890	13,845	13,579	13,321	13,115	12,787	12,617	12,512	12,486
Prebbleton	14,073	13,556	13,122	13,148	12,932	12,689	12,555	12,181	12,176	12,058
Rolleston	15,845	16,418	16,876	16,041	15,315	15,152	14,530	14,188	13,942	13,788
Lincoln	7,488	8,532	7,068	7,896	9,162	11,978	12,456	12,624	12,565	12,522

Figure 3. VKT for light passenger vehicles in Greater Christchurch 2002-2012

Christchurch City witnessed the largest reduction in VKT over the same decade (Table 1). VKT in Greater Christchurch began to stabilise around 2008 indicating that whilst the continually rising cost of fuel had an impact on VKT in New Zealand, it was not possible for vehicle users to continue to reduce their annual VKT further due to minimum travel patterns.

Table 1. VKT summary for light passenger vehicles 2002-2012

Area	**VKT Decrease 2002-2012 (%)**	**VKT Decrease 2002-2012 (km)**	**Diesel VKT > Petrol VKT 2002-2012 (km)**
Christchurch	20%	1,973	2,186
Rangiora	21%	2,430	1,255
Oxford	3%	497	3,247
Kaiapoi	11%	1,368	2,250
Prebbleton	17%	2,015	-1,813
Rolleston	15%	2,057	1,777
Lincoln	-40%	-5,034	1,355

4.2. Energy demand (Fuel Consumption)

Energy demand is presented as the average litres of fuel consumed over a 12 month period per vehicle for each area. Fuel consumption figures for light passenger vehicles newer and older than 12 years were developed for use in VEDAS (Table 2 &Table 3). The parameters had to be applicable to a range of vehicles, such as, a newer luxury high performance saloon or 4x4 vehicle; both with an engine capacity of 3000cc.

Table 2.VEDAS fuel consumption parameters for light passenger vehicles older than 12 years

Vehicle engine capacity (VEC)	Petrol: litres/100km	Diesel: litres/100km
<1200	7.5	N/A
>=1200 &<1500	8.5	N/A
>=1500 &<2000	10.0	7.5
>=2000 &<3000	12.0	9.5
>=3000	16.0	13.0

Table 3.VEDAS fuel consumption parameters for light passenger vehicles newer than 12 years

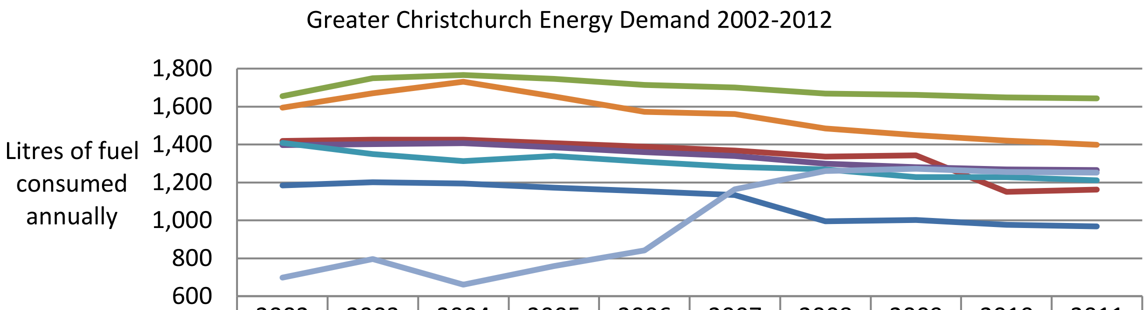
Vehicle engine capacity (VEC)	Petrol: litres/100km	Diesel: litres/100km
<1200	7.0	N/A
>=1200 &<1500	7.5	6.5
>=1500 &<2000	8.8	7.0
>=2000 &<3000	10.5	9.0
>=3000	13.0	10.0

Over the previous decade there has been a reduction in energy demand for Greater Christchurch with the exception of Oxford where there has been little change in demand and Lincoln where there has indeed, been a significant increase in demand. The minimal changes in energy demand for Oxford may be attributed to its geographical location. The anomaly with Lincoln is likely due to the significant growth in the town's population from rural village to commuter town. The city of Christchurch with the exception of Rangiora witnessed the greatest reduction in energy demand over the previous decade at 18% (Table 4).

Table 4.Energy demand summary for light passenger vehicles 2002-2012

Area	Energy Demand Decrease 2002-2012 (%)	Energy Demand Decrease 2002-2012 (Litres)
Christchurch	18%	217
Rangiora	18%	256
Oxford	1%	13
Kaiapoi	9%	132
Prebbleton	14%	197
Rolleston	12%	196
Lincoln	+79%	+553

Energy demand in Christchurch City has historically been significantly lower than its commuter towns. Indeed, over the previous decade, the energy demand of Christchurch City has been around 350 litres lower per vehicle than in Greater Christchurch (excluding Lincoln) (Figure 5). Energy demand began to stabilise for the Greater Christchurch commuter towns from 2008 onwards. In addition, the level of reduction in energy demand for Christchurch City was less significant than in previous years. Christchurch City also experienced a slight increase in energy demand in 2011-2012, but this was most likely caused by the unusually low energy demand in 2010-2011 due the Darfield and Christchurch earthquakes. The commuter towns located the furthest distance from Christchurch City witnessed the smallest reduction in energy demand and the towns closest witnessed the largest reduction in energy demand.



	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
Christchurch	1,185	1,201	1,194	1,172	1,155	1,134	995	1,002	977	968
Rangiora	1,419	1,426	1,425	1,407	1,388	1,369	1,337	1,343	1,150	1,163
Oxford	1,656	1,749	1,767	1,746	1,714	1,701	1,669	1,662	1,649	1,643
Kaiapoi	1,397	1,402	1,407	1,385	1,360	1,339	1,300	1,281	1,269	1,265
Prebbleton	1,409	1,350	1,313	1,339	1,310	1,282	1,269	1,228	1,229	1,212
Rolleston	1,594	1,671	1,732	1,653	1,573	1,560	1,485	1,449	1,420	1,398
Lincoln	699	797	661	759	842	1,165	1,261	1,272	1,256	1,252

Figure 5. Energy demand for light passenger vehicles in Greater Christchurch 2002-2012

The effects of both vehicle kilometres travelled and an ageing Light vehicle fleet maybe compared against the energy demand results in order to establish the most influential factors with regard to energy demand. In comparison with increasing vehicle engine capacity and vehicle age, VKT has witnessed a significant decrease over the previous decade. VKT has historically been lower for Christchurch City as opposed to the commuter towns. This is also mirrored in the energy demand findings, suggesting that VKT plays a significant role in energy demand. This would suggest that whilst vehicle engine capacity and vehicle age undoubtedly have an influence on energy demand, their role is not as significant as that of VKT.

4.3. Energy demand for commuting and non-commuting residents

This section analyses energy demand for two distinct types of residents. The first resident type consists of those who both reside and are likely to be employed within the commuter town (non-commuting residents – Appendix 1). The second type is those who reside within the commuter town but are most likely employed in the city or another commuter town (commuting residents – Appendix 2). Scenario A is designed to represent the energy demand of non-commuting residents. Scenario B is designed to represent the energy demand of residents who commute for approximately 222 days per year (Table 5).A series of parameters were input into the scenario analyser in VEDAS to calculate the energy demand for the different scenarios. The parameters included number of days commuted annually and the minimum and maximum number of vehicle kilometres travelled (depending on the resident type).

Table 5. Approximation of days spent commuting

Reason	**No. of Days**	**Percentage of Year**
Public Holiday	11	3%
Annual Leave	28	7%
Weekend	104	28%
Work	222	61%
Total	365	100%

The commuting parameters used in the scenario analyser in VEDAS represent distance travelled between centres such as central Rangiora and central Christchurch (Table 6). The commuting distances are for an estimated 222 employment days annually (Table 5).

Table 6. Estimated commuting distances

Area	**Distance (km)**	**Return (km)**	**Commute (km)**
Rangiora	33	66	14,652
Oxford	55	110	24,420
Kaiapoi	20	40	8,880
Rolleston	24	48	10,656
Prebbleton	13	26	5,772
Lincoln	23	46	10,212
Pegasus	29	58	12,876

Scenario A: Non-commuting residents in Rangiora, Kaiapoi, Rolleston, Prebbleton, Lincoln and Pegasus have a similar energy demand to residents in the central areas of Christchurch (Appendix 1). However, Oxford the most outlying township has a higher annual energy demand for non-commuting residents, similar to that of the more outlying areas of Christchurch. This may be attributed to the greater distance from Christchurch City. For instance, if a non-commuting resident from Oxford chooses to visit Christchurch once a week, this will obviously use more fuel than a resident from Kaiapoi making the same trip. From the results in VEDAS (Table 7) it is possible to calculate and compare the difference between the minimum annual VKT required for commuting residents and the total VKT for non-commuting residents. The total VKT (essential and non-essential) for the non-commuting residents in all case study towns is only 50-60% of the minimum essential (employment) VKT which commuters travel.

Table 7. Scenario A energy demand 2011-2012

Area	**Commute (km)**	**Average VKT (km)**	**Energy Demand (Litres)**	**Fuel Cost ($)**	**Percentage of non-commuting vehicles**
Rangiora	14,652	8,062	808	$1,723.75	71%
Oxford	24,420	12,671	1,281	$2,719.97	81%
Kaiapoi	8,880	5,606	569	$1,213.64	30%
Rolleston	10,656	6,842	702	$1,496.79	32%
Prebbleton	5,772	3,375	339	$723.16	11%
Lincoln	10,212	6,629	650	$1,392.71	38%
Pegasus	12,876	8,291	848	$1,822.27	29%

The outlying townships of Rangiora and Oxford have significantly fewer commuters (Table 7). This is most likely driven by the greater number of local employment opportunities. Geographical location may also be a factor for consideration as many residents may consider a daily commute to Christchurch as unacceptable due to the cost of additional fuel and the time lost commuting.

Scenario B: Residents who commute to Christchurch for employment purposes have a significantly higher annual energy demand (Table 8). The energy demand for Kaiapoi, Rolleston, Prebbleton and Lincoln exceeds that of outlying suburbs of Christchurch. However, the significance of the relationship between residential location and energy demand is highlighted in the case of Rangiora, Oxford and Pegasus where the energy demand is greater than any suburb within Christchurch (Appendix 2). Furthermore, there is a direct correlation between the percentage of commuting residents and the distance from Christchurch City; the greater the commute, the lower percentage of commuters (Table 8).

Table 8. Scenario B energy demand 2011-2012

Area	**Commute (km)**	**Average VKT (km)**	**Energy Demand (Litres)**	**Fuel Cost ($)**	**Percentage of commuting vehicles**
Rangiora	14,652	20,368	2,046	$4,356.73	29%
Oxford	24,420	31,323	3,150	$6,664.17	19%
Kaiapoi	8,880	15,401	1,560	$3,321.91	70%
Rolleston	10,656	17,048	1,725	$3,678.36	68%
Prebbleton	5,772	13,095	1,316	$2,803.79	89%
Lincoln	10,212	16,156	1,623	$3,462.19	62%
Pegasus	12,876	20,242	1,976	$4,213.99	71%

From the results in VEDAS it is possible to calculate the difference between VKT required for commuting and VKT required for none commuting. This includes essential VKT for supermarket trips and optional travel for leisure purposes. This allows for the comparison of energy demand for commuter towns which are in the main self sufficient with regard to employment and all other facilities, with commuter towns which are mainly residential, offering few facilities. The calculations are based on data from Table 8.

Whilst Oxford is located further from Christchurch City than any of the case study towns, its commuting residents have the lowest annual non-commuter related VKT (30%). This may be attributed to Oxford commuters regarding further travel to the city over and above that required for employment as not cost effective in terms of time, taking into consideration Oxford has access to supermarket and leisure activities both within Oxford town centre and in the nearby town of Rangiora. Moreover, perhaps residents feel the cost in terms of dollars also cannot be justified; Oxford having the lowest median income of the Greater Christchurch case studies ($35,700 NZD).

Similar to Oxford, Rangiora commuting residents also have a relatively low annual non-commuter related VKT (40%). Facilities in Rangiora are well established. For instance, there are a range of schools, supermarkets, hardware stores, food and other retail outlets, restaurants, cafes and bars. However, due to Rangiora’s closer proximity to Christchurch, it would appear more commuting residents are willing and able to travel outside of the town for none employment purposes.

In contrast to Oxford and Rangiora, Prebbleton (the closest case study town to

Christchurch) has the highest annual non-commuter related VKT for commuting residents (130%). This may be attributed to three factors; close proximity to Christchurch, the lack of facilities in Prebbleton which necessitates additional travel but moreover, the high median income, the highest of any Greater Christchurch case study town at $77,000 NZD.

The commuting residents of the other Greater Christchurch study towns, Rolleston and Lincoln have a similar (relatively high) annual non commuter related VKT (60%). This may be attributed to the further distance from Christchurch and the higher than average median incomes ($69,900 and $59,600 NZD respectively). Annual income for Kaiapoi is lower at $43,133, although closer to Christchurch and this may account for the relatively high annual non-commuter related VKT (70%). Income data for Pegasus wasn't available from the 2006 Census (new town). However, the calculations highlight Pegasus also has a relatively high annual non-commuter related VKT (60%). This could be attributed to the absence of facilities as Pegasus is a new town currently under development.

It is clearly evident that in the Greater Christchurch case study, residents who reside in one of the commuter townships but are employed in the city (commuters) have a much greater energy demand than those who are both employed and reside locally. There is no overall difference in energy demand for residents who live and work locally (non-commuters) regardless of their place of residence. Indeed, the results show that in some instances it is actually more energy efficient to reside in a commuter town more so than the city. This is directly linked to a commuter town having not only local employment but also a range of fully established services.

4.4. Energy demand for a new residential development

This section examines the potential energy demand for five residential developments of one thousand new homes through a number of scenarios using the Scenario Analyser in VEDAS. Three scenarios were based on development in Rangiora and two on Christchurch. The purpose was to gain an understanding of the differences in energy demand relative to residential location.

Scenario A is based upon the development of 1000 new residential homes on the edge of Rangiora Township (North Canterbury). It simulates the energy demand of these new homes, assuming 100% of the residents are employed locally and travel less than 14,652km annually. The purpose of such a scenario is to highlight energy demand in an idealistic environment.

Scenario B is based upon the development of 1000 new residential homes on the edge of Rangiora Township. It simulates the energy demand of these new homes, assuming that 71% of the residents are employed locally and 29% commute more than 14,652km. The non-commuter / commuter split are based on the 2012 Rangiora data from VEDAS. The purpose of this scenario is to represent the current situation.

Scenario C is based upon the development of 1000 new residential homes on the edge of Rangiora Township. Itisassumeda bus service between Rangiora and Christchurch is used by commuting residents for 80% of their annual commute (178 days).This would equate to the average commuting Rangiora resident using public transport for almost 50% over their yearly travel needs. The energy demand of the bus service (fuel consumption) is based on 4 return trips per day and 64 litres per 100km fuel consumption (Becken, 2002).It is assumed the bus service is provided every day throughout the year. The non-commuter / commuter split are based on the 2012 Rangiora data from VEDAS. The purpose of such a scenario is to calculate the potential energy saving through the implementation of transportation demand management principles such as transit orientated development.

Scenario D is based upon the development of 1000 new residential homes in the suburb of Monavale in central Christchurch. The purpose of such a scenario is to represent urban environment principles such as the densification of housing in areas were employment, shopping and leisure facilities are already in existence.

Scenario E is based upon the development of 1000 new residential homes in the suburb of Parklands in North-East Christchurch. The purpose of this scenario is to represent housing development on the fringe of the city where there are few established facilities (employment, shopping and schools).

As expected Scenario A produced the lowest energy demand (Table 9). However, whilst Scenario A is unrealistic (100% non-commuting residents) it highlights the importance of locating housing near to employment and other facilities such as schools and supermarkets. Furthermore, the importance of locating housing near to employment and in established areas is highlighted through the energy demand of Scenario D, which was only slightly above that Scenario A. Scenario C highlights the importance of transit orientated development and other such transportation demand management systems. Scenarios B and D have the highest energy demand. Both of these scenarios require commuting, one from a commuter town and the other from the edge of Christchurch City. Despite Rangiora being further from Christchurch than Parklands, Rangiora residents also have access to other services such as schools and shopping facilities in the local vicinity.

Table 9. Energy demand results for chosen scenarios

Area	**Energy Demand Per 1000 Homes (litres of fuel consumed)**
Scenario A - Rangiora	1,286,358
Scenario D - Monavale	1,394,260
Scenario C - Rangiora	1,479,761
Scenario B - Rangiora	1,806,002
Scenario E - Parklands	1,806,080

5. CONCLUSION & RECOMMENDATIONS

The research highlights the considerable impact of residential location on light passenger vehicle energy demand in New Zealand. It demonstrates the strong link between residential location and proximity to employment and other essential services such as schools and supermarkets. As distance increases, so too does vehicle kilometres travelled and thus energy demand. The case study analysis and scenario modelling show the most significant reduction in energy demand was witnessed in areas which provided localised employment and essential services.

Dismissing the impact of residential location on light passenger vehicle fleet energy demand will have significant implications for New Zealand as fuel shocks and long term fuel price increases will reduce accessibility and mobility. As a result, it will be necessary for New Zealanders to make changes to their use of transport energy. However, due to the design and layout of New Zealand’s urban and suburban environment, there is a limit as to how far the public can effectively adapt. The issue needs to be urgently addressed so as to allow for a period of steady behavioural change.

Although the Government is unable to control the global oil price, it controls transport and land-use policy. Thus, it needs to introduce policies which will significantly reduce the energy demand of the light vehicle fleet, lessening the reliance on foreign oil and reducing the impact of episodes of supply uncertainty and price shocks such as witnessed in 2008. Traditionally, residential development in New Zealand has been driven by market demand and investors under the Resource Management Act (RMA). However, the RMA does not currently consider the energy demand of residential developments or incorporate transportation demand management systems. It is particularly important when planning new developments that full consideration is given to the location of the area with respect to distance to employment and other services. Were feasible, mixed use areas should be established, accommodating residential, commercial and social facilities. Furthermore, transit orientation development principles should be applied to all future developments and were possible retro-fitted in existing areas.

Due to numerous factors such as preferred lifestyle, limited public transport and geography, it will always be necessary for New Zealanders to own light passenger vehicles. Thus, it is imperative that not only is the vehicle fleet as fuel efficient as possible, but moreover, the vehicle kilometres travelled are reduced to a realistic minimum. This can be achieved through the adoption of policy and legislation which will force the necessary changes in land-use and urban environment.

Tools such as VEDAS will allow the Government and local authorities to gain an insight into current and future energy demand relative to residential location. This has been proven through the results of the two case studies analysed using VEDAS and in addition, the scenarios modelled (also using VEDAS). An extended analysis of all major New Zealand cities and their associated commuter towns would confirm the relationship between residential location and light passenger vehicle energy demand. This would be particularly relevant in cities which are expected to experience significant growth in the foreseeable future.

Moreover, specialised research could be undertaken using the unique functionality of VEDAS. This would be focussed on cities such as Auckland and Wellington due to their established rail and bus transport networks. The energy demand of vehicles located within specified distances to the rail and bus stations (Auckland and Wellington) would be examined and the results compared with areas in these cities where such transport is limited. Such scenarios (Transit orientated and location efficient development) were modelled in this research. However, this would be an opportunity to utilise real New Zealand data.

The research could then be extended to other cities such as Christchurch where there is potential to develop the existing rail link. For instance, if it was proven vehicles in Auckland and Wellington located within 1km of a railway station had a 30% lower annual VKT, hypothetical stations could be modelled for cities such as Christchurch. This would be achieved by assigning a 30% reduction in annual VKT to vehicles located within 1km of hypothetical stations. VEDAS could be used to calculate the potential energy (fuel) reduction which could be achieved. This concept could also be applied to other modes such a cycling, pedestrian and bus rapid transit. This would emphasise the need for New Zealand to adopt smart growth and transportation management strategies such as transit orientated and location efficient development.

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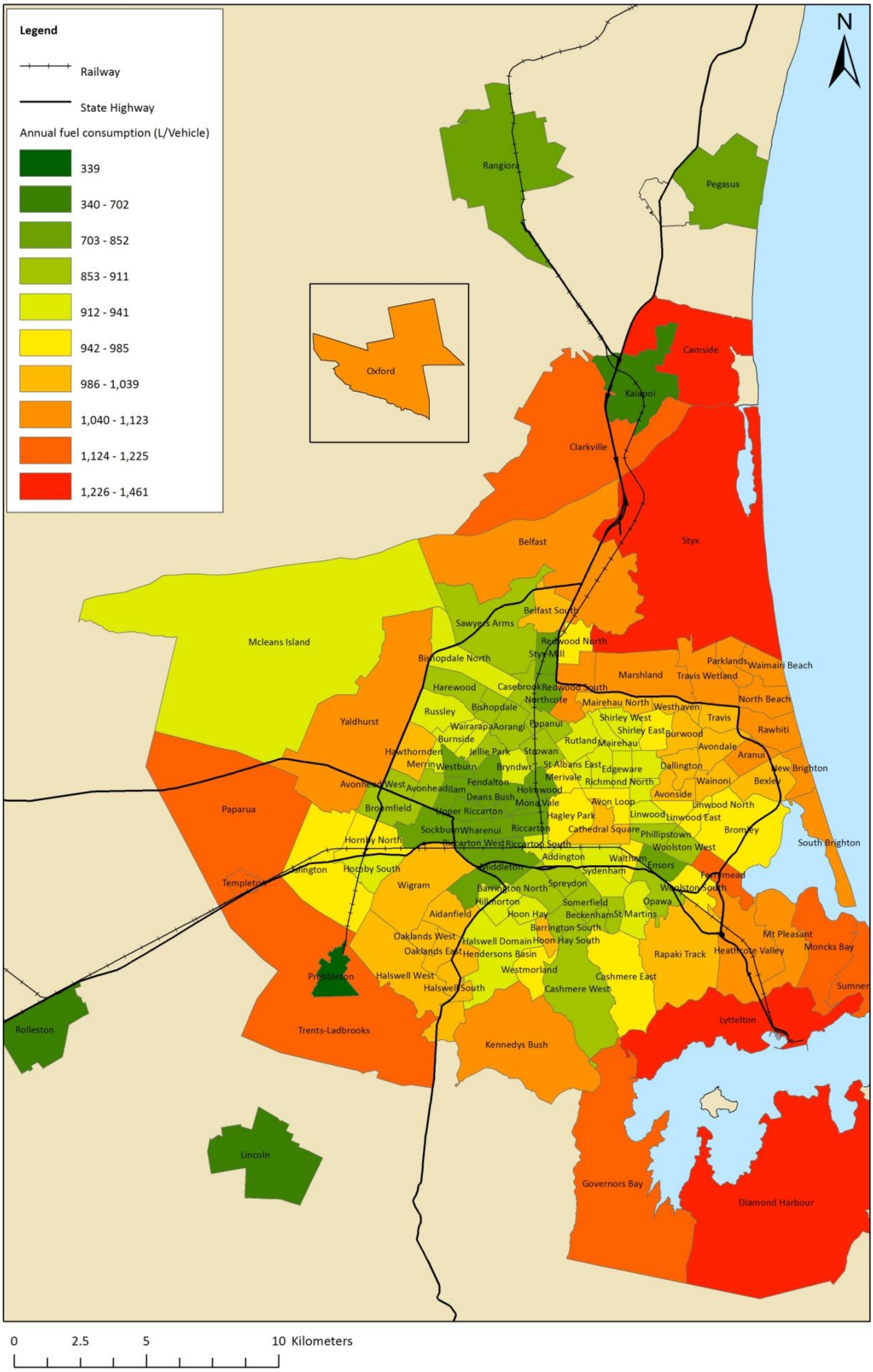
7. APPENDICES

The two maps attached were originally designed for A3 paper. The maps show energy demand for Greater Christchurch – both non-commuting and commuting residents (2011-2012).

Appendix 1. Energy demand (fuel consumption) for non-commuting residents in Greater Christchurch 2011-2012



Appendix 2. Energy demand (fuel consumption) for commuting residents in Greater Christchurch 2011-2012