

Final report

Liquid Fuel Use in New Zealand

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Outcome Management Services Ltd
42 Seaview Rd
Paremata
Wellington

Outcome Management Services Ltd (OMS):

Outcome Management Services is a specialist consulting firm that applies Cost/Benefit evaluation and stakeholder consultation to provide a wide range of policy advice to clients in the public and private sectors, both in New Zealand and Australia.

Authorship:

This document was prepared by Martin Rosevear. For further information email Martin.Rosevear@omsl.co.nz or phone 04 233 2491.

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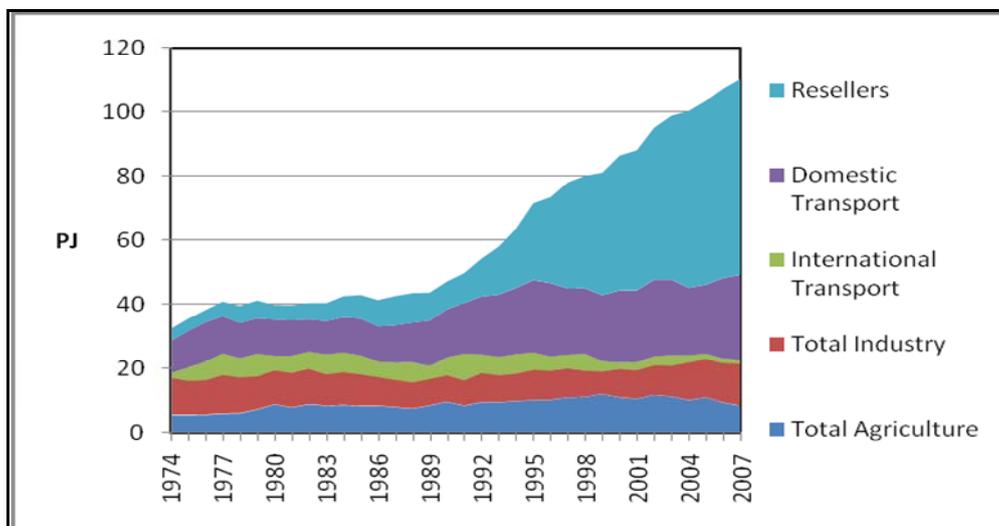
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1 Executive Summary

The Ministry of Economic Development (MED) is responsible for collecting energy statistics to meet national and international reporting obligations and to support policy development. Information on the consumption of liquid fuels is based on data supplied by the oil companies defining deliveries to their major customers. However changes in the liquid fuels supply chain from the mid 1990's, and modal shifts in freight from rail/sea to road, started to raise questions about the reliability of this data for the reporting purpose. A summary of the existing information is presented in the graph below.

Diesel Sales



The rapid growth in 'resellers' (retail network and distributors) category was becoming a significant risk to the reporting, as although the use of this fuel was largely unknown, it was all assumed to be for transport. As a result a project was initiated to investigate the liquid fuel supply chain and the end-use of fuel.

This project investigated two approaches to improve New Zealand's national liquid fuel statistics. A dual approach was employed as there was some uncertainty that either would succeed. The first approach involved combining the physical fuel delivered by the oil companies and other distributors to sectors, and the second used survey and expenditure data and econometric analysis to estimate fuel use by sector. Both approaches were informed through discussions with government experts, sector specialists, oil company representatives and liquid fuel distributors.

The key finding (of both approaches) is that the current reporting assumptions and collection methods need to be improved as a result of major changes to the liquid fuel supply chain. Oil companies used to be involved in most aspects of wholesale, distribution and retail, but have now moved towards more of a wholesaling role. Subsequently, smaller distributors have taken over the supply of 'small drop' customers. As a result, information on final customer deliveries no longer resides entirely with the oil companies, and the current approach of only surveying the 5 oil companies means that significant information from the

supply chain is missing. The role of the distributor is expected to become increasingly important as the oil companies continue to consolidate on their core wholesale business and pull out of distribution and retail.

For 2007, it was found that approximately 19% of the country's diesel was delivered by distributor companies, the extent of which was previously unknown. The net result is that although the total fuel remains the same, significantly more diesel is being used for non-transport activities. It has been established that 64% of diesel sales in 2007 were used for transport, compared with the previously reported figure of almost 80%. The majority of this change is due to a significant increase in the diesel now known to be used by the Agriculture Sector (the majority of this being used 'off'-road) where reported values have increased from ~6 PJ to ~12 PJ. The results for diesel are:

Diesel Deliveries	Off-road (PJ)	On-road (PJ)
Agriculture	10.66	1.11
Fishing	2.90	-
Other Primary Industry	5.65	0.01
Industry (incl. construction)	12.45	1.03
Commercial	6.53	24.15
Household off-road	1.47	
Retail network ¹	0.44	44.46
Total	40.08	70.75

In summary, the aim of this project was to establish an accurate, practical method to enhance national liquid fuel statistics, especially the 'off'-road use. After consideration it is proposed to base the approach on physical delivery of fuel to customers (from oil companies, distributors), supplemented with surveyed opinion from the distributors on 'off'-road use by their customers combined with expert opinion on 'off'-road use by households. This report documents the results from the initial implementation of this Practical Approach and a path to fully implement the method.

¹ Includes service stations, truck stops and marina fuel outlets

Definitions

The following definitions have been used in this report:

Distributors	Represent the dominant companies who purchase fuel from the Oil Companies and then sell this fuel on their own 'paper' to rural and smaller users (nominally less than 5,000L/drop). Companies are: Direct Fuels, Rural Fuel, United Petroleum, Minifuels, Waitomo Petroleum, Allied Petroleum, SouthFuels/NorthFuels, McKewen Petroleum, Nelson Petroleum, Kauriland Petroleum, CRT, Southern Heating, Wealleans Petroleum, BSP Services, Aratuna Freighters, Bushetts, RD Petroleum, McFalls,
Oil Companies	The major oil companies in New Zealand who act as wholesalers of fuel from the Whangarei refinery and fuel imports: BP, Mobil (MobilExxon), Caltex (Chevron), Shell, and Gull
'Off'-road:	Fuel used 'off'-road is not subject to road user taxes (excise tax for petrol and Road User Charges for diesel vehicles), and hence understanding this use of fuel is relevant when advising on likely income from regional fuels tax. In addition the factors used to estimate Green House Gas emissions are different when considering the machinery using fuel 'off' and 'on' road. This is due to less regulation of fuel efficiency and emissions for 'off'-road machinery.
'On'-road	Fuel used for transport.
PJ	Petajoule represents the 'energy' equivalence of the liquid fuel. 1 PJ of diesel represents approximately 26 million litres of diesel.
Resellers	Agents who sell fuel to end-users, including service stations, truck stops, marina fuel outlets and distributors
Retail network	Services stations, truck stops and marina outlets used by the 'public' to purchase fuel
Vehicle Fleet Emissions Model	(VFEM) The model used by MED and New Zealand Transport Agency for estimating fuel use by the transport sector predominantly based on vehicle kms travelled with assumptions about fuel efficiency by vehicle class. This project is intended to provide a calibration for the total fuel use predicted by this model.

2 Introduction

This report describes the approach and results of a project to “Enhance the Understanding of Liquid Fuel Use within New Zealand’s Economy”. Specifically it critically examines the assumptions:

- *That sales to a sector are a proxy for use*
- *That all sales by the oil companies to Resellers of Petroleum Fuels are used for transport*

This report discusses the need for liquid fuel information, the current data sources, issues with current assumptions, the changes to the diesel supply chain which underpin structural changes to the sector, and the need for more accurate reporting.

2.1 Information Need

The Ministry of Economic Development (MED), as part of national, international and public reporting requirements, manages data on energy supply, production, generation and consumption of all major energy types. As well as meeting reporting obligations, these data are used to support both national and international policy development regarding energy security and supply issues, greenhouse gas emissions negotiations, emission standards, regional fuel tax policies etc.

2.2 Fuel Distribution in New Zealand

Until the late 1980’s and early 1990’s the international oil companies in New Zealand were heavily involved throughout the supply chain to produce, wholesale, distribute and retail liquid fuels. However the changing economics of distribution and retail have seen the oil companies pull back from distribution and retail, and concentrate on wholesaling, influenced by the following pressures:

- Increased compliance costs to maintain onsite fuel tanks
- Economics of supplying small and remote customers
- IT systems development and the use of remote call centres for order processing
- Growing importance of grocery retailing to maintain a retail fuel outlet

As a result the distribution has been contracted to distributors (often independent companies) who purchase fuel from the oil companies and sell to final customers on their ‘own accounts’. Some distributors are also starting to run service stations in rural areas, especially in the South Island and some parts of the North Island as small service stations have been closed or sold. The economics of the local market have also resulted in many of the major oil companies moving their backroom capacity offshore as well as developing associations with super-markets and other vendors such as with McDonalds, to support the economics of their retail outlets. Scale and a consistent business model are dominating change in the sector

towards consolidation and the move away from an integrated supply chain towards specialist providers at each step in the liquid fuel supply chain.

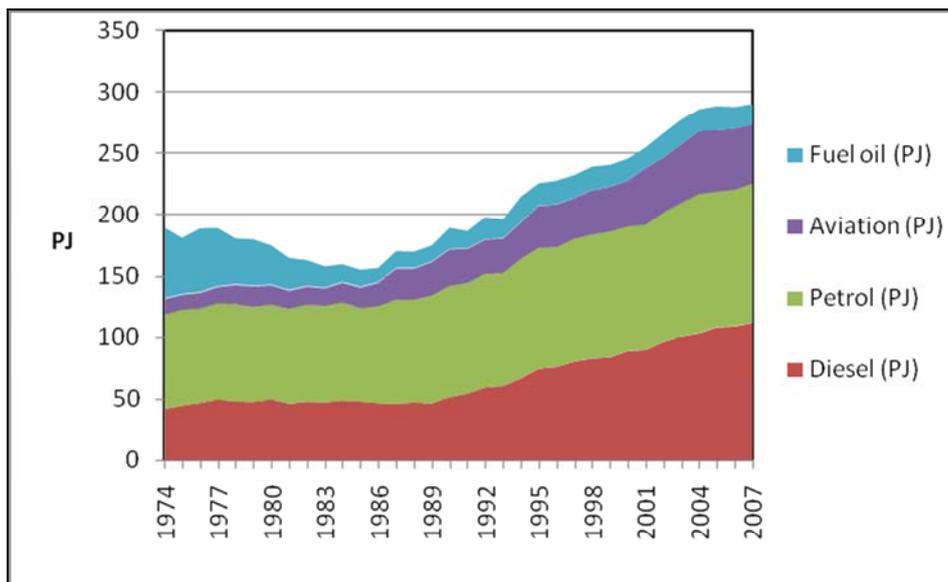
As the major oil companies exit the fuel retail business, the distributors and retail franchisees are increasing their market share.

2.3 Current Liquid Fuel Demand Data

The MED currently uses sales data from the Delivery of Petroleum Fuels by Industry (DPFI) survey to allocate liquid fuel sales to sectors within New Zealand's economy. The DPFI is a quarterly survey administered by Statistics New Zealand² recording sales of petroleum products from the 5 oil companies. The dataset provided to MED is a national set of deliveries (by fuel type) to 15 categories (including "other uses" and a catch-all category of "Resellers of Petroleum Fuels") which are loosely based on the Australian and New Zealand Standard Industrial Classification (ANZSIC) codes.

At a total level this information captures all liquid fuel sales in the country and provides a picture of national demand for the major liquid fuels:

Figure 1: DPFI Submissions (All liquid fuels PJ)



Of note is the rapid growth in diesel use since the 1990's driven by economic growth and the increasing transfer of freight from rail and sea to the road transport fleet³. The more sedate growth in petrol consumption is driven by growth in population and car ownership.

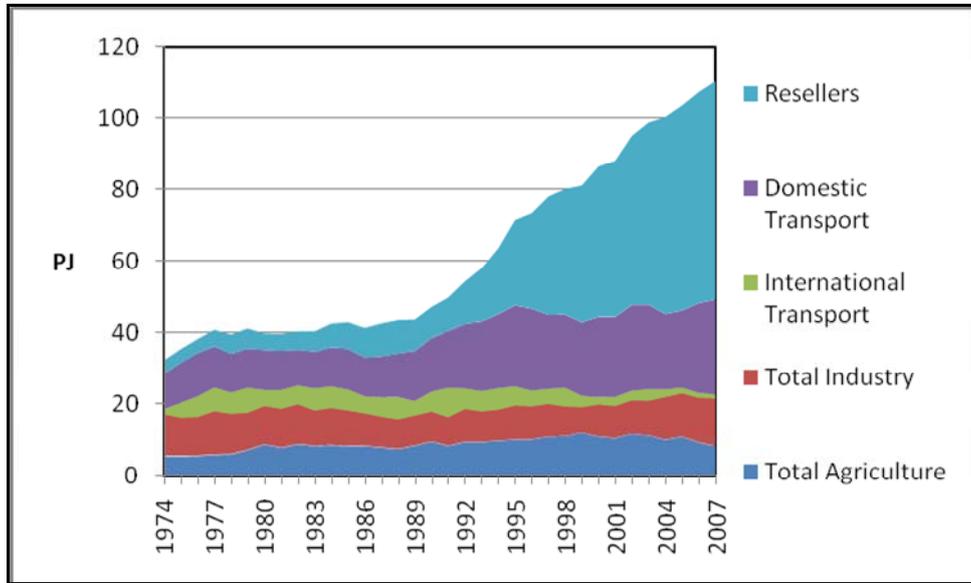
When we look at a diesel sales in more detail, the rapid growth of the 'Resellers' category has produced a significant distortion in understanding diesel end use. Historically, the 'Resellers' category included predominately retail outlets (service stations), therefore, based

² To be taken over by the Ministry of Economic Development in 2009

³ The removal of the requirement to use sea or rail to transport goods >100km in the late 1980's probably had a major part to play in this, as well as the economics of 'just in time' delivery which penalises any double handling of goods.

on expert opinion, it was assumed that all diesel sold through this category was used for transport. With changes to the supply chain, the 'Resellers' category now includes service stations, truck stops, marina refilling stations and distributor companies (as discussed in 2.2). While the supply chain has changed, the DPFI maintained the assumption that 'Resellers' continued to be retail outlets.

Figure 2: DPFI Submissions (Diesel PJ)



The assumption that 'Resellers' fuel is used 'on'-road would have been largely true pre 1990's, but the rapid growth in the fuel delivered by distributors makes this assumption invalid. Therefore, the DPFI in its current form has become less useful for policy purposes, such as advice on regional fuels tax and emissions policy. It also provides little information about the detailed use of liquid fuel within sectors of the economy, i.e. transport versus non-transport use, and fishing versus forestry use etc.

3 Methods

This project focused on investigating two approaches to improve New Zealand's national liquid fuel statistics. Two approaches were used as it was initially unclear whether either one would be sufficient. The first approach improved the measurement of physical fuel delivered by supplementing the oil companies information with data surveyed from the distributors (called 'Physical Delivery'). The second approach investigated the use of econometric techniques to estimate fuel use by each sector, based on surveyed fuel expenditure information (called 'Sector Allocation'). Both approaches were informed through discussions with government experts, sector specialists, oil company representatives and liquid fuel distributors. This involved:

- Interviewing oil company staff involved in the completing the DPFI to understand the administration and issues with this survey;
- Interviewing Oil Industry experts to understand industry practise and customer use,
- Compiling a list of downstream distributors;
- Interviewing and compiling information from the distributors;
- Surveying a selection of large fuel use customers (such as Defence, Police, Rail, Mining, Contractors etc), and;
- Exploring other data sources including results from Statistics New Zealand's Manufacturing Energy Use Survey (MEUS), Household Expenditure Survey (HES) and Commodity Data Collection.

Both approaches drew similar major conclusions, using very different methods with respective strengths and weaknesses. Therefore, the conclusion was to adopt the best attributes from both, by developing a Practical Approach for collecting and reporting liquid fuel information which is discussed below.

3.1 Physical Delivery Method

This method involves collecting and reporting actual volumes of fuel delivered to customers. The principle behind this approach is to supplement the data received from the oil companies with additional information obtained from the distributors on the sectors using liquid fuel.

3.1.1 Strengths

The strengths of this approach are:

- All figures are actual volumes of fuel delivered to customer sites;
- The information is easily managed since it is based on returns from a limited number of suppliers (5 oil companies plus approximately 20 distributors) provided there is buy-in from the respondents.

3.1.2 Weaknesses

The weaknesses of this approach are:

- It only provides information on direct deliveries; and
- In its simple form, it makes the assumption that all fuel delivered to a non-transport customer is used “off-road” and all fuel sold via a retail outlet is used for transport.

3.2 Sector Allocation Method

This method allocated liquid fuel sales to 55 individual industry sectors, as defined by ANZSIC using information from the Household Economic Survey (HES), the Manufacturing Energy Use Survey (MEUS)⁴, and the Ministry of Agriculture’s Cost Model Data. This information is augmented by data from the DPFI and large fuel users where available. The remaining gaps were filled using information from Statistics New Zealand’s Commodity Data Collection survey, which is based on a 1995 survey of petroleum product expenditure by sector. Movements in sector GDP are used to generate time series data for each of the sources listed above, where required. Total fuel use is calibrated to match total deliveries in the DPFI and distributor opinion was used to estimate each sector’s ‘on’ and ‘off-road’ use, which the future work programme will update.

3.2.1 Strengths

The strengths of this approach are:

- provides a significant amount of low level detail i.e. fuel used in 55 industry sectors;
- fuel use is split between transport and non-transport use; and
- readily includes new survey data (like the up-coming Primary Energy Use Survey) as it becomes available.

3.2.2 Weaknesses

The weaknesses of this approach are:

- has significant uncertainty associated with it, especially since petroleum product expenditure for many sectors is estimated using the Commodity Data Collection which has a number of weaknesses; it is out of date, was not designed for this purpose and lacks the detail needed to split between fuel types;
- largely ignores actual volumes delivered to sectors as reported by the oil companies and distributors; and
- is complex and needs analyst support to maintain and enhance it.

3.3 Practical Method

As our experience and understanding progressed during the course of this project, so did our understanding of what was feasible, practical and useful. To be useful the statistics produced from this project need to be:

- transparent and simple to produce;

⁴ Both the HES and MEUS are run by Statistics New Zealand.

- to the greatest extent, based on actual volumes delivered;
- able to provide aggregated detail of where the fuels are being used; and
- able to identify the country's transport liquid fuel use.

To obtain the best result a Practical Approach was developed with an emphasis on using physically delivered fuel. The DPF1 has been used as the base, supplemented with sales information from the distributors and surveyed distributor opinion to split fuel use between 'off' and 'on'-road use, augmented with expert opinion to estimate the 'off'-road use by households.

3.3.1 Strengths

The strengths of this approach are:

- simple and transparent approach,
- the information is based on actual fuel deliveries; and
- meets reporting objectives stated above.

3.3.2 Weaknesses

The weaknesses of this approach are:

- the 'off-road use of fuel sold through service stations, truck stops etc, and the 'on'-road use of fuel delivered to customer sites is not well informed by this approach, and further work is required to refine these estimates.

3.3.3 Future development

It is proposed to adopt the Practical Approach for future liquid fuels reporting. Development work on the Sector Allocation model has been discontinued since it has validated the Practical Approach and its detailed fuel use output will eventually be supplied in a more reliable form from StatsNZ programme of sector energy surveys as they come on-stream. Steps to implement the Practical Approach are discussed in section 6 below.

4 General Discussion

This section presents general discussion on the economics of fuel distribution and fuel use as relevant to the ongoing liquid fuels reporting.

4.1 Diesel fuel distribution

4.1.1 Physical Networks

Historically the oil companies supplied many of their customers directly by delivering fuel into onsite tanks. However, this practice has largely changed in preference to using publicly accessible Truck Stop networks driven by:

- Environmental concerns over leakage and the cost of maintenance
- Concern over theft as fuel becomes more valuable
- The Truck Stop network is accessible, widespread and provides a low-cost route for most customers for 'on'-road use
- However, for some high volume customers, competition has driven the major oil companies to install a private Truck Stop at a customer's premises where the fuel is owned by the oil company until dispensed via a Fuel Card. The reporting of this fuel use can be misleading since it assumes the fuel purchased at a 'Truck Stop' is used 'on'-road, but in the case of the Army and some contractors, a significant part of the fuel is being used 'off'-road.

4.1.2 Sales by customer segment

The major oil companies nominally code their customers using Australian and New Zealand Standard Industrial Classification (ANZSIC) codes, and hence report the DPFI on this basis. However there are some issues to be aware of in this process:

1. Uncertainty

The ANZSIC codes are used by Statistics New Zealand to describe the dominant business of a company, but individual company codes are not public knowledge, and making the 'correct' allocation can be uncertain in some cases i.e. a 'fishing' company that has a processing plant could be coded as a Food Manufacturer or a Fishing company.

2. End-use

Coding a customer to its industry is not necessarily useful in describing the fuel use i.e. it is arguably more useful to know that a customer is using fuel for heating purposes or for transport, for instance, rather than they are a textile manufacturer.

To add to these issues is the historical nature of the coding used to setup ANZSIC codes in the customer databases. Once a customer is loaded they are seldom reviewed, which will introduce inaccuracy where customers move their business into other sectors. For example, contractors could change their dominant business from an 'off'-road operation to being

predominantly a trucking operation, and vice versa. One oil company currently code their distributors as 'Agriculture' since they originally supplied the farming sector, but these distributors now sell fuel across a range of sectors and hence should now be coded as 'Resellers'. As a result we have had to adjust the DPF1 to account for the changing nature of the ANZSIC coding and recommended a routine QA process to review the ANZSIC coding for all the oil companies, since experience has indicated that miss-coding to date has affected approximately 4% of diesel submissions, mainly from the rural sector.

4.1.3 Fuel Card Purchasing

Oil companies tend to be organised into two major business silos reflecting customer relationships:

1. Direct supply customers who are supplied fuel directly from fuel terminals
2. Fuel card customers who purchase fuel from public retail outlets such as service stations, Truck Stops and marine outlets

The customer databases and business processes for these business units are quite separate, and hence the coding of customers to ANZSIC is likely to follow different and possibly inconsistent rules.

The DPF1 currently represents sales to direct delivery customers, and hence purchasing using Fuel Cards via the public retail networks is captured in the 'Resellers' category.

We considered whether reporting of Fuel Card sales from Truck Stops and service stations by ANZSIC code would be useful to supplement direct site delivery information included in the DPF1. The following issues were considered:

1. Accurate sector allocation

More accurate allocation to each sector would be possible, but the end-use of fuel between 'off' and 'on'-road is more difficult to predict, although knowing a transport operator from a farming customer would inform this allocation.

2. Compliance cost

Compliance cost is expected to be significant. For at least one oil company accessing the fuel card customer database and verifying ANZSIC compliance would not be easy.

3. Survey distributor opinion

It is possible to meet reporting needs by using distributor opinion to infer the 'off'-road use of fuel sold via the retail networks, combined with expert opinion for household use.

Current view favours the use of distributor and expert opinion since it meets reporting needs at minimum cost. Therefore use of Fuel Card data for reporting has not been explored.

4.1.4 Distributors

The oil companies supplied the contact details for the distributors they work with. These distributors were interviewed to identify:

- Overview of their business model

- Total annual volume of Petrol and Diesel purchased
- Percentage allocation to the sectors they supply
- An estimate of 'off' versus 'on' road use of fuel

Fuel sold by distributors on their 'own paper' (predominately diesel) was a significant proportion of the fuel that oil companies were reporting as 'Resellers' in the DPF1. It was also established that almost 43% of fuel sold by distributors (11.4 PJ) is delivered to farms or agricultural contractors. Small rural service stations (coded as 'Transport') are the next most significant user, followed by contractors in earth moving, logging, and mining. Space heating in homes and commercial sites was found to be a significant use of fuel. Consumers of fuel for this purpose included homes, commercial sites (such as panel beaters, for heating their spray painting booths), and warehouses.

The distributors made the point that fuel delivered to non-transport users is mostly used 'off'-road since it is more expensive (by approximately 4 c/L) to use their delivery service, than purchase diesel from service stations or Truck Stops using a Fuel Card. Hence for any equipment that is operating 'on'-road with access to the retail network, it makes economic sense for customers to fill-up at the retail network, rather than use the more valuable direct delivered product.

Three distinct distributor business models were observed during discussions:

1. Local operations

Distributors tend to be local cartage and contracting companies who have branched out into fuel distribution and now supply remote users in their region such as farms, agricultural contractors, earth moving firms, logging gangs, home/commercial heating etc. Most are small operations that operate with low overheads and may lack sophisticated systems; but they are very close to their customers.

2. Regional networks

Some companies have become large and sophisticated operations. As the major oil companies pull out of remote and 'low throughput' locations these sites are being taken over by distributors as part of their supply network. These distributors have created self branded service stations in the south of the South Island, and in parts of the North Island. In other cases distributors have directly taken over parts of a major oil company's business and their customer relationship systems.

3. Mini-tanker

The 'mini-tanker' concept first arose in Australia in the late 1980s and was translated to New Zealand soon after, where it suits our rural and contracting environment. The economic rationale is that it is more efficient for a contractor such as an earth mover to have the fuel come to their equipment, rather than use their own staff and equipment to do the refuelling, and to risk onsite fuel dumps to theft and environmental contamination. Somewhat surprisingly New Zealand is one of only three countries (Australia, Canada are the others) who have a mature mini-tanker service.

4.2 Fuel use assumptions

After talking to the experts, the major assumption arising from this work is that fuel delivered to a site is most likely to be used 'off'-road since it costs extra for this service; whereas fuel sold via the retail network is probably used 'on'-road, since customers have access to efficient suppliers of site delivered fuel. To address the exceptions to this rule, we have surveyed the distributors as the most reliable method of obtaining the 'off'-road use of the fuel they deliver which is presented in the results section. Two examples are presented below from the agricultural sector where there is good information to illustrate some of the issues involved.

4.2.1 'On'-road use of site delivered fuel

We have considered the mix of 'on' and 'off'-road fuel use by farmers. The distributors tell us they deliver 8 PJ of fuel to farms and 2 PJ to agricultural contractors and they charge approximately 4c/L more for this service than customers would pay at a service station. Hence the fuel is expensive, but it is also convenient, and farmers often use their farm supply to fill their vehicles for 'on'-road use. The degree to which their farm supply is used for 'on'-road use was estimated as follows:

Item	Value	Source
Total fuel use	10,000 L/annum	MAF 2007 Cost Model
'On'-road use	2,000 L/annum	Expert opinion which reflects the extra travelling that farmers do relative to the 1,200 L petrol + 200 L diesel for the average household
'Off'-road use of farm delivered fuel	100%-80%	Depends on level of purchasing at service stations
Fuel purchased at service station	690 L/annum	Fuel card data from one distributor.
'Off'-road use of farm delivered fuel	86%	Farm delivered fuel; $9,310 = 10,000 \text{ L} - 690 \text{ L}$ 'Off'-road fuel; $8,000 = 10,000 \text{ L} - 2,000 \text{ L}$ 'Off'-road use of delivered fuel; $86\% = 8,000/9,310$

By contrast most distributors 'estimate' that farmers use 90%-95% of farm delivered fuel for 'off'-road use. Given the limited fuel card data the result above is not used in this report. Instead this report uses a weighted combination of data supplied from the distributors informed by their estimates of their customers' fuel use. This issue will need to be further refined as the distributor survey work proceeds in the future.

4.2.2 'Off'-road use of contractor purchases from retail network

The Truck Stop network is widely used by transport users to collect diesel in preference to on-site fuel dumps. However the network is also used by agricultural and other contractors as they travel between jobs, who primarily use that fuel 'off'-road. Based on limited Fuel

Card purchase information from one distributor, it is estimated that agricultural contractors may purchase 25% (0.5 PJ) of their total fuel from retail outlets, on top of the 2 PJ delivered directly to site, most of which would be used 'off'-road. Given the limited survey data supporting this finding it has not been included in the final results. Further work will be needed to survey the extent of 'off'-road use of fuel purchased via the retail network.

4.3 Critical Examination of Assumptions

Considering the evidence that has emerged from this analysis it is useful to review the questions posed to this project:

"...That all sales by the oil companies to Resellers of Petroleum Fuels are used for transport.."

Previously all fuel supplied via the "Reseller" category is deemed to be used for 'transportation', for both Petrol and Diesel. However this assumption neglects the impact of the following:

1. Off-road commercial activity

Much of the growth in the 'Resellers' category is to supply clients such as farmers, earth moving contractors, forestry and fishing operators, whose primary activity is 'off'-road.

2. Marine recreation

Survey work by Maritime New Zealand (see appendix) suggests that 0.8 PJ of diesel and 1.8 PJ of petrol is consumed by the recreational boating sector alone.

Therefore the assumption to allocate all of the fuel in the Resellers category to transport is invalid.

"...That sales to a sector are a proxy for use..."

It was assumed that sales to a particular sector present a reasonable representation of what the fuel is being used for. Initially it was thought that this assumption was inaccurate because fuel delivered to sites would be used for a range of activities including transport. However, further research and discussions with distributors suggest that although this may have historically occurred, and may still occur in places, this is the exception rather than the rule. Hence delivery to site for a non-transport customer is now assumed to be mainly used for 'off'-road applications since:

1. direct delivery fuel comes as a service and therefore has extra costs,
2. environmental and regulatory concerns of having fuel onsite mean that it is costly to hold it onsite,
3. it is less costly for on-road vehicles to access Truck Stops and use Fuel Cards to pick up fuel while on the road

However research also indicates that further work is required to fine-tune the extent of 'on'-road use by fuel delivered to agricultural and construction sites where there is a significant

convenience factor in using site delivered fuel for 'on'-road use, and the 'off'-road use of fuel purchased in the retail network, primarily by contractors.

4.4 Statistical survey data

The Sector Allocation method made use of many datasets from Statistics New Zealand and others which is reported below.

4.4.1 Commodity Data Collection

In the absence of good quality direct delivery data it was considered initially that the Commodity Data Collection provided by Statistics New Zealand would provide a useful data source for estimating petroleum fuel use across the total economy. The Commodity Data Collection is a survey of approximately 3,000 firms by Statistics New Zealand which captures costs at a 'commodity' level including the expenditure on petroleum products. This data was surveyed across industry in 1995, and the resulting data has been updated to 2003 based on price and capacity movements.

While a useful starting point, this dataset is subject to some issues. For instance excise tax on petrol is excluded to enable comparison to different jurisdictions. The process assumes all petrol is used by the household sector, whereas survey data (see HES below) suggests only 60% is, which introduces a distortion for other sectors using petrol. Finally the expenditure information is reported at total petroleum product expenditure level and does not distinguish between different fuels such as petrol, diesel, aviation fuel, fuel oil, LPG etc, which must be inferred from survey or expert opinion.

In summary the Commodity Data Collection survey was not intended for reporting fuel use by sector, therefore lacks accuracy and needs to be scaled to the total fuel delivered by the oil companies.

4.4.2 Household Economic Survey (HES)

The Household Economic Survey administered by Statistics New Zealand collects household expenditure information by major cost categories. Historically this was conducted annually but is now every three years where approximately 4,500 households nationwide are requested to fill out a diary recording expenditure information. This survey is subject to the usual sampling and transcription errors, but the purchase of petrol and diesel is a significant cost item for households and therefore, these data are statistically robust. However the three year duration between surveys introduces uncertainty in using HES values when fuel prices and economic circumstances are changeable.

The HES report augmented with distributor data suggests households consume the following fuel (see appendix for details):

Fuel	Litres per household (ex HES)	Home Heating ex distributors (PJ)	Total Household PJ
Diesel	137	0.7	9.8
Petrol	1,095		68.7

The petrol and diesel data reported by the HES is officially for transport use only. In reality Statistics New Zealand expect that the small amounts purchased for garden maintenance and recreational marine are likely to be included in this total. HES values for home heating have a large sampling error and were not used in this work; therefore the quantity of fuel used for home heating was measured using data submitted by the distributors. This report has treated home heating fuel as additional to the HES 'transport' fuel recorded above since it is a relatively large purchase for the households involved and has a separate designation in the HES.

4.4.3 Energy use surveys

Statistics New Zealand is currently developing and implementing a rolling set of sector energy use surveys. This set of surveys are sample based and intended to collect information from all sectors (excluding residential) of New Zealand's economy on a rolling basis (5 separate surveys released on a 1.5 to 2 year basis) aiming to complete a picture of energy use after 5 iterations. This work builds on the information collected in the initial Manufacturing Energy Use Survey (MEUS). The information provided via this approach is ANZSIC based with information gathered in the questionnaires also providing 'off' versus 'on' road activity information. Once a full set of surveys has been completed, this information will provide a strong energy use data source for New Zealand's industrial and commercial sectors.

MEUS was the only survey data available to date to inform the Sector Allocation approach. Two main issues exist with using this data as it currently stands:

- It only provides data from a single year, which needs to be extrapolated using some method (i.e. movements in sector GDP); and
- Other sectors not surveyed had to be estimated using available information, meaning that the un-surveyed sectors are subject to recalibration as each new dataset is obtained.

Results from the Sector Allocation model suggest that the highest priority for the next survey is the Construction sector, due to its size and uncertainty on the extent of fuel use in 'off'-road applications.

4.5 Other sources of information

Other information that was considered in this project was petrol excise tax and road user charges (RUC) refunded for 'off'-road use by New Zealand Transport Authority (NZTA). The following results were found:

- Petrol
18 million litres petrol (or 0.7 PJ) had excise tax refunded in 2007, 55% to farmers, with the balance mainly to tourism operators and contractors. Based on our current understanding, this implies that only 15% of the estimated 2.5 PJ of 'off'-road petrol used in agriculture is being claimed.
- Diesel

1% of all RUCs were rebated for 'off'-road use, which is useful information but does not say how much fuel is involved, nor whether this was purchased from a retail outlet or a distributor.

The above tax rebate data has not been used in the Practical Approach and is simply recorded as a possible future source of information.

In addition, results from the Vehicle Fleet Emissions Model (VFEM) were considered. However since the results from this project were intended to calibrate the VFEM model they have not influenced any allocations. Operators of the VFEM stated the preference that the approach taken in this project should be exclusive of RUC, excise taxes, fuel efficiencies and Vehicle Kilometres Travelled so that the information can be used as an independent calibration of the VFEM and other transport models. However we have observed that results from this project place transport diesel use within 5% of the VFEM results.

4.6 Sector Allocation model development

The Sector Allocation model was developed as an alternative to direct measurement and as a 'research tool' to test critical assumptions. Having validated the results of the Practical Approach, it was decided to discontinue development on the Sector Allocation model for the following reasons:

1. The Primary sector energy survey will soon be available which will supersede the output of the Sector Allocation method;
2. Resources are required to maintain it in a publishable form; and
3. The modelling uncertainties in some areas are high (i.e. construction) making the output less useful.

5 Results

This section presents a summary of results from the proposed Practical Approach.

5.1 Diesel demand

Combining data from the DPFI, oil company 'miss-coding' and distributors gives the following demand information:

Sector	DPFI (PJ)	Corrected DPFI (PJ)	Distributors (PJ)	Total (PJ)
Agriculture	5.87	1.73	10.03	11.76
Fishing	2.31	2.31	0.60	2.90
Other Primary Industry	3.39	3.39	2.27	5.66
Industry (incl. construction)	9.86	9.86	3.61	13.48
Commercial	1.93	1.93	1.26	3.19
Transport Industry	26.60	26.24	1.24	27.48
Resellers	60.89	65.37	-19.01	46.36
Total	110.83	110.83	0.00	110.83

The DPFI column represents the previous knowledge on fuel use, and relative to that column we note the following changes:

- The DPFI was corrected to account for 'miss-coding', mainly of distributors coded as 'Agriculture' rather than as 'Resellers';
- Agriculture has nearly doubled from ~6 PJ in the DPFI to ~12 PJ for the total 'hybrid' approach;
- 19 PJ of diesel is delivered by distributors on their own paper to customer sites; and as a result 46.36 PJ is left in the 'Resellers' category as opposed to the 61 PJ which was stated in the DPFI, representing household, commercial/transport and industrial diesel purchase via service stations and Truck Stops.

Next is it necessary to estimate the 'off' and 'on' road use of this fuel which is presented below.

5.1.1 Diesel 'off'-road use

The 'off'-road use of diesel is estimated using a three step process:

1. Distributor opinion was surveyed for the 'off'-road use for the fuel they deliver to their customers. This is then used to estimate the sector 'off'-road use of direct delivered

fuel for both oil companies and distributors⁵. This includes the 'off'-road use of fuel sold via retail outlets.

2. Household off-road consumption is a combination of physical delivery for home heating and expert opinion for recreational marine (see appendix)
3. Large volume 'off'-road users, where known, were used to remove volume from the 'on'-road values, but for confidentiality purposes these quantities are not shown.

The final table summarises the off and on-road use of diesel:

Diesel Use by Sector	Total (PJ)	Off-road %	Off-road (PJ)	On-road (PJ)
Agriculture	11.76	91%	10.66	1.11
Fishing	2.90	100%	2.90	-
Other Primary Industry	5.66	100%	5.65	0.01
Industry (incl construction)	13.48	92%	12.45	1.03
Commercial	3.19	100%	3.19	-
Transport Industry	27.48	-	3.34	24.15
Household off-road	1.47	-	1.47	-
Retail network ⁶	44.90	1%	0.44	44.46
Total	110.83		40.08	70.75

We note that the estimate for 'off'-road use of 40 PJ, is significantly larger than the previous estimate of 27 PJ, which was derived from the DPFI returns alone. These results show that about 64% of diesel is used 'on'-road, with the balance used 'off'-road. This differs from the currently assumed figures of 80% and 20%, respectively. An 'on'-road figure of 64% agrees more readily with expert opinion.

In summary, the use of diesel is grouped as follows. We have joined Transport Industry and Commercial, as Transport a sub-set industry of Commercial. We note that most of the fuel sold via the retail network is nominally purchased by commercial/transport, household and industrial users for 'on'-road activity therefore representing New Zealand's 'on'-road Transport Sector at 70.75 PJ for 2007:

⁵ For 'Transport' the % 'off'-road applies to the distributor data only. DPFI transport is assumed to be on-road.

⁶ Includes Service Stations, Truck Stops, and Marine fuel outlets

Diesel Use by Sector	Off-road (PJ)	On-road (PJ)
Agriculture	10.66	1.11
Fishing	2.90	-
Other Primary Industry	5.65	0.01
Industry (incl construction)	12.45	1.03
Commercial	6.53	24.15
Household off-road	1.47	-
Retail network	0.44	44.46 ⁷
Total	40.08	70.75

5.2 Petrol demand

Combining data from the DPFI, oil company 'miss-coding' and distributors gives the following demand information:

Petrol Use by Sector	DPFI (PJ)	Corrected DPFI (PJ)	Distributors (PJ)	Total (PJ)
Agriculture	0.91	0.41	1.42	1.83
Fishing	0.02	0.02	0.00	0.02
Other Primary Industry	0.01	0.01	0.02	0.02
Industry (incl construction)	1.74	1.74	0.09	1.83
Commercial	0.33	0.33	0.07	0.40
Transport Industry	0.82	0.77	0.02	0.79
Resellers	110.04	110.58	-1.62	108.96
Total	113.86	113.86	0.00	113.86

The DPFI column represents the previous knowledge on fuel use, and relative to that column we note the following changes:

- Corrections to the DPFI to account for miss-coding of distributor data is small
- 1.62 PJ has been delivered by the distributors directly to customers and this amount taken off the 'Resellers' total; and
- As a result 109 PJ is left in the 'Resellers' category as opposed to the 110 PJ which is stated in the DPFI, representing household, commercial/transport and industrial petrol purchase via service stations.

5.2.1 Petrol 'off'-road use

The 'off'-road use of petrol is estimated via the same process used for diesel, where the 'off'-road percentage comes mainly from surveying the distributors on their customers' use of fuel:

⁷ The household component of the Retail Network sales is estimated to be 10 PJ ± 2 PJ (see appendix)

We note that petrol is mainly used 'on'-road, with very little delivered to a customer's site, unlike diesel.

The 'off'-road estimate of 3.2 PJ purchased via the retail network has been estimated on the following basis (see appendix for details),

1. Garden maintenance:
 - a. 28 L/property/annum based on a survey of garden maintenance contractors maintaining properties approximately on a 3 week cycle
 - b. 2006 census records 1,478,000 dwellings, of which 253,000 are flats/apartments which are removed from the number of gardens to be maintained
 - c. $1.37 \text{ PJ} = 34,300,000 \text{ L (petrol)} = 28 \text{ L/property/annum} * 1,225,000 \text{ properties}$
2. Recreational marine:
 - a. Petrol: $1.79 \text{ PJ} = 45,000,000 \text{ L (petrol)} = 120,000 \text{ craft} * 375 \text{ L/annum/craft}$

Petrol Use by Sector	Total (PJ)	Off-road %	Off-road (PJ)	On-road (PJ)
Agriculture	1.83	91%	1.66	0.17
Fishing	0.02	100%	0.02	-
Other Primary Industry	0.02	100%	0.02	0.00
Industry (incl construction)	1.83	92%	1.69	0.14
Commercial	0.40	100%	0.40	-
Transport Industry	0.79	N/A ⁸	0.01	0.79
Household off-road	3.16	-	3.16	-
Retail network ⁹	105.80	-	-	105.80
Total	113.86		6.96	106.90

Other 'off'-road uses such as motor-racing, 4WD, off-road motor-cycling, etc, have not been included due to lack of information.

In summary, the use of petrol is grouped as follows (we have joined Transport and Commercial into one line). We note that in the absence of evidence to the contrary all fuel sold by service stations in the 'retail network' category is used for transport purposes.

⁸ Transport 'off'-road use is estimated using confidential returns.

⁹ Includes Services Stations, Truck Stops, and Marine fuel outlets

Petrol Use by Sector	Off-road (PJ)	On-road (PJ)
Agriculture	1.66	0.17
Fishing	0.02	-
Other Primary Industry	0.02	0.00
Industry (incl construction)	1.69	0.14
Commercial	0.41	0.79
Household off-road	3.16	-
Retail network	-	105.80 ¹⁰
Total	6.96	106.90

5.3 Indicative fuel consumption data

During the course of this project several fuel use “drivers” were identified that inform our understanding of the activities which influence fuel use. The following results are presented as background information and the reader should be aware that they are indicative and the level of certainty can be variable as indicated:

Factor	2007 information	Certainty	Source and comment
Household (private motorists)	<ul style="list-style-type: none"> • 1,200 L petrol + 200 L diesel per household • 1.8 vehicles per household • 1.5m households 	High	HES: Historically driven by growth in used vehicles imported from Japan and immigration.
Sheep/Beef farms	<ul style="list-style-type: none"> • 10,000 L/farm or 8 L/ha • Diesel; 55% of total fuel • 12,200 farms and 673 ha/farm 	Medium	MAF 2007 Cost Model: Petrol use is for farm bikes and ‘on’-road use. ‘On’-road use is estimated at 2,000 L/farm using a 3:1 petrol:diesel split.
Dairy farm	<ul style="list-style-type: none"> • 8,000 L/farm or 64 L/ha • Diesel: 75% of total fuel • 11,800 farms and 126 ha/farm 	Medium	MAF 2007 Cost Model: 30% petrol use since less use of farm-bikes. See household above.
Orchard	<ul style="list-style-type: none"> • 7,200 L per orchard or 324 L/ha • 1,700 orchards and 35 ha/orchard 	Medium	MAF 2007 Cost Model: See household above. 50% of diesel estimated for frost control.

¹⁰ The household component of the retail network sales is estimated to be 70 PJ ± 4 PJ (see appendix)

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Factor	2007 information	Certainty	Source and comment
Cropping	<ul style="list-style-type: none"> • 98 L/ha • 185,000 ha under cultivation 	Medium	MAF 2007 Cost Model
Agricultural contractors	<ul style="list-style-type: none"> • Contractors use 35% of total agriculture fuel used 	Medium	Distributor sales estimates between Farms and Agricultural contractors.
Fishing	<ul style="list-style-type: none"> • 250 L/tonne wild fish • 491,000 Tonne wild fish in 2007 	Low	MFISH: Depends on mix of inshore, farmed and deep-sea activity.
Earthmoving	<ul style="list-style-type: none"> • 1 L/m³ earth moved = 0.7 L/tonne of earth moved 	Low	Personal communication
Logging	<ul style="list-style-type: none"> • 2.62 L/tonne harvest • 11 million tonne per annum harvest 	Very Low	Forest owners forum: The model implies forestry gangs use predominantly diesel machinery.
Mining	<ul style="list-style-type: none"> • 0.5 L/tonne rock mined ($\pm 50\%$) 	Very Low	Personal communication: final figures are dependent on mix of mining conditions; travel distance, ore:spoil ratios etc.

6 Future Work Programme

This project has identified an improved approach for collecting and reporting liquid fuel statistics while also collecting distributor sales information for 2007. For this to be fully integrated into MED's reporting obligations several steps are required. These and other steps are presented below as an ongoing work program to enhance these statistics (note not all of the following are required to be completed at once):

- 1 Establish a working relationship with significant distributors and verify changing dynamics and players in the fuel distribution and fuel retailing business
- 2 Develop a simple consistent annual data request for distributors
- 3 Work with distributors and oil companies to assist them meet the new data request
- 4 Establish a historical time-series of distributor data (where possible)
- 5 MED take over responsibility for the DPFI survey in 2009
- 6 Enhance the relationship with oil company respondents of the DPFI
- 7 Work with the oil companies to improve the DPFI return including setting up a consistent reporting framework and consistent classifications
- 8 Work with oil companies to disaggregate the DPFI to identify fuel sold at wharves and marinas (i.e. marine fuel use), identify customers whose direct deliveries are used 'on'-road, and customers purchasing from the retail network whose use is primarily 'off'-road.

Appendix: Household Fuel Consumption

Household Sector Supplementary Information

This appendix details the survey data used to estimate household use of fuel

Total fuel used

Households use fuel in 2.7 million cars, an estimated 120,000 pleasure craft, uncounted lawn-mowers, garden maintenance machinery and home heating systems that still use liquid fuel. The total expenditure on fuel was first estimated using Household Economic Survey (HES) data, and then expert opinion combined with selective surveying was used to estimate the small percentage of total fuel expenditure that is used in 'off'-road applications.

The HES is conducted every three years and records household expenditure using diaries against a set of expenditure categories. Household (hld) spend on petrol and diesel for 'transport' purposes has been used to estimate fuel consumed as follows:

Year	Petrol (L/hld)	Diesel (L/hld)	Petrol (PJ)	Diesel (PJ)	Diesel % of total	Petrol \$ nominal per hld	Diesel \$ nominal per hld	Households 000's
1989	1,144	4	45.7	0.2	0.4%	1,033.9	2.5	1,139.9
1992	1,112	13	46.7	0.6	1.3%	1,119.3	7.6	1,200.1
1995	1,184	49	52.2	2.4	4.4%	1,124.3	25.0	1,260.3
1998	1,259	131	57.8	6.6	10.3%	1,131.1	63.2	1,311.8
2001	1,272	130	63.8	7.1	10.1%	1,392.8	93.1	1,432.0
2004	1,233	115	64.5	6.6	9.3%	1,506.1	83.7	1,494.5
2007	1,231	170	68.7	9.86	13.2%	1,981.2	177.8	1,580.1

Source: Statistics New Zealand

Statistical error on these values has been estimated to be:

Petrol: 1,231 L \pm 4%, Diesel: 170 L \pm 22%

Trends to note are:

1. Growth: Household liquid fuel use has increased 21% over the last 10 years as cheaper Japanese used cars have made vehicle purchase less expensive. Subsequently the number of cars per household have grown:

Year	Cars	Households	Cars/Household
2003	2,414,840	1,473,667	1.64
2004	2,525,401	1,494,500	1.69
2005	2,622,357	1,523,032	1.72
2006	2,702,485	1,551,564	1.74
2007	2,775,717	1,580,096	1.76

Source: New Zealand Transport Authority and Statistics NZ

2. Diesel growth

Diesel use has increased from almost nothing to 13% of household transport fuel use over this time. The availability of less expensive 4WD vehicles in the late 1990's and the rising cost of petrol has driven interest toward more efficient diesel vehicles

Garden maintenance

Petrol used in garden maintenance was estimated by surveying a small sample of garden contractors in Wellington:

1. 177 properties under management
2. 417 L/month used
3. 2-3 weekly maintenance cycle for lawn mowing, tree maintenance, trimming etc

Fuel use per property was estimated as:

$$28 \text{ L/property/annum} = 417 \text{ L/month} * 12 \text{ months} / 177 \text{ properties}$$

Total household consumption was then estimated using Statistics New Zealand 2006 census data record of 1,478,000 dwellings, of which 253,000 are flats/apartments which we have removed from the garden maintenance estimate of:

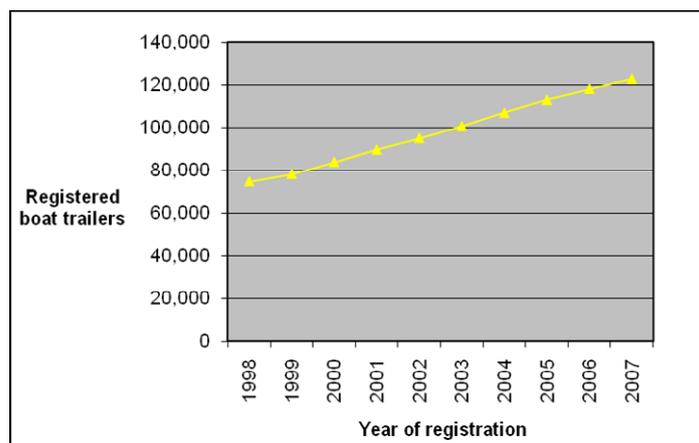
1.37 PJ = total garden maintenance

A robust measure of household consumption will need to reflect an average mix of garden size and frequency of maintenance, and therefore a statistically valid sample will require an additional question in the HES or a separate survey of both households and garden maintenance firms.

Marine recreation

Marine recreation has been growing with an almost 50% growth in pleasure craft over the last ten years indicated by growth in registered boat trailers:

Figure 3: Registered Boat Trailers



Source: New Zealand Transport Authority

A Maritime New Zealand study (personal communication) estimates the following recreational fuel use:

Petrol: 45 million L/annum in 2007 or 1.79 PJ

Diesel: 18 million L/annum in 2007 or 0.78 PJ

This was based primarily on the following method:

1. Marine two-stroke oil

Sales of marine two-stroke oil were available for 2003 (500,000 L), and converted to petrol in 2003 using the following factors:

- a. Fuel:Oil mixture which can be between 1:50 and 1:100 depending on size and age of engine. An effective mix close to 1:100 was estimated.
- b. Two-stroke versus four-stroke engine ratio; 80% two-strokes were estimated.

The total petrol consumed was then converted to a per trailer equivalent (375 L/trailer) for 2007 conditions.

2. Diesel powered craft

Marina berths for cruisers and yachts registered with local authorities are estimated to be 23,000. It was estimated that 90% are fitted with diesel engines with approximately equal that on trailers also fitted with diesels. Expert opinion estimates cruising consumption as follows which nominally agrees to marina fuel supplies:

18 million L = 23,000 moorings * 800 L/marina craft

Home heating

Given price trends of recent times it was a little surprising to find that many homes still use diesel heating systems, and direct measurement of fuel consumption from the distributors puts this consumption at 0.68 PJ.

Household summary consumption

In summary households consumed the following liquid fuel in 2007:

Use	Petrol (PJ)	Diesel (PJ)
'ON'-road transport	65.58	8.40
Recreational marine	1.79	0.78
Garden maintenance	1.37	
Home heating		0.68
Total	68.74	9.86