Disaggregation of Petroleum Product Usage by End Use Category

Sri Lanka Sustainable Energy Authority

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Sri Lanka Sustainable Energy Authority
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Executive Summary

Petroleum fuel consumption in Sri Lanka shows a steady long-term growth from year 1990 onwards, with minor dips highlighting economic down turns. This is mainly due to the fast-growing vehicle fleet of the country. New registrations and the fleet size of two wheeled motor cycles and three wheeled motor tricycles show an alarming growth over the last few years. This situation is further aggravated by the poor load factors across all private modes of transport, combining with the reducing share of mass transport. Steady decline of the public mass modes of passenger transport and increase of private modes of transport is a key contributor to the increasing demand for petroleum fuels.

This study was initiated by the Sri Lanka Sustainable Energy Authority (SEA) to ascertain the level of misreported transport fuel demand, as considerable volumes of fuels are dispensed by fuel stations for non-transport uses. These misreporting have contributed to consistently overstate transport energy use and understate other non-transport uses such as construction and agriculture. Disaggregation of demand data at the point of vending was thus identified as a necessity to correct the misreported values. Basis of the pilot study was a limited scale study conducted by a researcher of the Road Development Authority (RDA) in early 2012. The study, which involved personal interview of road users who turnup at fuel stations for refueling was further enhanced to reveal user behavior and practices, in an effort to identify room for improvement. A questionnaire was developed by the Department of Census and Statistics (DCS) to take down volumes of fuel vended at nozzle level, category of vehicles, usage behavior, attitude towards vehicle operation and maintenance and trip purpose etc.. The study was also used to identify ways and means of improving transaction efficiency at fuel stations. A key output of the pilot study was to conduct a statistical analysis to derive the scope and terms of reference for a country wide survey, which is proposed to be under taken in year 2022.

The survey questionnaire developed by DCS was administered in fifteen fuel stations (ten operated by Ceylon Petroleum Corporation (CPC) and five operated by Lanka Indian Oil Company (LIOC)) by several hundred enumerators provided by SEA and CPC. The survey was conducted on the seven different work days of the week during the latter part of 2015 under the supervision of DCS. The paper-based survey was found to be a strenuous effect requiring four work shifts covering the 24-hour periods of selected survey dates. The data collected on paper was digitised by a hired data entry operator company.

The study revealed that the highest volume of fuel vended was 92 octane gasoline followed by auto diesel. During the study of the demand for gasoline, 54.6% was found to be from cars followed by 18.3% and 11.9% from three wheeled tricycles and two wheeled motor cycles respectively. Sports Utility Vehicles (SUV)s too, accounted for a sizable 9.3% of the gasoline demand. In the case of diesel, the shares were more evenly distributed among lorries (24.1%), vans (20.4%), buses (13.6%) SUV (11.0%) and different truck and cab types (collectively 19.4%).

The fuel stations were patronised mostly by three wheelers (37.2%) followed by motorcycles (25.8%) and cars (19.9%). Arrival of vehicles at fuel stations peaked between 0700 – 1700 hrs. with a noticeable slump between 1300 – 1500 hrs. As a result, the demand curve exhibited twin peaks occurring at 0700-0900 hrs in the morning and 1500-1800 hrs in the evening.

The weekly demand pattern showed a peak on Monday steadily declining till the lowest demand on Thursdays, to pick up again till Saturday. On the behavioural aspects of vehicle users, a dominant 91% of users claimed that they refuel when it was necessary, without following a refuelling routine. Personal transport (42%) and hiring (32%) dominated the trip purpose followed by office transport (10%). Two thirds of the users have no habit of inflating tyres as a routine and attended only when it was deemed necessary. Similarly, vehicle tuning was attempted by 39% of the users only when prompted by a malfunctioning engine.

Further, the fuel pumping lid was placed on either left (29%) or right (27%) and in a larger fleet in the centre (44%) accessible by any side of the vehicle. Users predominantly (92%) used cash for fuel purchases, followed by 6% credit card user and 2% coupon users.

Maximum demand from non-transport uses was for diesel (39%) followed by octane 92 gasoline (14%) in particular fuel station disregarding the 33% demand for domestic kerosene which is not taken as a transport fuel. Demand for non-transport activities also followed the same pattern with twin peaks and a more noticeable slump between 1100-1300 hrs. End use purpose of non-transport fuel varied quite much, depending on the location of the fuel station, whether in an urban setting or a rural setting. The demand was dominated by stocking, construction equipment, generator, boats and heaters. All these end uses were surpassed by the demand caused by users of stranded vehicles who rushed to purchase fuel into an empty vessel.

In conclusion, the study revealed that 5% of diesel and 1% of petrol is used in non-transport activities.

The pilot study proposes to conduct a country wide study, covering 600 fuel stations on a 0800-1600 hrs single shift study, scatted across the year 2022. It also proposes to monitor annual fuel dispensing closely to capture any seasonality effects.

The study further recommends to:

- Conduct an industrial engineering study of fuel station operations;
- Provide dedicated spacious fuel station for articulated trucks and long vehicles and buses;
- Avoid fuel unloading during busy hours;
- Impose a minimum vending volume to reduce the number of visits made by three wheelers and motor cycles to fuel stations;
- Encourage cashless transactions using a special fuel purchase card;
- Stricter monitoring of opening/closing times of fuel station and mandatory facilities offered by those stations.

In addition, the study also proposes to:

- Identify enduse in fuel vending points, at least the volumes used by public transport;
- New regulations to prevent vehicle usage without properly functioning odometers;
- New regulations to make roadside vehicle stranding due to empty fuel tank an offence;
- Offer tyre inflation services as a proactive measure;
- Launch a mobile phone based ranking scheme to enable a crowd sourced monitoring service;
- Extend vehicle tuning and improvement services as a part of the Vehicle Emission Testing (VET) programme;
- Bring unauthorised stockists in rural areas under a regulatory framework;
- Automate fuel station operations to enable nozzle level data acquisition to routinise operations using quick recognition (QR) or radio-frequency identification (RFID) technologies;

Acknowledgement

We wish to express our sincere thanks to;

The Department of Census and Statistics – for their support, coordination and supervision throughout the study

The Ceylon Petroleum Corporation – for providing fuel stations for the study and enumerators

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Road Development Authority – for guiding us by sharing us the details of a previous study

The staff of the Sri Lanka Sustainable Energy Authority – for enumeration and support

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01 Introduction

1.1 Petroleum fuels in transport

The transport sector in Sri Lanka is a primary consumer of petroleum fuels. The majority of vehicles in Sri Lanka are powered by either diesel or gasoline. Road transport is fuelled primarily by petroleum fuels and marginally by electricity. Rail transport however, is entirely fuelled by petroleum (diesel). Only a marginal share of 2.1% is consumed by rail transport. Table 1-1 indicates the fuel volumes consumed in the transport sector in 2015.[1]

Table - 1-1 : Fuel Usage in transport sector (2015)

Fuel Demand (kt)	2015
Gasoline	836.1
Auto Diesel	1,815.1
Super Diesel	46.1

The most popular transport fuel is auto diesel. The demand for transport has increased over time, as indicated in Figure 1-1.

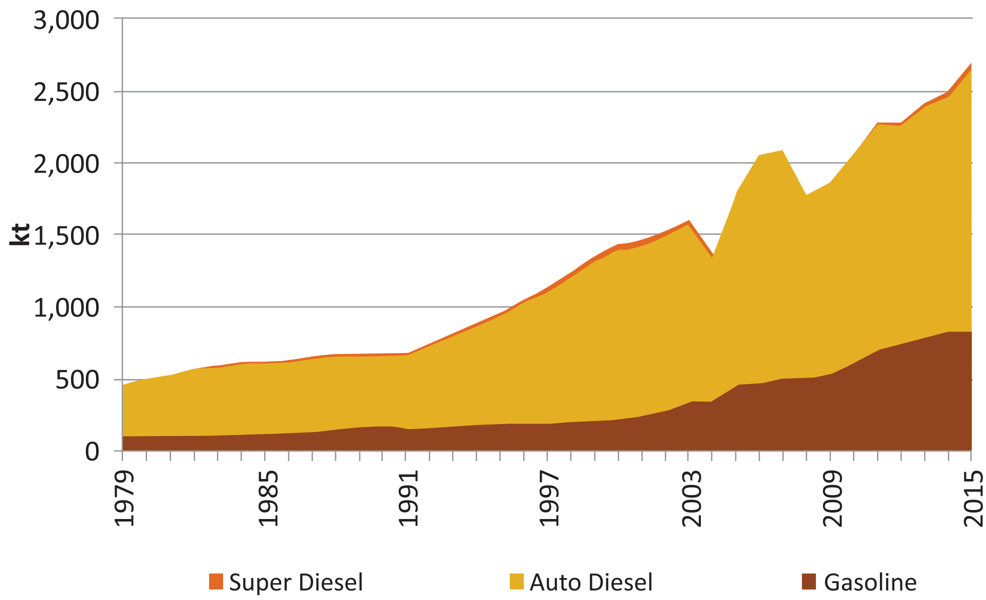


Figure - 1-1 : Transport demand by fuel type

[1] Sri Lanka Energy Balance 2015, published by the Sri Lanka Sustainable Energy Authority (2016).

1.2 Vehicle fleet

Motor cycles and three wheelers account for the highest number of registrations each year. The registration of motor cars too shows an increasing trend. Figure 1-2 gives a snapshot of the cumulative vehicle fleet.[2]

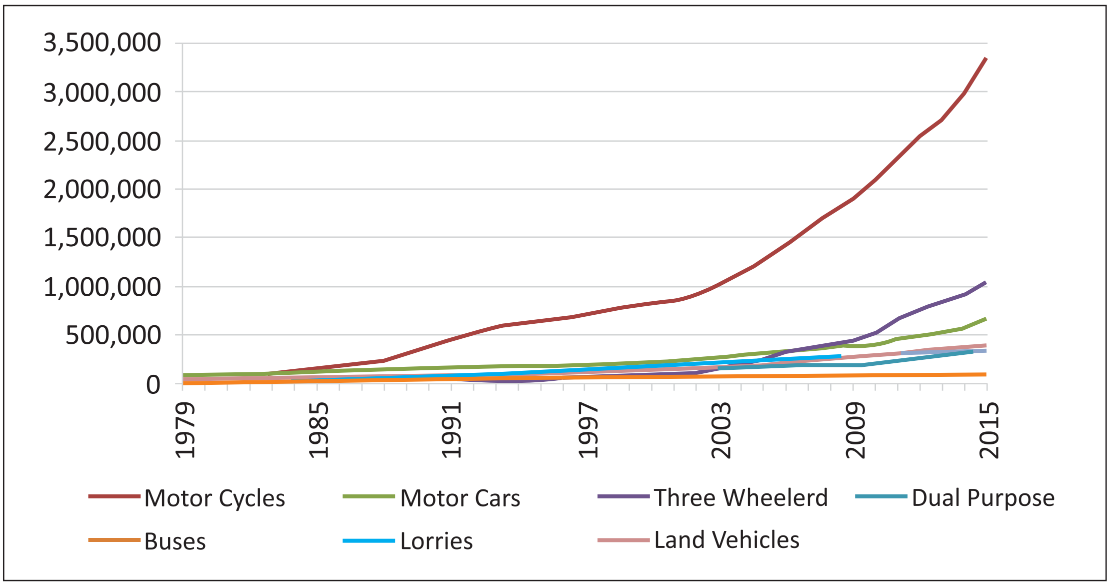


Figure - 1-2 : Growth pattern of the road fleet

1.2.1 Salient characteristics of the vehicle fleet

1.2.1.1 Composition

The active vehicle fleet is reported from the Air Resource Management Centre (AirMAC) of the Ministry of Environment and Renewable Energy, using information from the Vehicle Emission Test (VET) programme (Figure 1-3).[1]

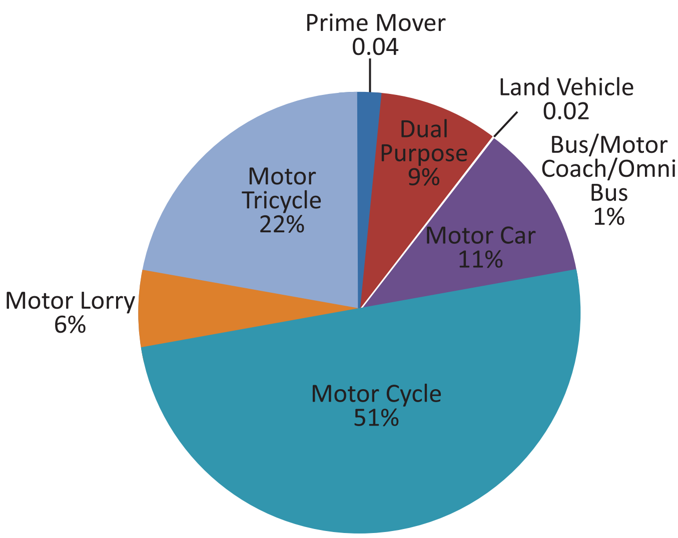


Figure - 1-3 : Active vehicle fleet (2016)

[2] Annual Report 2015, published by the Central Bank of Sri Lanka (2016)

Sri Lanka's active fleet is characterised by an increased population of motor cycles (51.32%) and motor tricycles (22.19%) also identified as three wheelers. This is a clear indication of the degrading public transport services in the country, which must be arrested early, to avoid a severe transport crisis in the medium term.

According to Figure 1- 4, the majority of vehicles are private vehicles (87%). Public transport comprises only 5%. The share of freight transport is 7%, which occupies a larger composition than public transport.

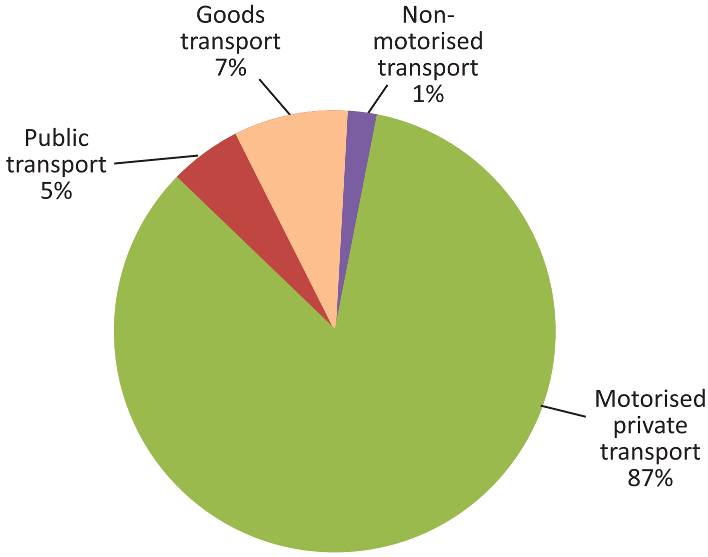


Figure 1-4 : Composition of road vehicles

Freight is mainly transported through trucks (46%). Tractors only account for 1% of freight transport.

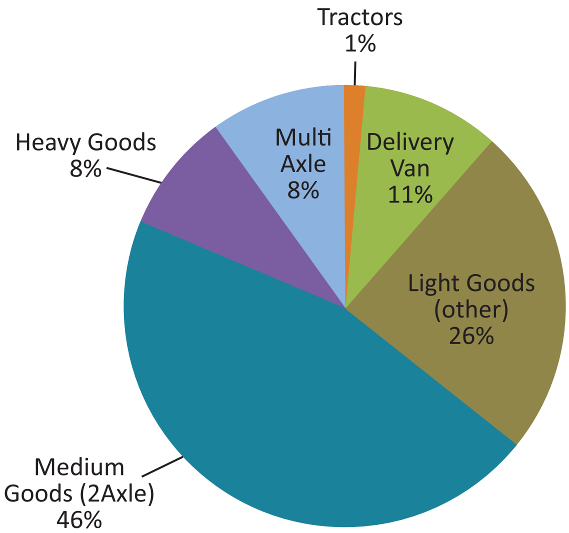


Figure 1-5 : Composition of freight transport vehicles

1.2.1.2 Load factors

The load factors of vehicles are given below in Table 1-2. The majority of private vehicles are underutilised.[3]

Table 1-2 : Load factors of vehicles

Passenger transport (persons/vehicle)	
Motor Cycle	1
Three-wheeler	2
Car/ Jeep/ Pickups	2
Pax. Van	3
School Van	16
School Bus	37
Routes Bus (On Service)	37
Route Bus (Out of Service)	10
Non-Route Bus	22
Non-motorised transport (persons/vehicle)	
Bicycles	1

1.2.1.3 Vehicle classes

The registration of new vehicles in 2015 is given in Table 1-3. A considerable share of the vehicle market comprises of electric and hybrid vehicles. Electric vehicles include cars, three wheelers, motor cycles and single and double cabs. Hybrid vehicles include cars, three wheelers, single cabs and even motor cycles. However, the share of these vehicles in the total fleet remains marginal.[4]

Table 1-3 : Registration of new vehicles (2015)

Type of vehicle		Nos.	%
Cars	diesel cars	2,488	0.37
	petrol cars	58,802	8.82
	petrol/electric cars	40,884	6.13
	diesel/electric cars	216	0.03
	electric cars	3,238	0.49
Three wheelers	diesel three wheelers	7,993	1.20
	petrol three wheelers	121,099	18.17
	electric three wheelers	4	<0.5
	petrol/electric three wheelers	2	<0.5
Motor tricycles vans	diesel motor tricycle van	416	0.06
	petrol motor tricycle van	33	<0.5

[3] Average passenger traffic study, Prof. Amal Kumarage (2012)
[4] Department of Motor Traffic, available at http://www.motortraffic.gov.lk/

Type of vehicle		Nos.	%
Buses	diesel buses	4,139	0.62
	petrol buses	1	<0.5
Motor cycles	petrol/electric motor cycle	12	<0.5
	electric motor cycle	167	0.03
	petrol motor cycle	370,710	55.62
Dual purpose	diesel dual purpose	6,515	0.98
	electric dual purpose	36	0.01
	petrol/electric dual purpose	14	<0.5
	petrol dual purpose	5,992	0.90
Single cabs	diesel single cab	25,917	3.89
	petrol single cab	980	0.15
	electric single cab	2	<0.5
Special purpose vehicles	diesel special purpose	1,204	0.18
	petrol special purpose	10	<0.5
Lorries	diesel lorry	5,350	0.80
	diesel/electric lorry	1	<0.5
	petrol lorry	5	<0.5
Prime movers	diesel prime mover	316	0.05
Tractord	diesel hand tractors	5,826	0.87
	diesel tractors	4,151	0.62
	Total	**666,523**	**100**

02 Issues at hand

2.1 Reporting petroleum fuel usage

Petroleum fuels are used for variety of purposes, ranging from the simple kerosene lamp in residential lighting applications to large scale thermal energy applications in industries. In between, the major consumption of petroleum fuels is in the transport sector. Many years ago, transport fuels meant gasoline and fuel oil (known as petrol and diesel respectively in Sri Lankan context).

Liquid petroleum fuels sold in the country are many types and there are only two distribution methods used in the country.

(a) Direct bulk delivery by road tankers to industrial and commercial customers;
(b) Bulk delivery to fuel stations and retail vending to vehicles and occasionally to small storage vessels;

Bulk deliveries are made as identified under (a) above, mostly to known customers, who are maintaining an account with the petroleum vendor, and the end use purpose is known with reasonable accuracy. If the country's businesses are categorised under the International Standard Industry Classification (ISIC) to five digit level, the end use can be identified with great precision.

In contrast, all bulk deliveries made to fuel stations as identified under (b) above are taken as transport sector usage. When the bulk deliveries to customers and fuel stations are taken together, it is seen that Sri Lanka has maintained a good record of end use data, gathered from the petroleum vendors over several decades.

2.1.1 Errors in reporting

However, the reliable sources of data alone are not adequate to analyse end uses, as there are many more events down in the supply chain which can alter the end use. Some of these events which cause erroneous reporting are identified below:

- Large scale manufacturing companies which operate a city office are often invoiced at the city address, but the fuels are used in a distant location in another province or district. These bulk deliveries are sometimes recorded as a Colombo district consumption.

- Fuels used in stand by generators are obtained mostly from fuel stations, and are accounted as transport fuels. This error could lead to substantial over reporting of transport energy and understatement of power generation fuels when the large number of standby generators in the country is counted.

- Fuels taken by persons engaged in agriculture, fisheries, building construction, roads/earth work and mining obtain fuels for their equipment from fuel stations. All such end uses are reported as transport fuels. There may be some unknown end uses for fuels, also accounted under transport energy.

- It is also observed that rural areas of the country where fuel stations are not within an accessible distance, secondary vending is taking place. Shares of end use fuels used by different sectors after vending by these places are unknown.

As a result of these errors, informed decisions cannot be made. For example, the kerosene subsidy granted to residences without electricity is no longer required, as the electrification of the country is near saturation. The large volume of subsidies granted to kerosene are thus channelled to unintended recipients, leading to adulteration of transport fuels and other such malpractices.

In another case, using electricity for agricultural water pumping is very profitable when compared with engine pumps using fuel for pumping energy. Since the volume of fuels used in water pumping is unknown, there is no clear view of the costs and benefits of a large-scale change over programme of water pumps.

Further, petroleum vendors are not very well informed of the growth trends in economic sub sectors, as end use industries are not systematically categorised. Policy decisions are taken with limited knowledge of the end use side, sometimes resulting in unexpected outcomes.

2.2 Need for the study

In an ideal downstream market condition, petroleum vendors would know each economic subsector quite well, and will be able to plan for future supply volumes with ease. However, such knowledge is difficult to gain and require frequent end use surveys implemented at great cost and effort.

As a first measure, there is a need to differentiate volumes dispensed at fuel stations on the basis of transport and non-transport use. If the volumes dispensed for non-transport uses are negligibly low, the country can afford to continue present practices. Accordingly, this study was designed to separate the volume of non-transport energy from the over reported transport energy.

The study was conducted in the Western Province of the country, accounting for more than 53% of the sales. Although the economic activities undertaken in this province is quite different to the other provinces, this was taken as a good baseline, which might establish the lower limit of non-transport fuel volume. This is stated with the assumption that greater volumes of fuels are used in agriculture in most provinces than the Western Province.

The study conducted will be able to provide a good breakdown of non-transport energy use, as the questionnaire is designed to capture such details. The effort made to capture non-transport energy data was enlarged to capture information in the transport sector as well. This was deemed necessary as there are serious misrepresentations of available information. For example, an industry association of motor tricycle users, accounting for 22% of the active fleet claim that they account for 75% of gasoline sold in the country. Similarly, motor cycles users also clamour for low priced gasoline, citing higher prices affect them more than other vehicle users.

The study was also gainfully utilised to understand the user behaviour in terms of vehicle usage pattern, purposes and efficiencies. The data and information gathered from the study can be used to improve transaction efficiency at pump level and also logistics at fuel station level.

The study, being a pilot scale study, limited to the Western Province is also used to derive the scope and terms of reference for a countrywide survey. It is expected that this study will provide guidance to develop a sampling plan for the country wide survey in terms of both temporal and spatial contexts.

2.2.1 Previous studies

This pilot study was inspired by a survey conducted by an Engineer attached to the Road Development Authority (RDA) from 2011 December 11 to 2012 March 19 using the staff available at the RDA. This refuelling study covering 383 fuel stations located in all nine provinces where each station was monitored for a 24 hour period contributed to the design of this pilot study. The previous study was an attempt to gauge the volumes of fuel used by each vehicle category. The aspect of non-transport energy was not investigated in this study. Nevertheless, it was a comprehensive study which recorded a large number of transactions across 383 fuel stations.

Other than this study which the SEA had prior information, there appear to be no other studies done in the past in the area investigated, as there are no such references available in the public domain. Methodology used in this pilot study was derived from the RDA study after modifications as proposed by the Department of Census and Statistics (DCS).

2.3 Goal and Objectives

As discussed in the previous section, the pilot study was conducted with the goal of disaggregating petroleum fuel usage by end use purpose. The study has several specific objectives as well. These are described below.

2.3.1 Goal

The goal of this pilot study is to ascertain the level of misreporting of petroleum fuel end uses. Knowing whether the scale of misreporting is considerable or negligible would cause the proposed full scale countrywide survey.

2.3.2 Specific objectives

In this pilot study, several objectives were to be achieved, contributing to the overall goal of disaggregation of end use data:

- Quantification of misreported volume of non-transport fuel use from the fuel station sales.
- Identification and quantification of non-transport uses of petroleum fuels.
- Disaggregation of volumes of fuels used by different vehicle categories.
- Identification of any patterns related to vehicle use behaviour in terms of vehicle usage patterns, purposes and efficiencies.
- Establish a relationship between electricity use and volume of fuel dispensed in given fuel station.
- Identification of opportunities to improve transaction efficiency of fuel stations.
- Derive scope and terms of reference to conduct a country wide survey.

2.3.3 Results framework

The pilot study was designed using a result-based approach, where a result framework, describing the expected results was first established. This framework carried the information requirement to be met through the study. Questionnaires were later developed by the DCS to derive the required results.

03 Study design

3.1 Selection of stations

The Department of Census and Statistics advised the SEA to carry out a pilot study, in collaboration with the CPC, LIOC and the DCS, in stations selected by the CPC and LIOC.

3.1.1 Basis for selection

The CPC and the LIOC selected ten stations each, from the Western Province, based on the volume of transactions. Owing to practical difficulties, the SEA narrowed down the list to fifteen stations. The list of fuel stations is given in Table 3-1.

Table 3-1 : List of fuel stations in the survey

	CPC Fuel Stations
1	K D O Arsakularathne & Sons
2	Colombo South Cooperative Society
3	Ceypetco Fuel Station, Mediwela
4	SL Navy Welfare Division, Welisara
5	M I M Sherief & Sons
6	Pathirana I P P
7	Kandanaarchci S N
8	Chithra Damayanthi Mrs. P K
9	Panadura Auto Service & Filling Stations
10	Karunaratne T D D N
	LIOC Fuel Stations
11	Felix Perera & Sons
12	H K S Ranasinghe
13	Swasthika Mills Ltd.
14	D H J Jayakody Brothers
15	Samapath Enterprises

3.2 Methodology

The survey was carried out with three questionnaires. Each enumerator recorded data in questionnaires. Questionnaires were developed by the DCS based on the results framework established by the SEA. The main questions covered in the survey are;

1) Quantity of fuel dispensed each day in thousand litres/year
2) Quantity of fuel pumped into each type of vehicle (litres/year)
3) Fuel used for other purposes than transport in litres by type of use/year
4) Time of day frequency distribution by class of vehicle (Nos.)
5) Time of day frequency distribution by class of vehicle (l/day)
6) Refuelling pattern by vehicle class
7) Vehicle usage pattern
8) Trip purpose, a share breakdown
9) Engine tuning interval by type of vehicle, by fuel type and by trip purpose
10) Tyre inflation interval

Fuel usage for transport and non-transport were recorded separately.

3.2.1 Sampling schedule

The survey was carried out in the fifteen stations covering all seven days of the week, on staggered basis. The seven days were distributed over several weeks, spanning November and December of 2015 (Table 3-2).

Table 3-2 : Survey dates

Date	Day
2015 November 12	Thursday
2015 November 27	Friday
2015 December 02	Wednesday
2015 December 08	Tuesday
2015 December 12	Saturday
2015 December 14	Monday
2015 December 20	Sunday

All fuel stations were surveyed throughout the operating hours on the given days. Each day was divided into four shifts, from 0000 – 0600, 0600 – 1200, 1200 – 1800 to 1800 – 2400.

Each nozzle in each fuel station was given a unique number, by way of a wraparound sticker.

3.2.2 Allocation of staff

Staff was allocated to each station, depending on the number of nozzles in each station and the volume of transactions. The staff usually comprised of a Station Leader from SEA and enumerators from SEA, RDA and CPC.

3.2.2.1 Supervisors

The DCS deployed a Supervisor per station. The Station Leader from the SEA also served as an enumerator. The overall supervision of the survey was carried out by the Programme Officers of the

SEA frequently, while additional Programme Officers of the CPC and the DCS carried out supervision on a random basis.

3.2.2.2 Enumeration

The staff and trainees attached to SEA and CPC served as enumerators. The LIOC however, did not provide enumerators as expected. Each enumerator recorded data by filling the questionnaires. The deployment of enumerators at each station was coordinated by the Station Leader appointed by the SEA. The completed questionnaires were collected by the Station Leader at the end of each survey day and transported back to the SEA.

3.2.2.3 Data entry

The task of entering data was outsourced. Data entry of the questionnaires was done in a spreadsheet application.

3.2.2.4 Data analysis

Data analysis was carried out by a team appointed by the SEA and was carried out on separate workbooks per station. Based on the results of this pilot study, the DCS provided insights on drawing the sample plan for the country wide survey of fuel stations.

04 Data analysis and results

4.1 Transport data

Data of all sheds were aggregated and analysed. Data of transport and non-transport were analysed separately.

4.1.1 Type of fuel by type of vehicle

The absolute quantities of fuel vended for transport is given in Table 4-1. Petrol 92 is the most popular fuel.

Table 4-1 : Fuel used for transport

Fuel	Litres
petrol 92	663,253
petrol 95	226,637
super diesel	128,200
diesel	524,365
Xtra premium Euro 3	45,566
Xtramile	10,513

According to Figure 4-1, the most vended fuel was gasoline. Combined, the two petrol fuels constitute a share of 55%.

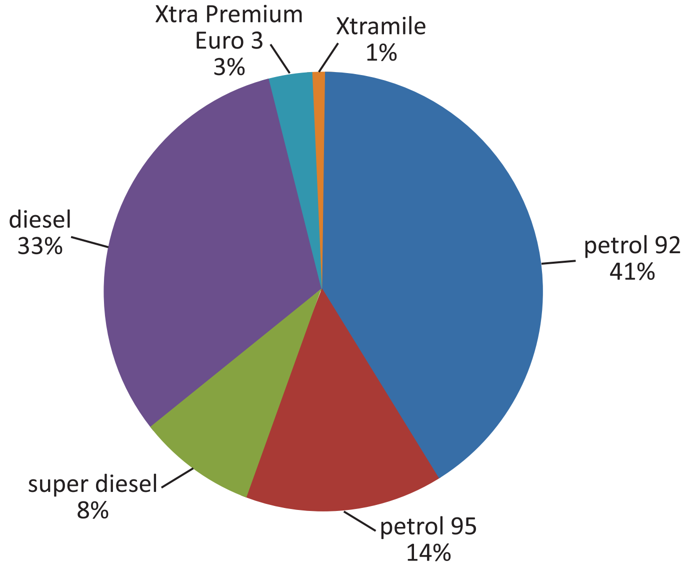


Figure 4-1 : Fuel composition in transport

This observation complies with the fuel pumped to different types of vehicles, as shown in Table 4-2.

Table 4-2 : Types of fuel by type of vehicle (litres)

	petrol 92	petrol 95	super diesel	diesel	Xtra Premium Euro 3	Xtramile
motor cycle	101,564	6,791			3,343	
three wheeler	159,100	6,540	1,491	10,040	5,406	258
car	327,054	155,666	18,474	19,005	28,384	859
van	28,144	4,260	23,233	108,040	1,075	4,177
cab	6,110	4,791	11,096	48,826	676	966
sports utility vehicle	33,975	46,233	52,448	17,868	6,382	2,677
lorry	1,308	640	6,328	153,419	60	61
bus	60		3,133	86,429	14	669
crew cab	797	203	741	6,165	12	206
D/S cab	2,440	1,060	9,023	15,807	204	590
small lorry	887	285	1,437	33,618	3	35
garbage truck	42		13	720		
other	1,771	168	784	24,416	7	15
Total	663,253	226,637	128,200	524,365	45,566	10,513

The share of fuels used by each category of vehicles, broadly categorised for gasoline and diesel, provide an interesting view of fuel demand, quite different to the number of vehicles in each category of the vehicle fleet.

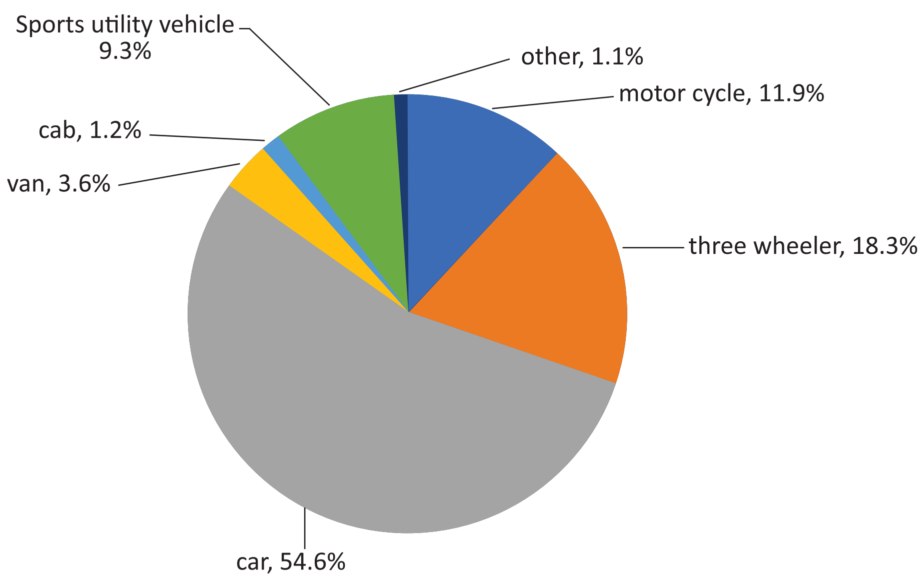


Figure 4-2 : Share of gasoline by type of vehicle

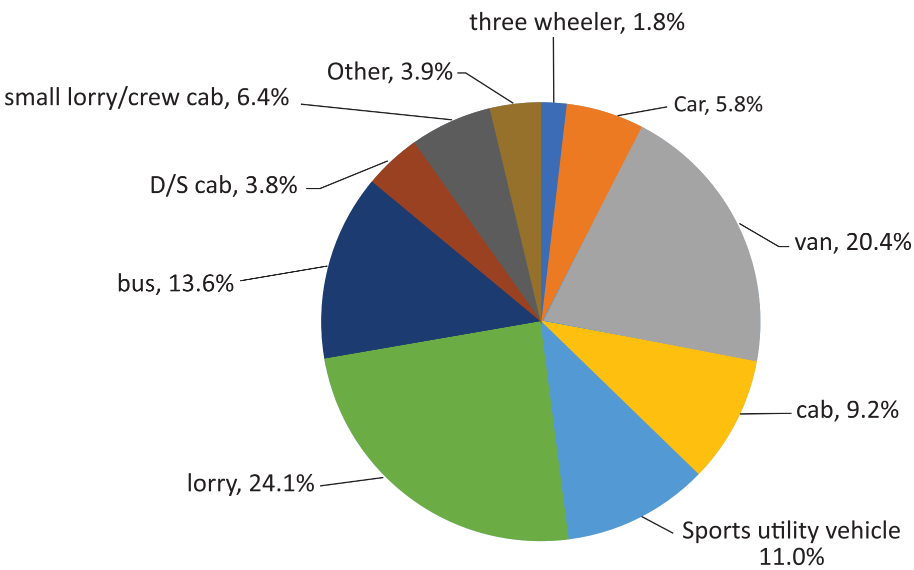


Figure 4-3 : Share of diesel by type of vehicle

4.1.2 Vehicle distribution

Three wheelers constitute the largest share of transactions (37%), followed by motor cycles (26%).

Table 4-3 : Vehicle distribution

Vehicle class	Count	Percentage
motor cycle	36,922	25.8%
three wheeler	53,337	37.2%
car	28,481	19.9%
van	8,168	5.7%
cab	1,486	1.0%
SUV	4,565	3.2%
lorry	4,118	2.9%
bus	1,635	1.1%
crew cab	266	0.2%
D/S cab	1,109	0.8%
small lorry	2,681	1.9%
garbage truck	34	0.0%
other	396	0.3%

The highest numbers of vehicles came for re-fuelling from 0700 to 1700 hrs. In general, this also corresponds to the office and school hours (Figure 4-4).

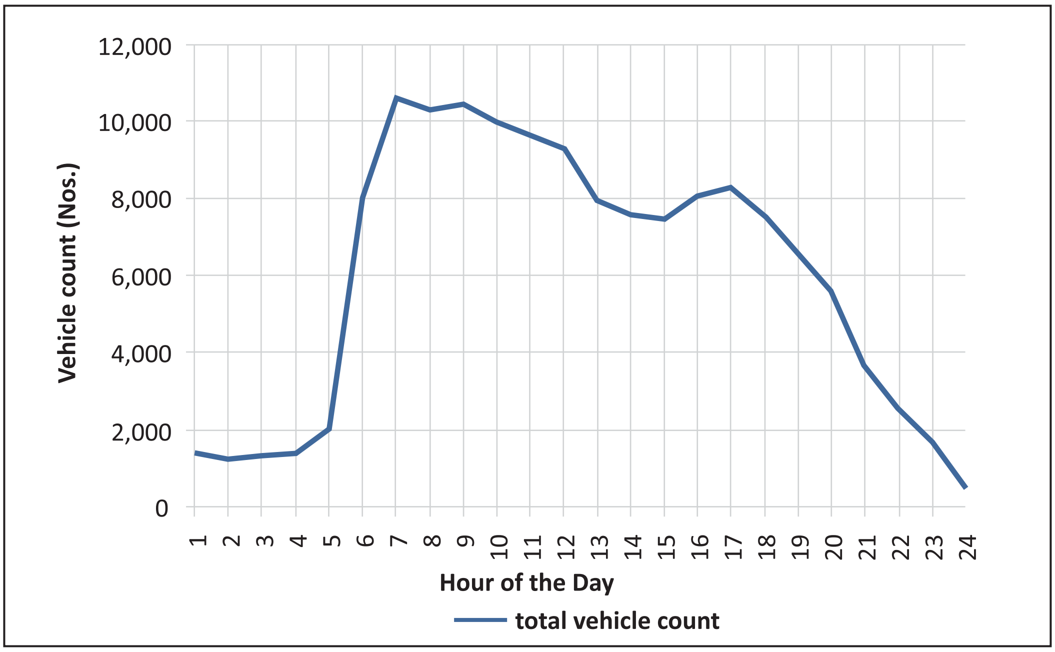


Figure 4-4 : Total vehicle distribution with time

The morning peak is higher than that of the evening peak.

The count of three wheelers, motor cycles and cars, which are the main vehicles of passenger transport, increase during the peak hours, as indicated in Figure 4 - 5.

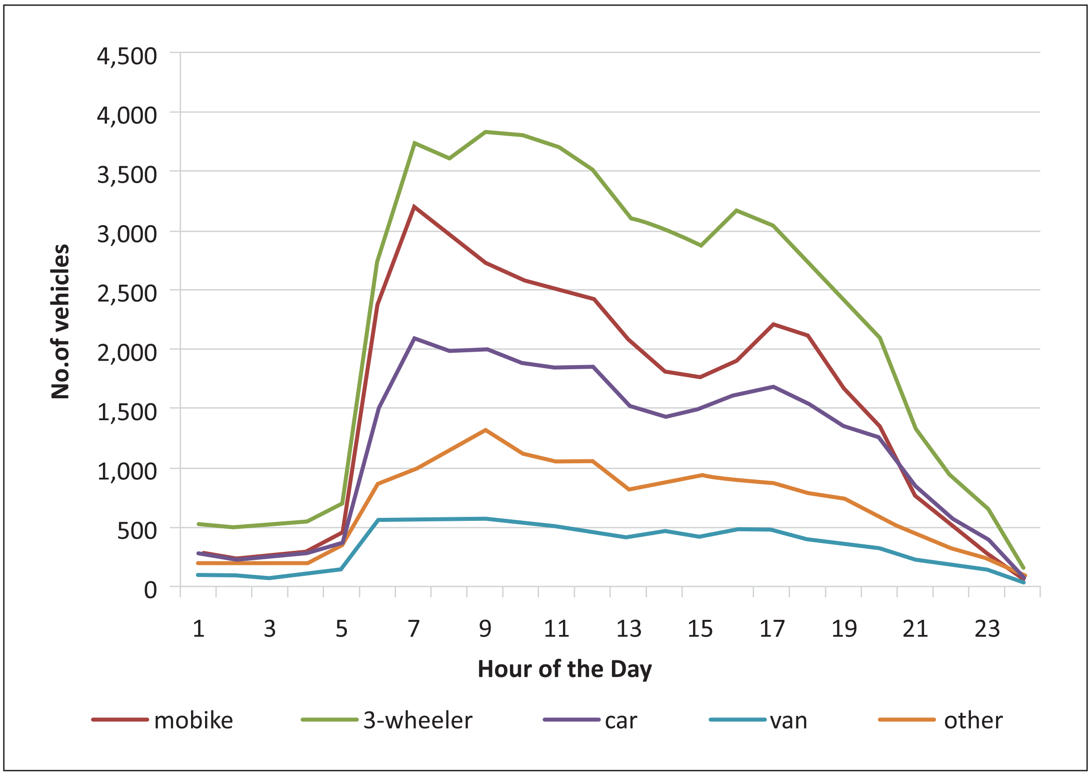


Figure 4-5 : Vehicle distribution with time

The distribution of vehicles across the seven days of the week varies quite much. The least number of transactions occurred on Thursday (Figure 4-6).

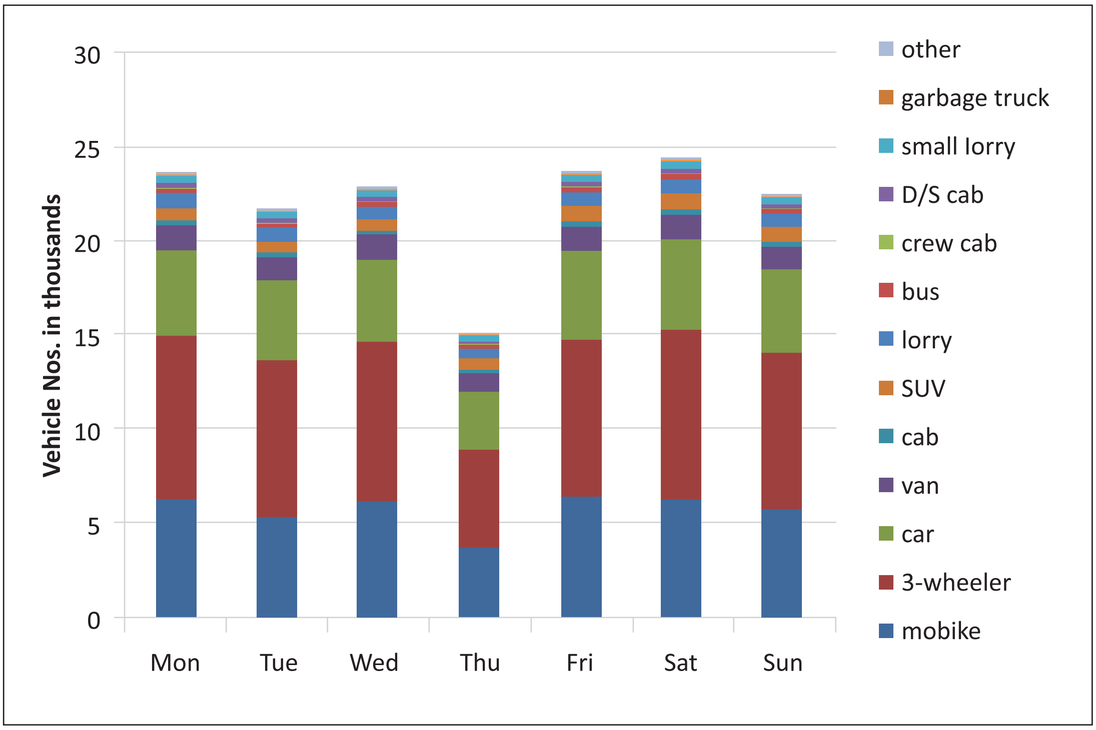


Figure 4-6 : Distribution of vehicles by day of week

Accordingly, the amount of fuel pumped into vehicles has also decreased on Thursday (Figure 4-7).

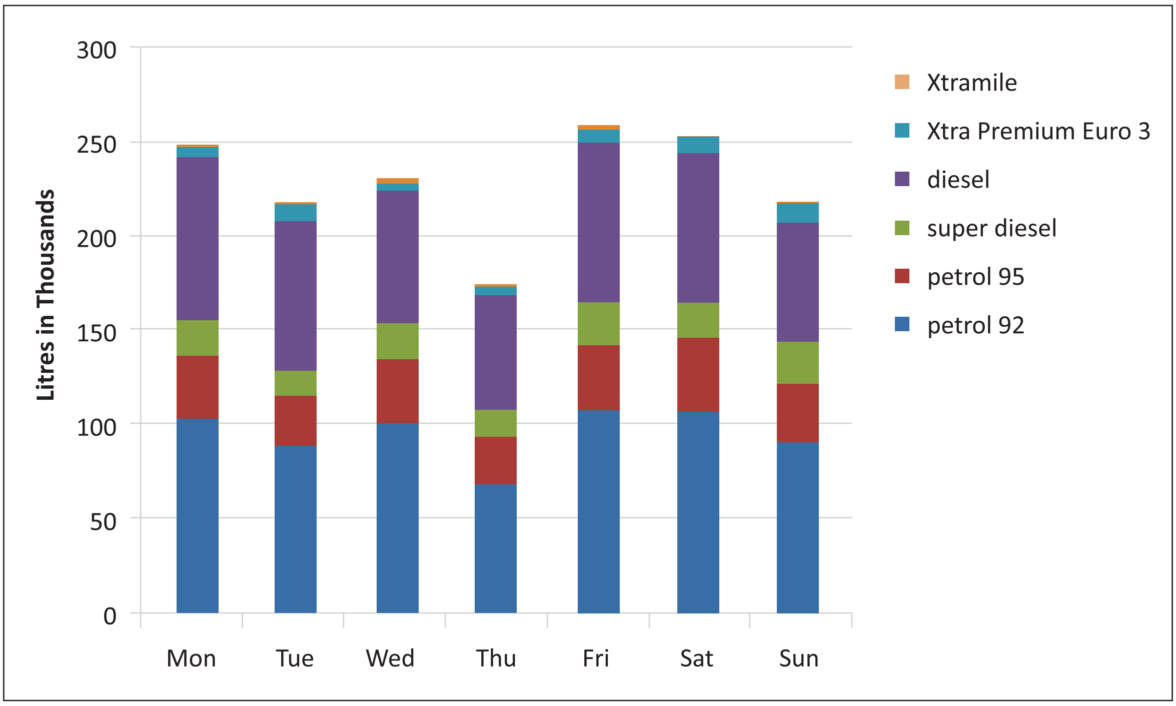


Figure 4-7 : Fuel distribution by day of week

4.1.3 Other trends

Pattern in pumping fuel

According to Figure 4-8, the vast majority of vehicles had no pattern in pumping fuel. However, in actual practice, the majority of vehicles appear to pump fuel in the time interval between 600 – 0900hrs..

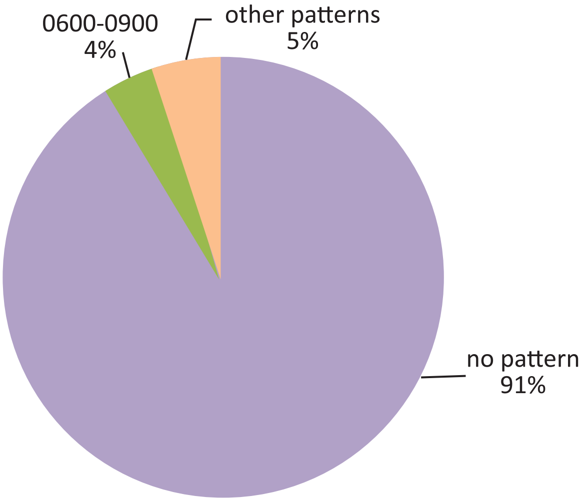


Figure 4-8 : pattern in pumping fuel to the vehicle

Pattern in vehicle usage

Public transport accounts for a meager share of transport (2%). The majority of vehicles are used for private transport (42%), according to Figure 4-9.

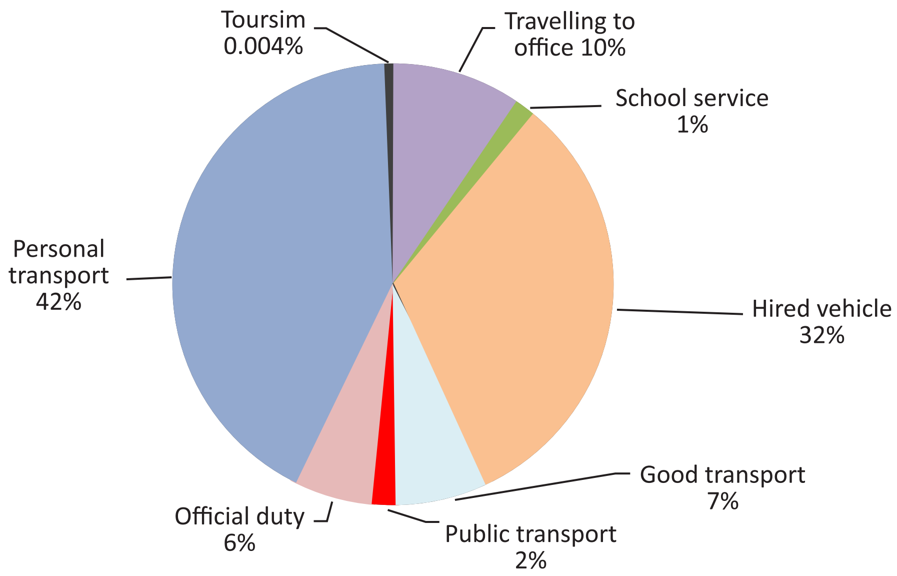


Figure 4-9 : pattern in vehicle usage

Vehicle usage frequency by day of week

The majority of vehicles are used all seven days a week (52%). According to Figure 4-10, only 5% of the vehicles were used on working days (Monday to Friday), while 7% was used from Monday to Saturday.

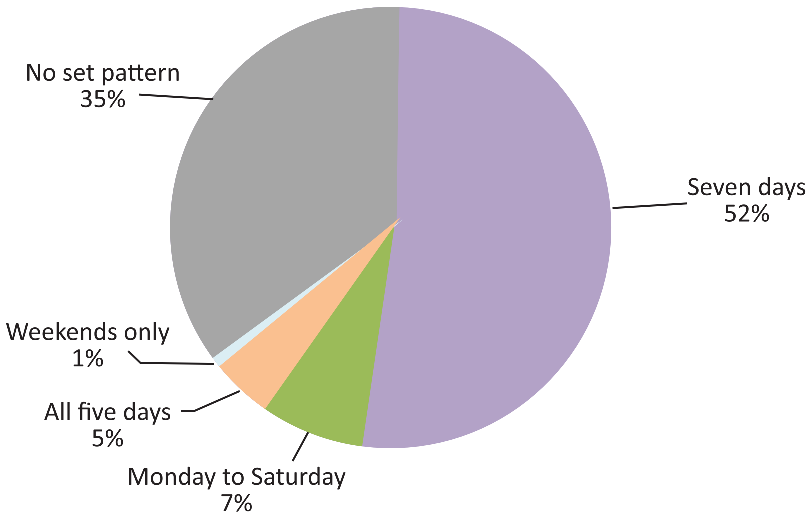


Figure 4-10 : Vehicle usage frequency

Tyre inflation

Only a minority of 3% of vehicle owners inflated the tyres of the vehicles on the dates of the survey. (Table 4-4).

Table 4-4 : tyre inflation

Tyre inflation	
No inflation	97%
For all tyres	2%
Only for tyres with insufficient air	1%

Type of air

The majority of vehicle tyres are inflated using normal atmospheric air (Table 4-5).

Table 4-5 : Type of air tyres

Type of air in tyres	
Nitrogen	13%
Normal Atmospheric	87%

Pattern in gauging air pressure of tyres

Only 17% of the vehicle owners are observing the good practice of gauging the air pressure of tyres once in two weeks.

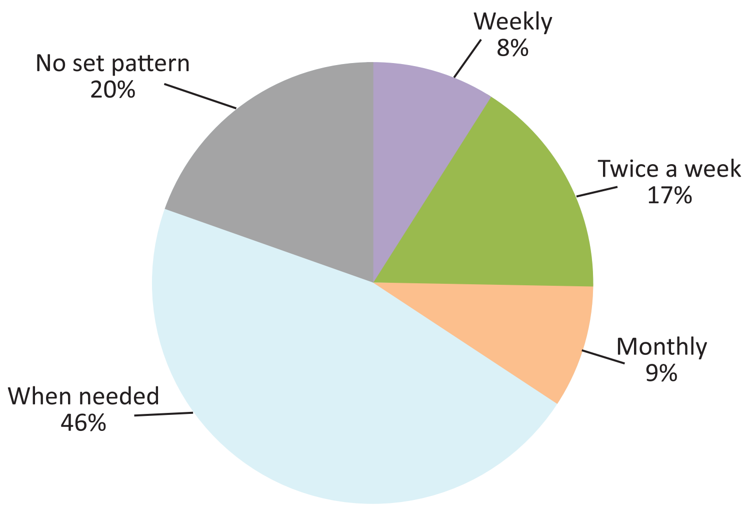


Figure 4-11 : Pattern in gauging the air pressure of tyres

Frequency in tuning the vehicle engine

Most respondents indicated that they do not attend to vehicle tuning unless the vehicle engines fail to function properly or when the vehicle is about to face the annual vehicle emission testing. Another large segment of the respondents indicated that engine tuning is done during the regular vehicle servicing. In either case, it can be derived that most of the owners do not pay sufficient attention to proper functioning of engines and the resultant fuel efficiency. According to Figure 4-12, the population of vehicle owners who pay reasonable attention to these aspects appear to be quite low, less than 13% who attend to engine tuning at annual intervals.

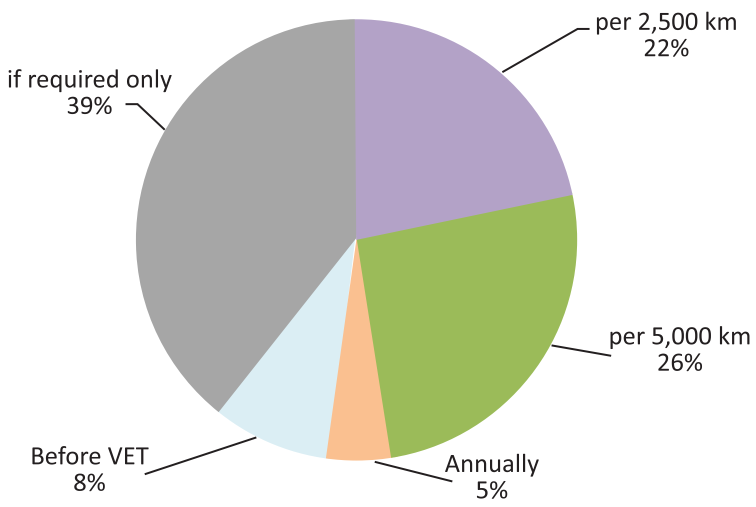


Figure 4-12 : Frequency in tuning vehicle engines

4.2 Non-transport Data

The usage of fuel for non-transport activities varied across the fuel stations, therefore, certain data was analysed per station basis.

4.2.1 Fuel composition

The absolute quantities of fuel vended for non-transport usage is given in Table 4-6.

Table 4-6 : Fuel dispensed for non-transport uses

Fuel	Litres
domestic kerosene	24,464.82
super diesel	8,578.37
Xtra mile	617.84
diesel	28,629.97
petrol 92	10,512.54
petrol 95	741.59
Xtra primium euro 3	107.43
Xtra primium euro 95	27.76

According to Figure 4-13, the most vended fuel for non-transport uses is diesel (39%) followed by domestic kerosene (33%).

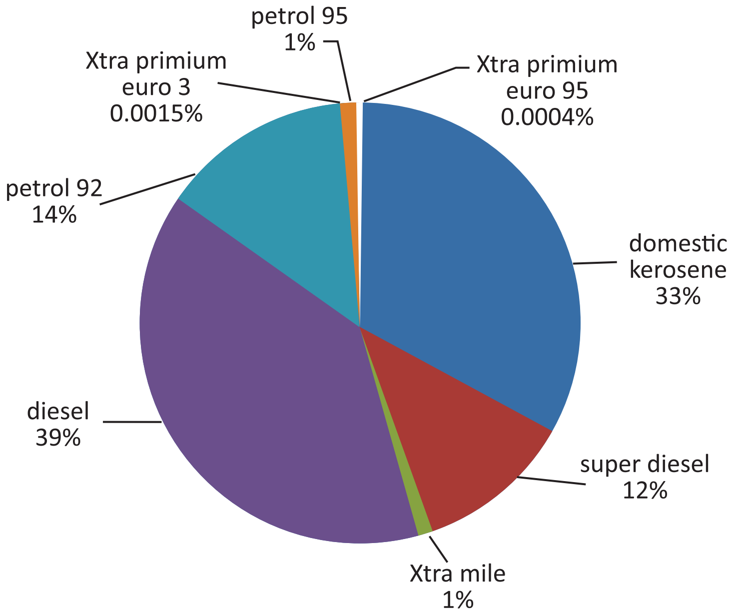


Figure 4-13 : Composition of fuel- non transport

4.2.2 Fuel distribution by type of use

Since the fuel stations concerned were from different geographical areas, the usage of fuel for non-transport varied among fuel stations. However, the fuel stations in Bambalapitiya, Colombo 07 and Kelaniya showed a similar pattern in consumption, as indicated in Figure 4-14.

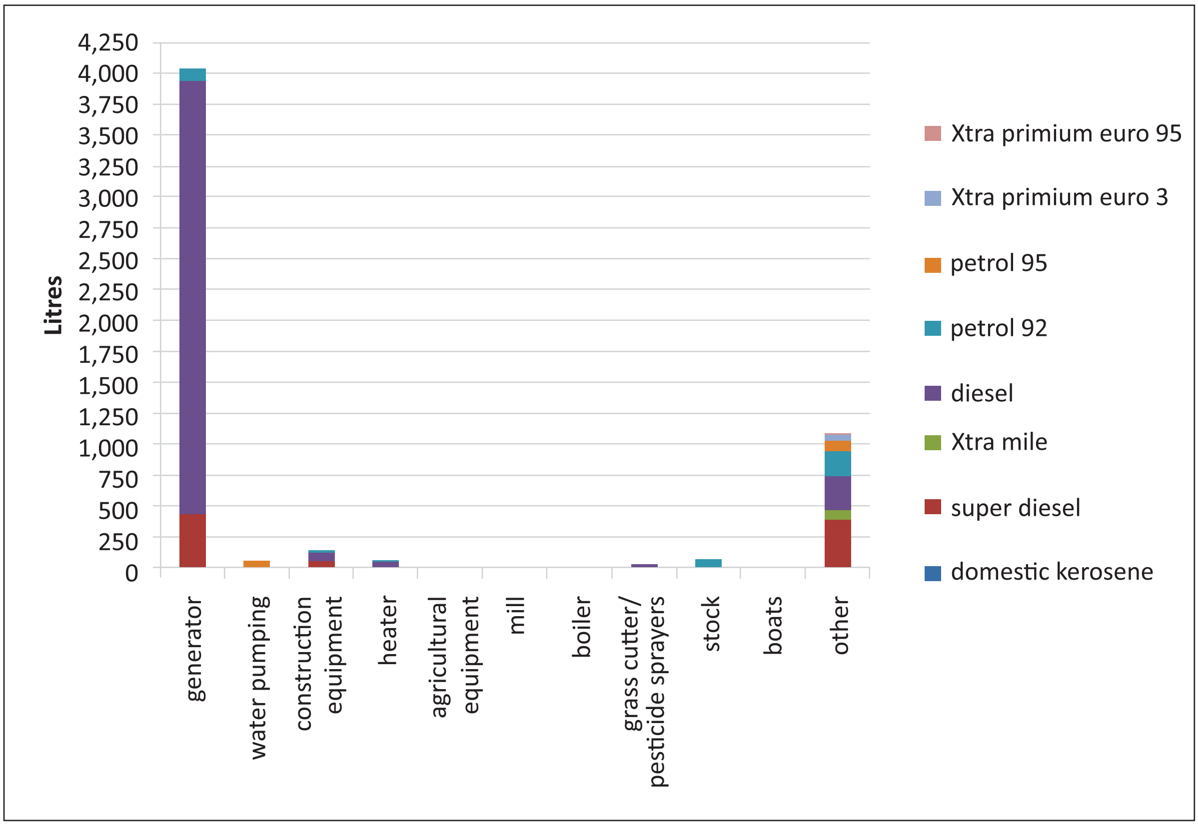


Figure 4-14 : Fuel consumption of the sheds in Bambalapitiya, Colombo 07 and Kelaniya

The highest fuel consumption is reported in the standby generators. The fuel dispatched under the 'other category' is mainly used for three wheelers, which are carried in bottles, and vehicles that got stranded on the road, owing to complete draining of the fuel tank.

In Awissawella and Havelock Town fuel was used in many applications, including construction equipment, generators, water pumps, heaters, agricultural equipment (*e.g.* chain saws) and mills (Figure 4 -15).

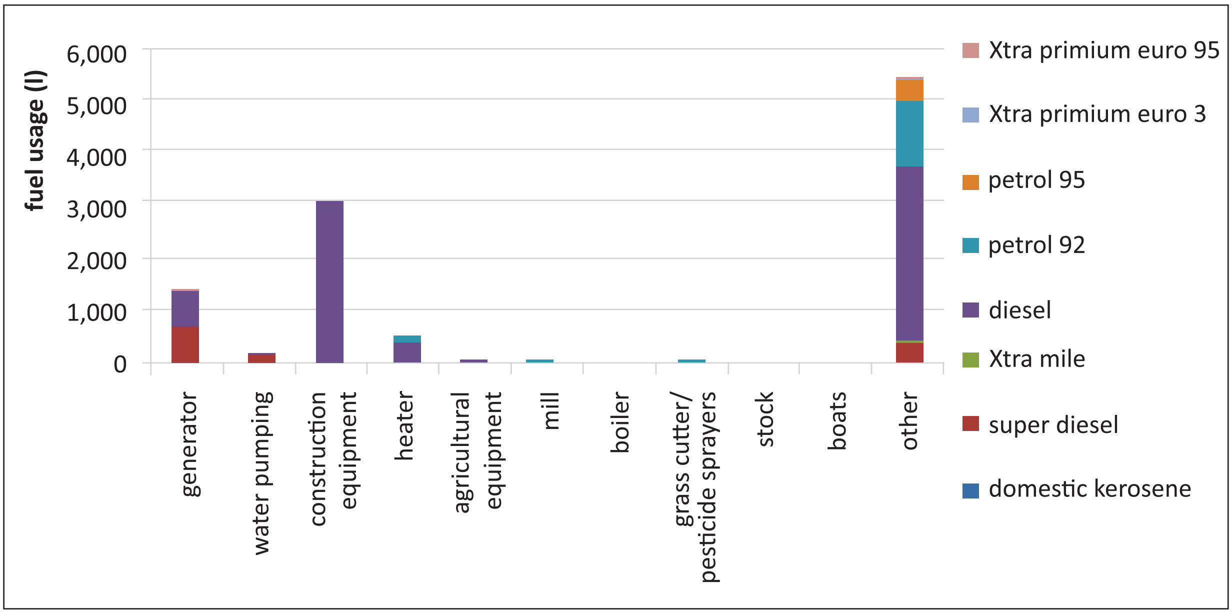


Figure 4-15 : Fuel consumption in Awissawella and Havelock Town

At the fuel station in Handapangoda, fuel is mostly taken to maintain stocks in secondary vending businesses. Usage of fuel is also reported in construction equipment, heaters, agricultural equipment, and marginally in mills and grass cutter / pesticide sprayers (Figure 4-16).

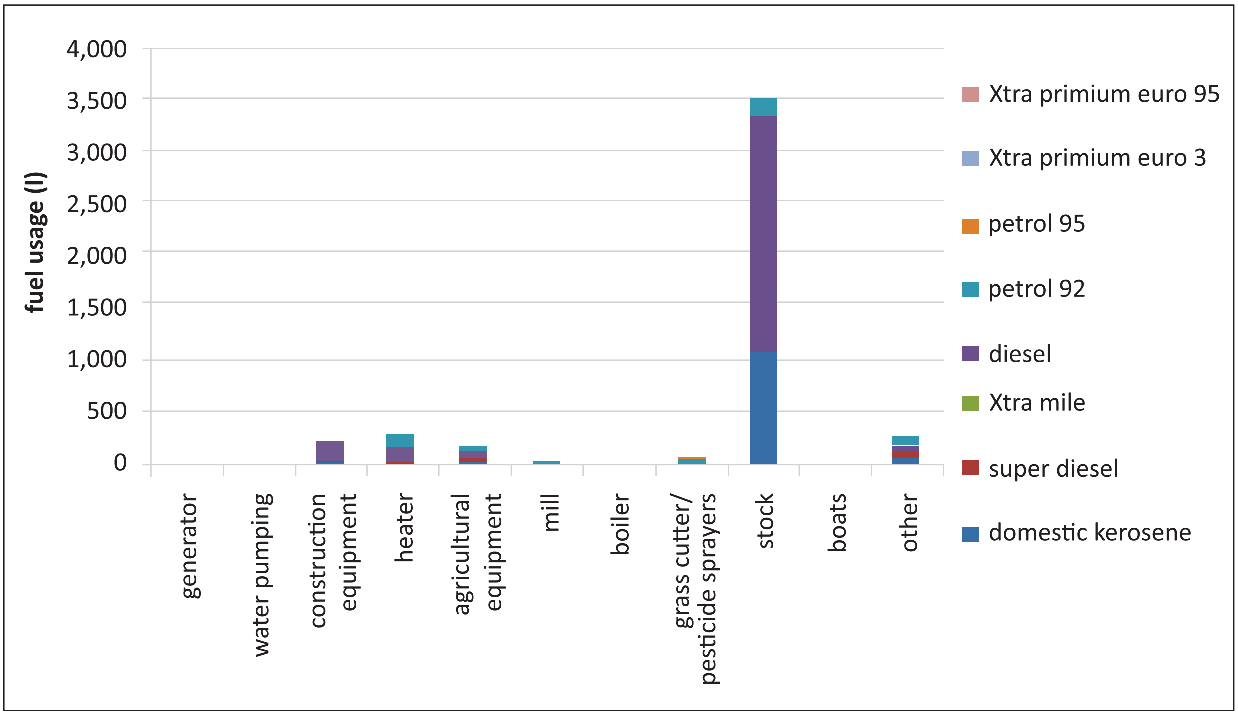


Figure 4-16 : Fuel consumption in Handapangoda

In Havelock Town, the highest fuel usage is reported in the construction sector. Marginal amounts have been dispensed for generators, heaters, agricultural equipment, grass cutters/ pesticide sprayers and for stocking (Figure 4-17).

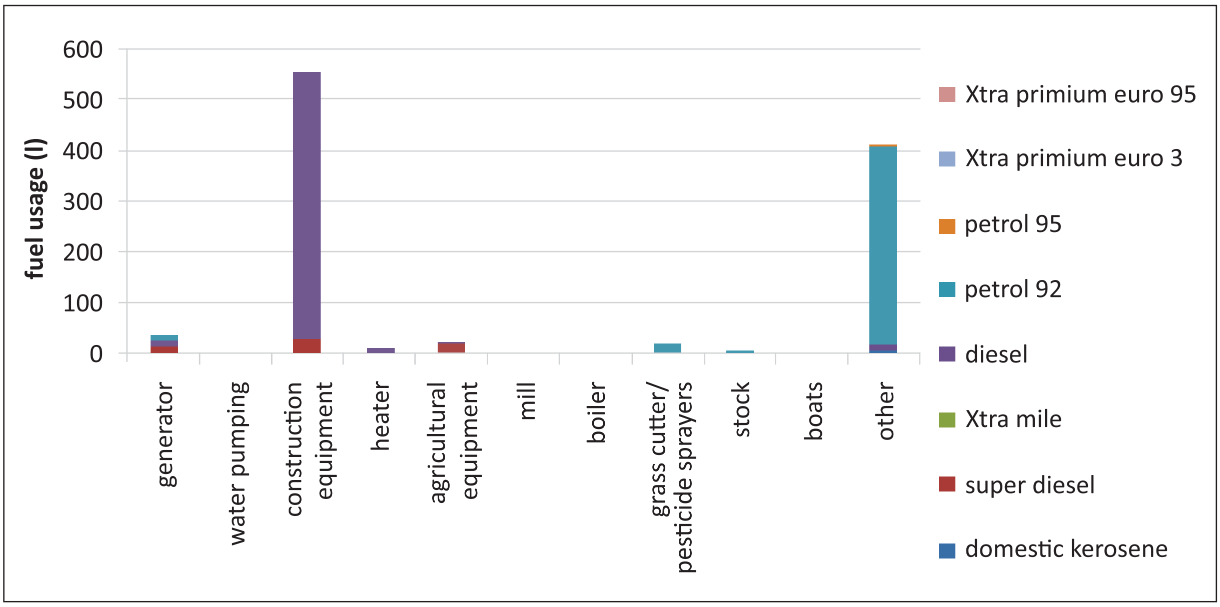


Figure 4-17 : Fuel consumption in Havelock Town

According to Figure 4-18, the highest consumption in Madiwela was used for construction equipment. The second highest usage was for maintaining stocks.

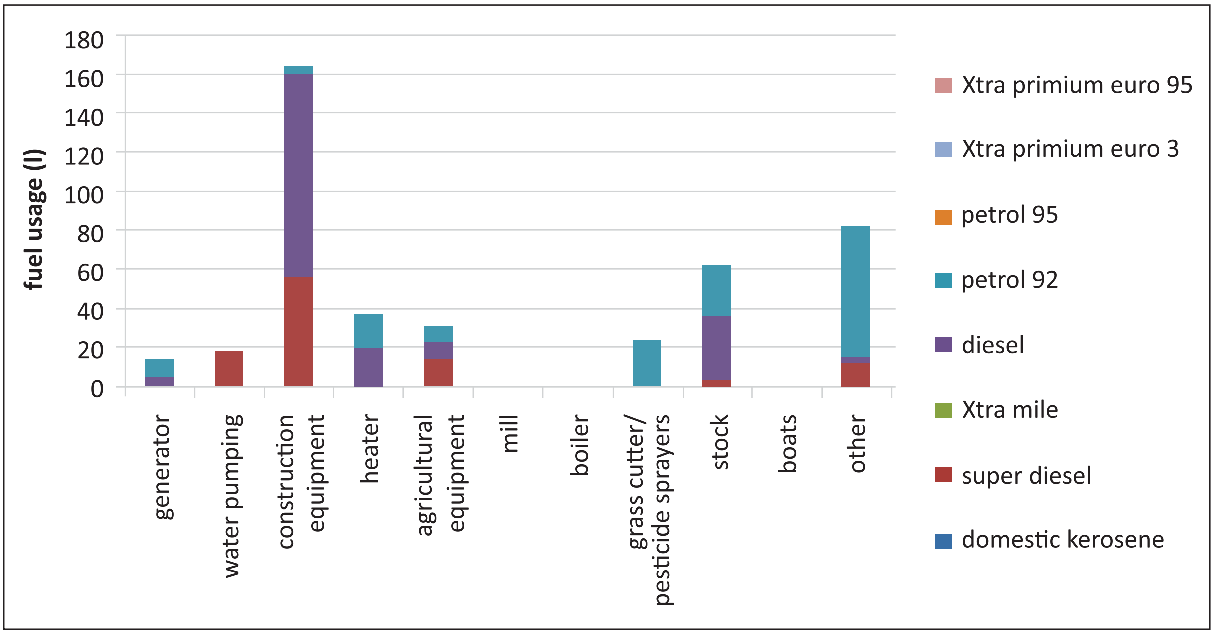


Figure 4-18 : Fuel consumption in Madiwela

Figure 4-19 indicates that, other than the usage of fuel for stranded vehicles, the highest usage in Mt. Lavinia has been in generators. Similar amounts of fuel have been used in water pumping, construction equipment and boats.

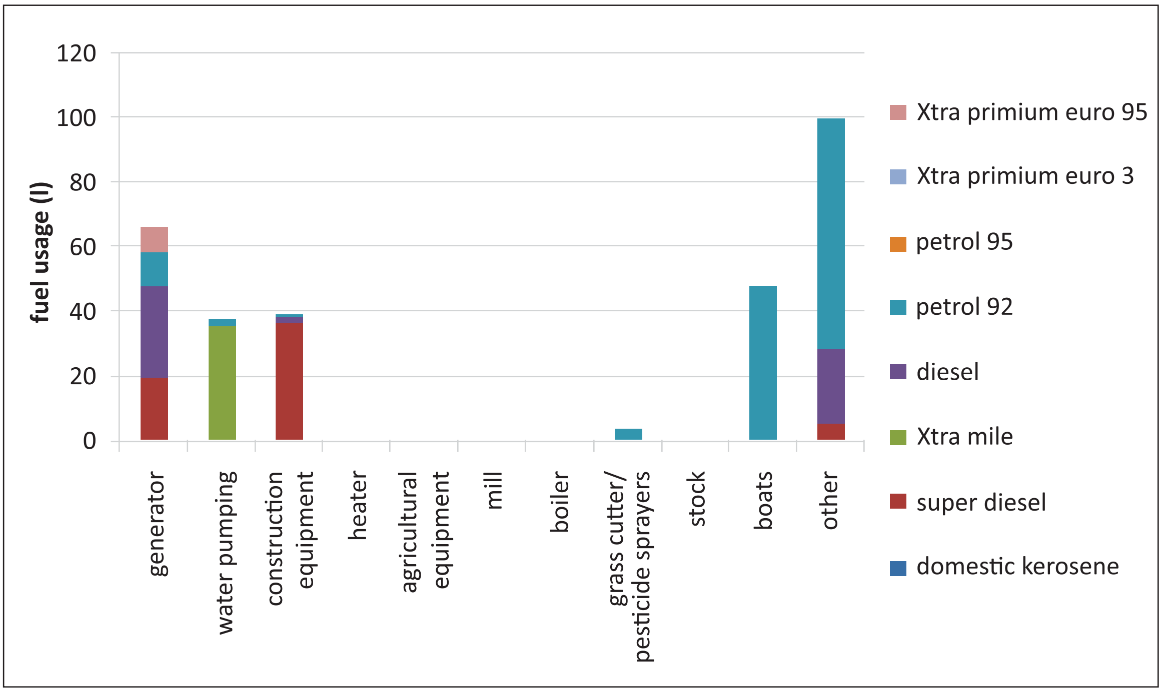


Figure 4-19 : Fuel consumption in Mt. Lavinia

According to Figure 4-20, the highest usage of fuel is to maintain stocks. Other than fuel usage for stranded vehicles, the second highest usage is reported for construction equipment. Similar quantities are used in agricultural equipment, grass cutters / pesticide sprayers and generators.

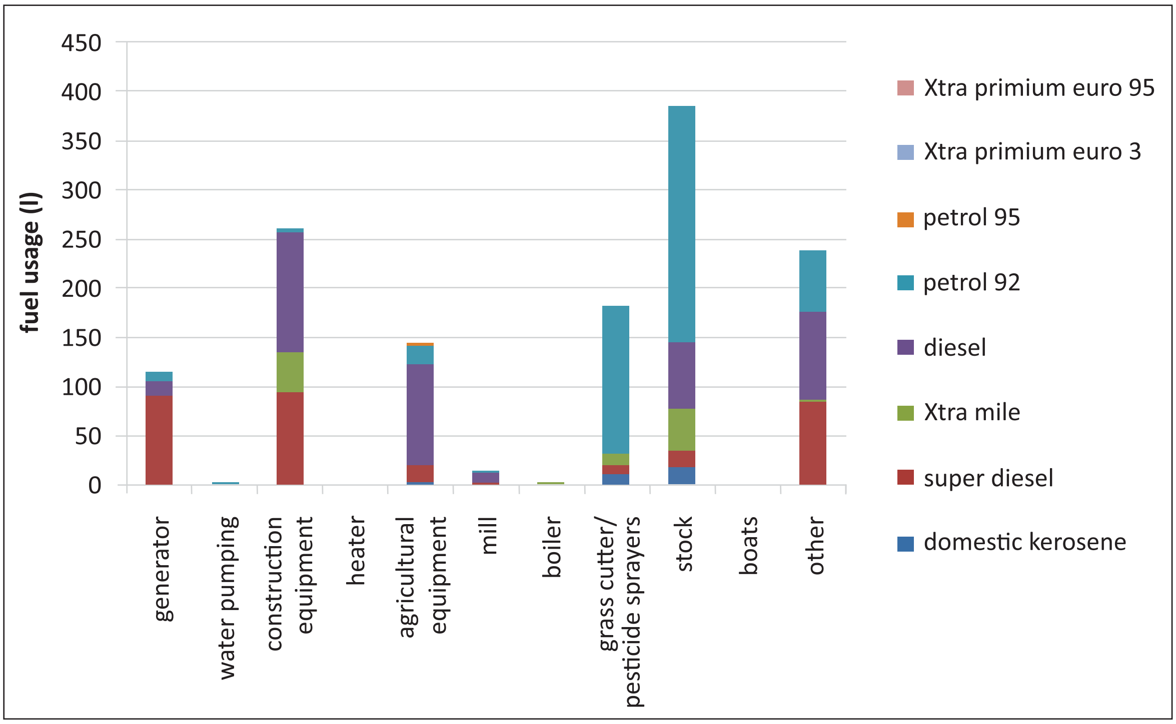


Figure 4-20 : Fuel consumption in Naiwala

In Nalluruwa, the highest usage was reported for stranded vehicles. Heaters and stocks used similar quantities, while marginal usage was reported for generators, construction equipment, grass cutters / pesticide sprayers, boilers and boats (Figure 4-21).

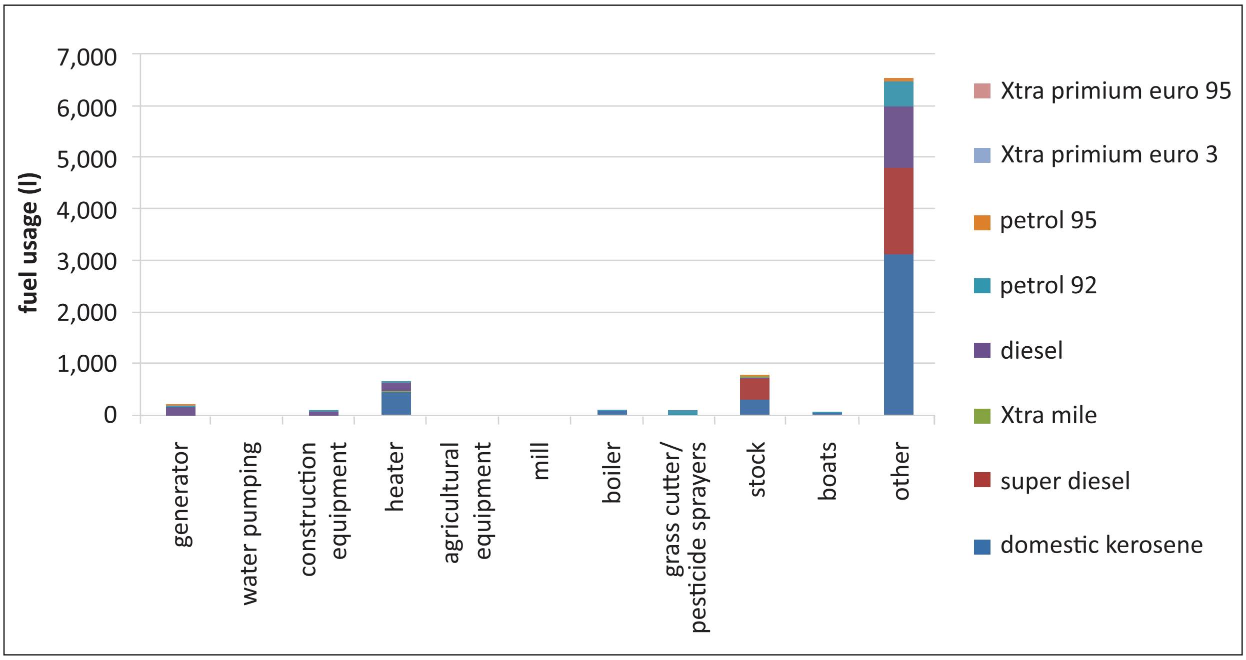


Figure 4-21 : Fuel consumption in Nalluruwa

In Welisara, according to Figure 4-22, other than the fuel used for stranded vehicles, the highest usage of fuel was for construction equipment and heaters, followed by boilers.

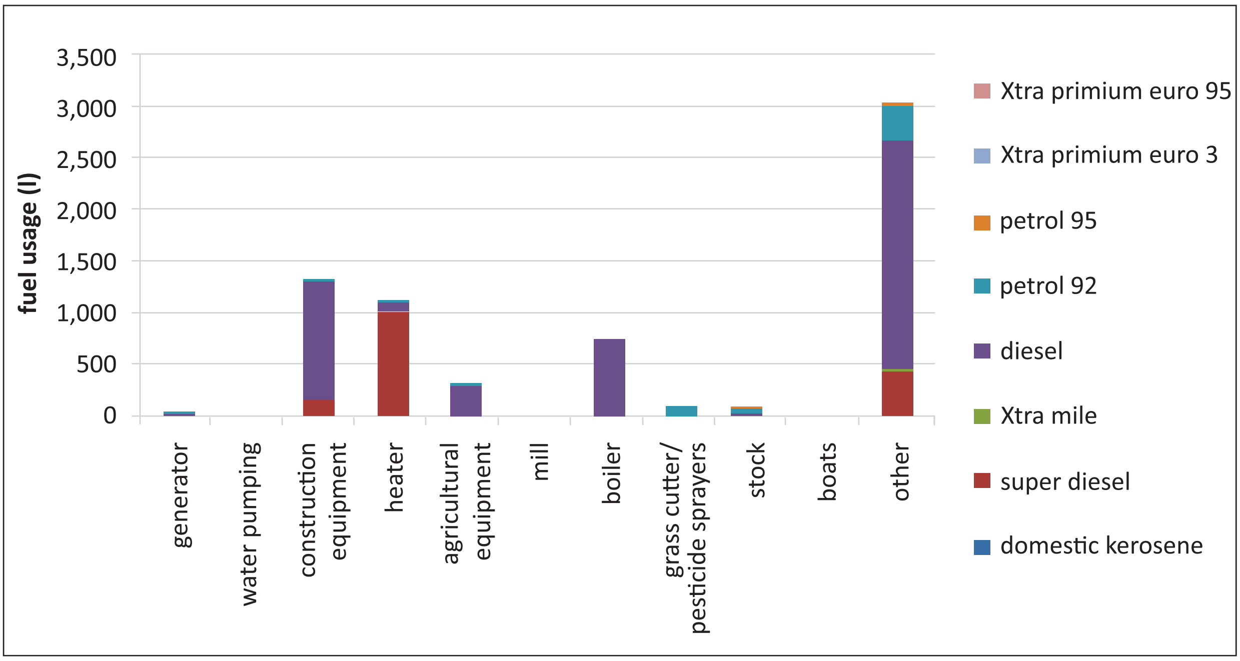


Figure 4-22 : Fuel consumption in Welisara

According to Figure 4-23, in Wellawatta the highest usage of fuels was for boats. The second highest usage, other than for stalled vehicles was for heaters.

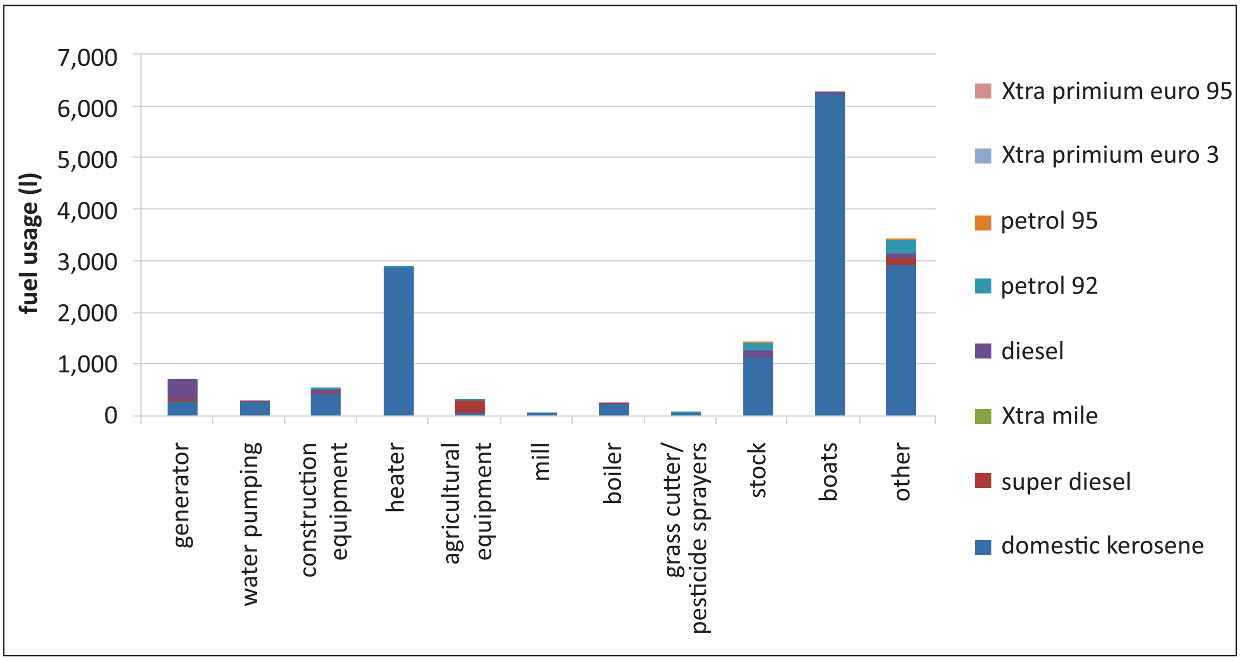


Figure 4-23 : Fuel consumption in Wellawatta

Figure 4-24 indicates that, in Wewaldeniya, the highest usage of fuel is to maintain stocks, followed by construction equipment and generators.

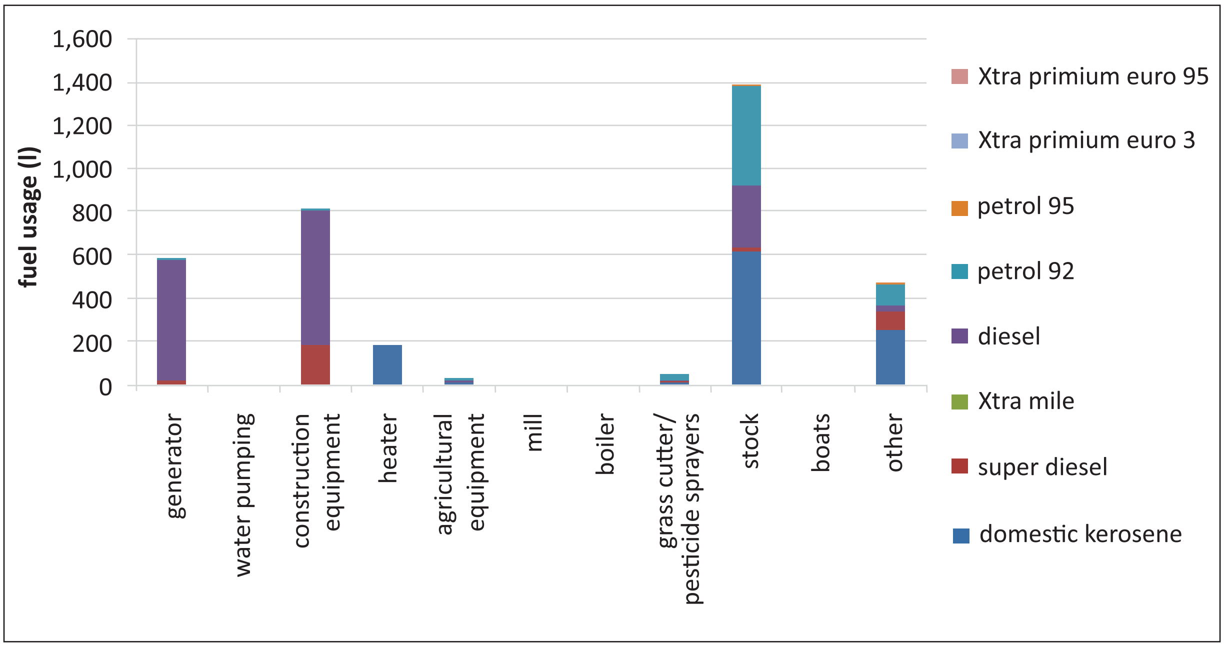


Figure 4-24 : Fuel consumption in Wewaldeniya

Other than for stranded vehicles in Yatadola (Figure 4-25), the highest use of fuels were to maintain stocks.

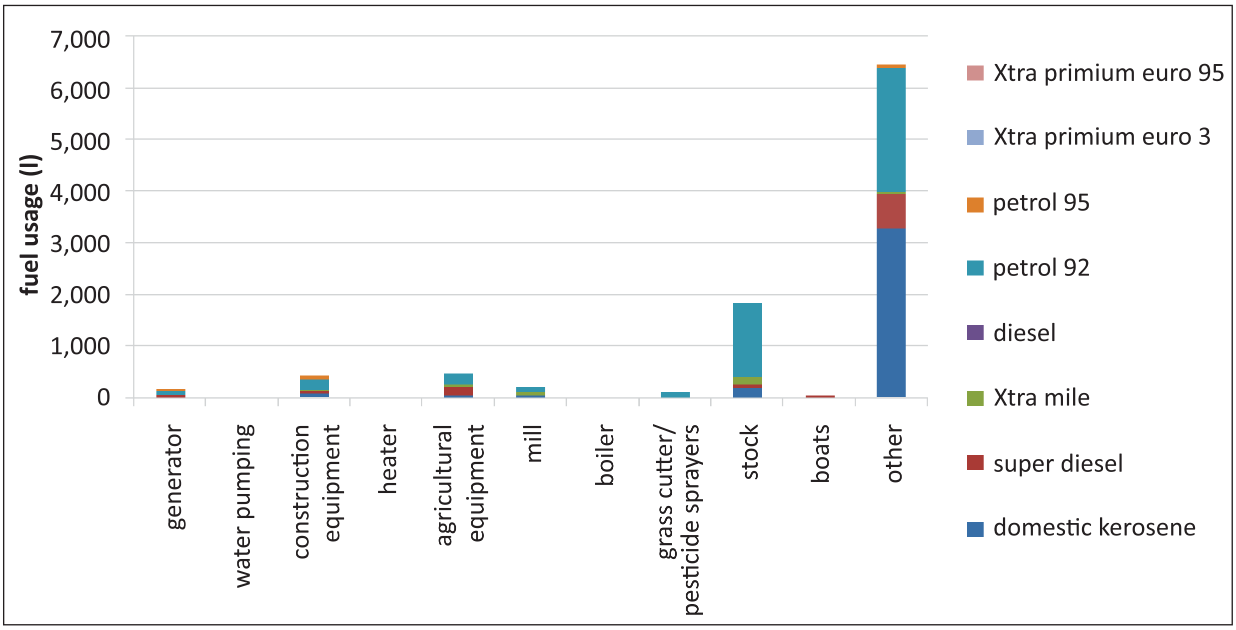


Figure 4-25 : Fuel consumption in Yatadola

4.2.3 Usage distribution

The highest use of fuels was for maintaining stocks. It was followed by generators, construction equipment and boats. Relatively smaller quantities were reported for agriculture activities (Figure 4-26).

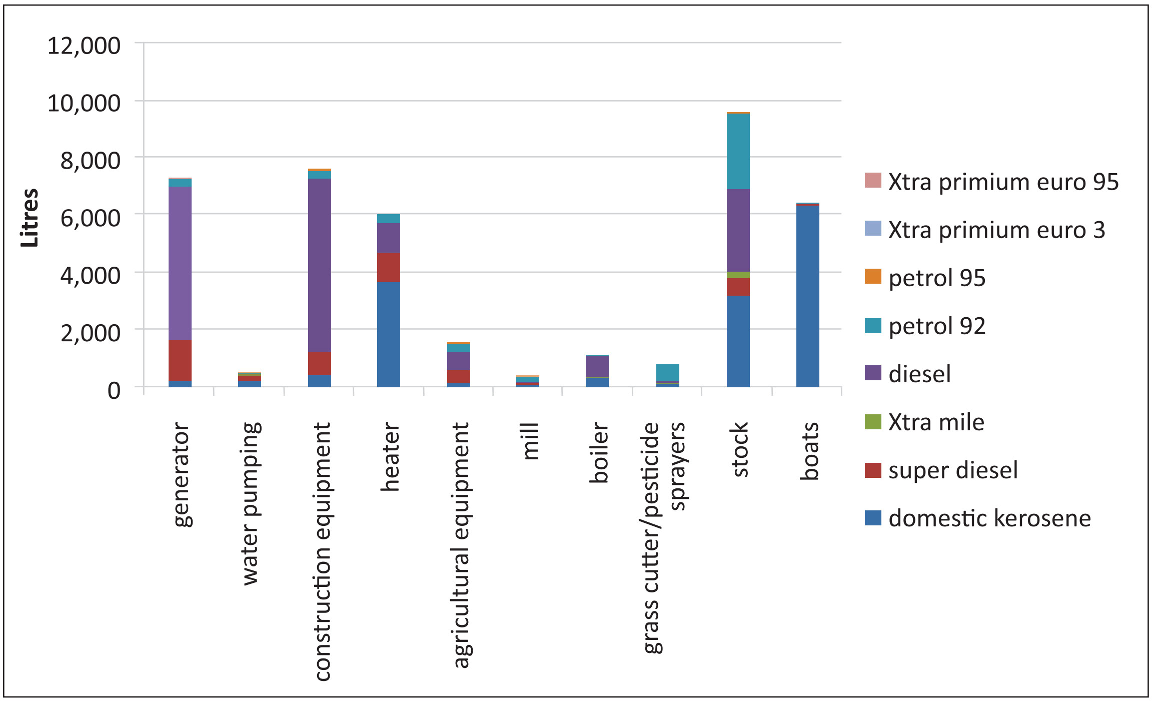


Figure 4-26 : Fuel by types of uses

**This chart has been plotted excluding the "other" category, which was predominantly used for stranded vehicles.*

The major portion of fuel dispatches for non-transport uses were reported during the period 0800 – 1800 hrs (Figure 4-27).

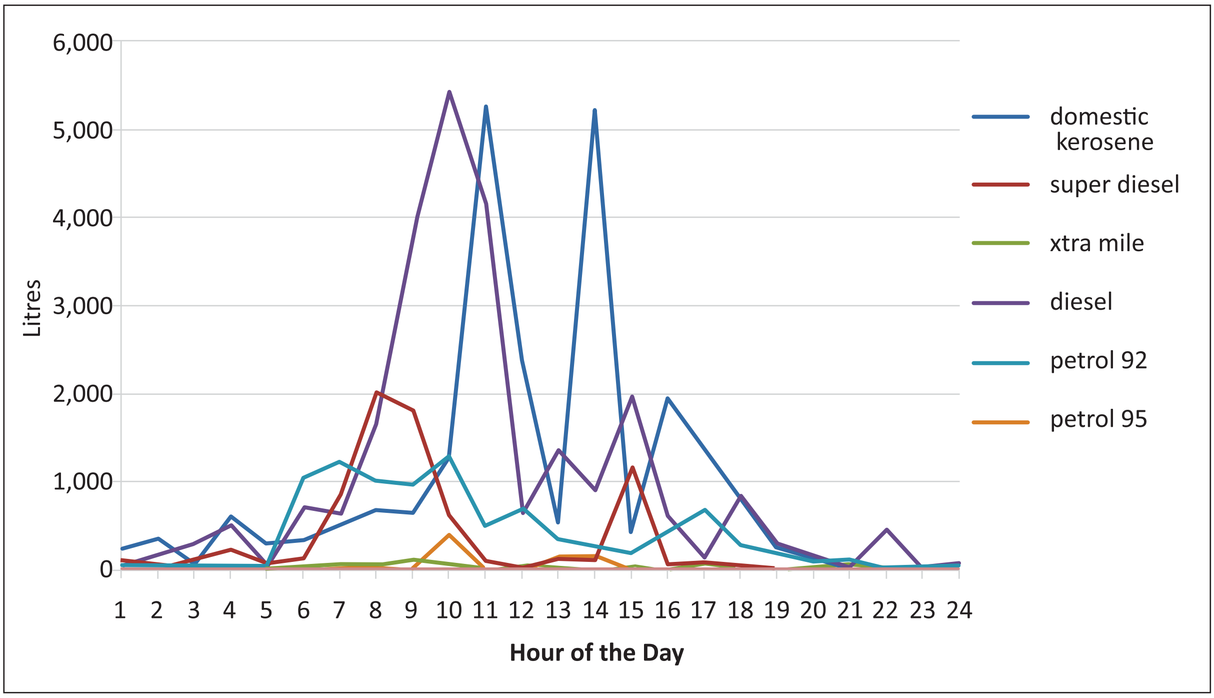


Figure 4-27 : Usage distribution across time

4.3 Comparison of Transport and Non-transport Data

When comparing the dispatches of fuel for non-transport against the total fuel quantities issued in fuel stations, over 85% of fuels in all sheds were issued for transport activities. According to Figure 4-28, fuel dispatches in Awissawella and Nalluruwa are highest for non-transport activities. On average, about 3% of total fuel dispatches is for the non-transport sector.

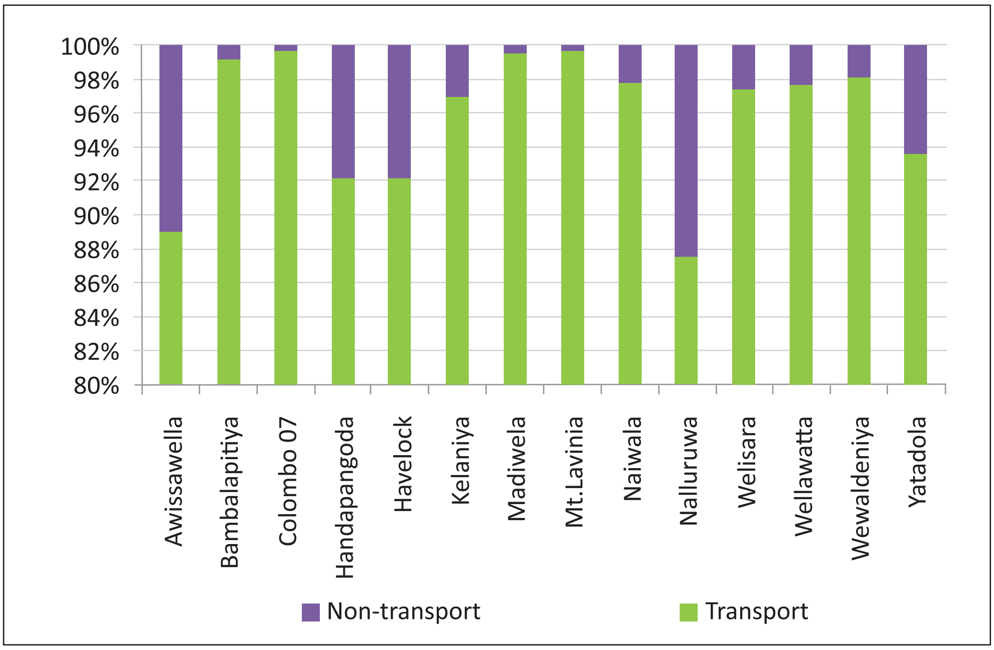


Figure 4-28 : Percentage shares of fuel dispatched for transport and non-transport activities

Table 4-7 indicates that the diesel products (diesel, super diesel and Xtramile) are the most dispensed fuels in the non-transport sector.

Table 4-7 : Dispatch percentage by type of fuel

Fuel	Dispatch % for non-transport
petrol 92	1.6%
petrol 95	0.3%
super diesel	6.7%
diesel	5.4%
Xtra Premium Euro 3	0.2%
Xtramile	5.9%

Figure 4-29 indicates that the vehicle distribution over time has a plateau from 0700 – 1200 hrs. and a smaller peak around 1700 hrs. Fuel dispatch for non-transport activities however, has two distinct peaks, at 1100 hrs and 1400 hrs.

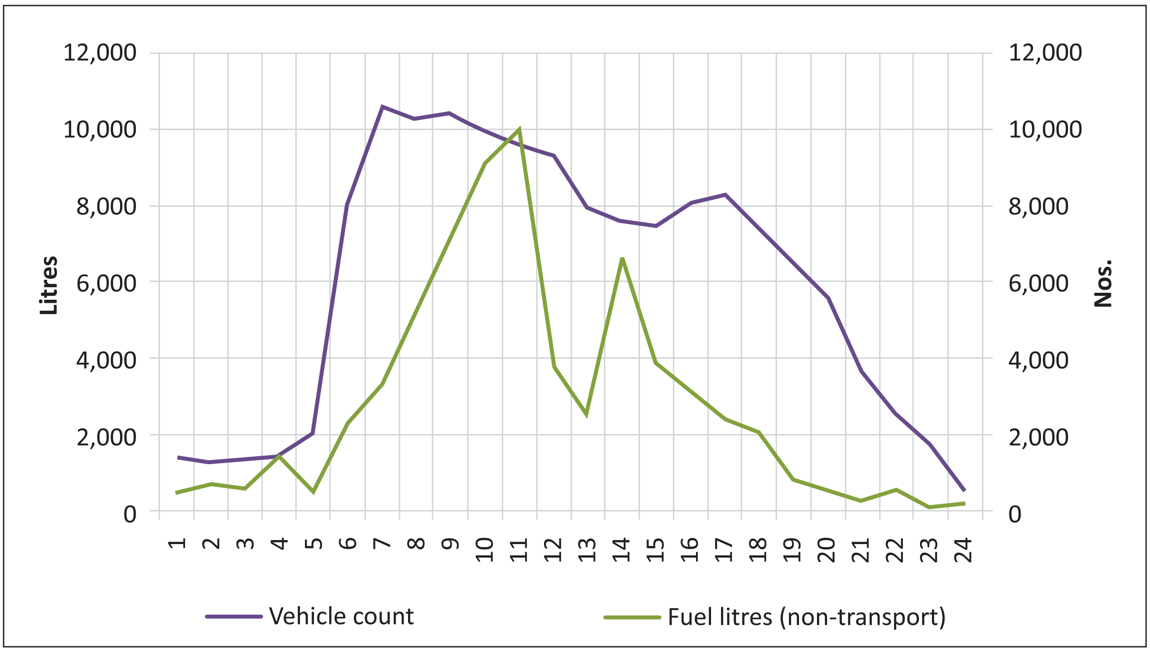


Figure 4-29 : Distribution of transport and non -transport activities across time

4.4 Other Patterns

4.4.1 Payment mode

The mode of payment differs, while 92% of the customers pay with cash and only 6% use credit cards (Figure 4-30). This is an indication of the lower use of cashless transactions by the society in general, as the fuel purchasing is a better reflection of the population than a glossary or clothing transactions would provide.

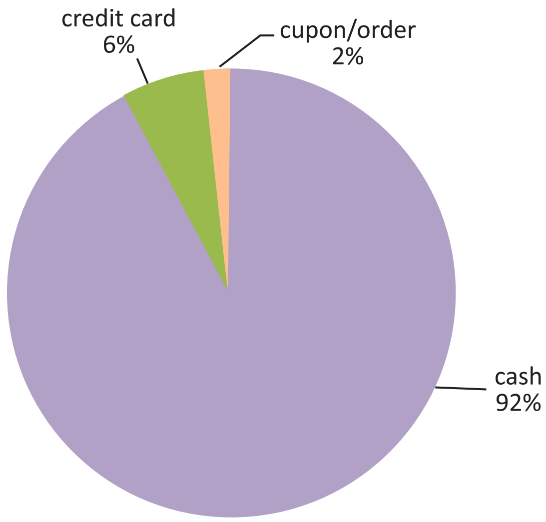


Figure 4-30 : Mode of payment

4.4.2 Location of the lid of the fuel tank

In the majority of vehicles, the lid of the fuel tank was located at the centre, since the fleet is dominated by motor cycles. Lids located at the left were marginally higher (29%) than that of lids located at the right (27%). This coincides with the vehicle composition derived from the survey, where the percentage of motorcycles and three wheelers combined, is higher than 50%. The lids of motorcycles are located at the centre of the tank, while in three wheelers, the majority are located in the centre. This information will be useful to future planning of fuel station layouts, in locating the nozzles and the connected fuel pipes of the fuel pumps.

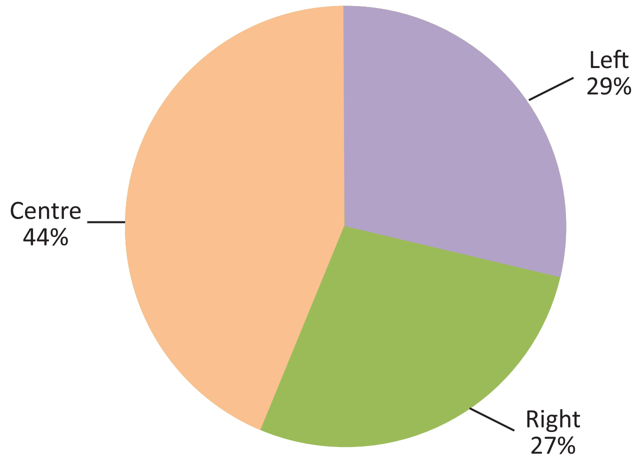


Figure 4-31 : Location of the lid of the fuel tank

05 Fuel Consumption Study – Sampling plan for a countrywide study

5.1 Sample Size Calculation

The Equation[5] used for this calculation is given below.

$$n = \frac{\frac{Z^2pq}{d^2}}{1 + \frac{1}{N}\left(\frac{Z^2pq}{d^2} - 1\right)}$$

Where,

N = Population size (Total number Fuel Stations in Sri Lanka)

p = Estimated proportion of fuel usage for non-transportation

q = 1 - p

K = Number of strata

d = Margin of error (Proportion of the difference between the actual value and the estimated value)

Z = Value of cut-off point of Z axis under (a/2) *100% of probability from right tail

In order to calculate the sample size, margin of error (d) should be known with the level of significance.

Table 5-1 : Calculated sample sizes for different margins of error and levels of confidence

Margin of error (%)		2.00%	1.50%	1.25%	1.00%	0.75%	0.50%	0.25%
Sample size; n	At 95% Con. Level (z=1.96)	234	364	464	599	775	981	1,167
	At 90% Con. Level (z=1.65)	176	282	369	494	671	903	1,138

From the pilot study, estimated **p = 3.1%**
Total No. of fuel stations, **N = 1,246**

Considering the 1 % of Margin of error and 95% level of confidence, sample size of 599 (600) was selected for the Survey

[5] Cochran W.G. *Sampling Techniques*, 1999 Third edition, Willey series in probability and Mathematical Statistics -applied, page 75

5.2 Sample allocation for each District

Using Proportional allocation, the sample size was assigned to each district.

Table 5-2 : Sample allocation for each district

District	N_h	n_h
Ampara	54	26
Anuradhapura	47	23
Badulla	31	15
Batticaloa	39	19
Colombo	151	73
Galle	66	32
Gampaha	156	75
Hambantota	37	18
Jaffna	59	28
Kalutara	56	27
Kandy	66	32
Kegalle	31	15
Kilinochchi	8	4
Kurunagela	111	53
Mannar	11	5
Matale	46	22
Matara	29	14
Monaragala	25	12
Mulativu	12	6
Nuwara Eliya	23	11
Polonnaruwa	28	13
Puttalam	72	35
Ratnapura	45	22
Trincomalee	26	12
Vavuniya	17	8
Total	1,246	599

5.3 Statistical Analysis

Table 5-3 : Descriptive statistics on monthly gasoline and diesel usage separately

District	No of Sheds	Gasoline			Diesel		
		SD	Mean	CV_%	SD	Mean	CV_%
Ampara	54	117.5	1,806	6.5	1,079.7	3,015.7	35.8
Anuradhapura	47	182.7	3,360	5.4	2,199.0	6,160.8	35.7
Badulla	31	114.5	1,808	6.3	1,343.0	3,495.2	38.4
Batticaloa	39	114.3	1,323	8.6	660.0	1,756.2	37.6
Colombo	151	795.9	18,869	4.2	11,438.1	31,976.7	35.8
Galle	66	185.4	3,813	4.9	1,317.2	5,317.3	24.8
Gampaha	156	527.9	12,217	4.3	4,745.9	18,082.7	26.2
Hambantota	37	112.1	1,896	5.9	1689.8	4,082.9	41.4
Jaffna	59	96.5	1,634	5.9	825.7	2,671.1	30.9
Kalutara	56	216.7	4,471	4.8	1,421.8	6,150.7	23.1
Kandy	66	180.0	4,351	4.1	2,236.2	7,147.4	31.3
Kegalle	31	133.7	2,258	5.9	921.5	3,378.4	27.3
Kilinochchi	8	20.3	309	6.5	**573.4**	**1,031.8**	**55.6**
Kurunagela	111	302.6	6,892	4.4	2,683.5	9,992.4	26.9
Mannar	11	22.7	252	9.0	317.3	643.5	49.3
Matale	46	80.5	1,578	5.1	930.2	2,668.1	34.9
Matara	29	169.6	2,382	7.1	2,130.8	5,016.6	42.5
Monaragala	25	106.2	1,284	8.3	903.0	2,319.6	38.9
Mulativu	12	25.3	326	7.8	**688.1**	**1,206.4**	**57.0**
Nuwaraeliya	23	70.6	1,010	7.0	1,174.7	2,601.5	45.2
Polonnaruwa	**28**	**403.6**	**1,369**	**29.5**	1,259.5	2,931.2	43.0
Puttalam	72	122.1	3,023	4.0	1,617.0	5,124.4	31.6
Ratnapura	45	169.1	3,201	5.3	1,706.4	5,256.5	32.5
Trincomalee	**26**	**417.8**	**663**	**63.0**	1,169.2	2,432.4	48.1
Vavuniya	17	36.6	499	7.3	**1,156.2**	**2,060.1**	**56.1**

Considering the coefficients of variation (CV) of monthly fuel usage for each district, it can be clearly seen that the values of petrol usage are considerably lower than that of diesel usage, which means that the monthly petrol usage is relatively more consistent than diesel usage. When the CV values by district are compared, Polonnaruwa and Trincomalee districts have large fluctuations during a year. For diesel usage, the same feature can be identified in Kilinochchi, Mulativu and Vavunia districts.

Table 5-4 : Descriptive statistics on monthly petrol and diesel usage

District	No of Sheds	Petrol and Diesel		
		SD	Mean	CV_%
Ampara	54	1,173	4,820	24
Anuradhapura	47	2,360	9,511	25
Badulla	31	1,415	5,305	27
Batticaloa	39	751	3,067	25
Colombo	151	11,811	50,890	23
Galle	66	1,388	9,145	15
Gampaha	156	5,025	30,356	17
Hambantota	37	1,721	5,988	29
Jaffna	59	900	4,303	21
Kalutara	56	1,509	10,645	14
Kandy	66	2,345	11,509	20
Kegalle	31	977	5,647	17
Kilinochchi	**8**	**587**	**1,341**	**44**
Kurunagela	111	2,899	16,879	17
Mannar	11	326	897	36
Matale	46	996	4,246	24
Matara	29	2,169	7,425	29
Monaragala	25	976	3,606	27
Mulativu	**12**	**705**	**1,534**	**46**
Nuwaraeliya	23	1,207	3,615	33
Polonnaruwa	28	1,564	4,188	37
Puttalam	72	1,699	8,157	21
Ratnapura	45	1,799	8,467	21
Trincomalee	**26**	**1,379**	**3,043**	**45**
Vavuniya	**17**	**1,173**	**2,556**	**46**

Table 5-4 indicates that when the CV values by district for petrol and diesel usage together are compared, Kilinochchi, Mulativu, Trincomalee and Vavunia districts have a large fluctuation during a year. Hence it is recommended to collect data from these districts in the selected months during the full scale data collection.

Table 5-5 : Recommended periods for data collection

District	Recommended period
Kilinochchi	Mar - Sep
Mulativu	Mar - Oct
Trincomalee	Mar - Aug
Vavuniya	Mar - Oct

5.4 Analysis from the pilot study

The results from the pilot study indicate that a proper sampling plan can be derived covering certain periods of the day and days of the week without affecting the estimation of national totals. The two aspects *i.e.* day of the week and time period of day were evaluated and the recommendations on each aspect were derived.

5.4.1 Days of the Week

Table 5-6 : Scatter diagram for total fuel dispensed (Kl) for transport and non-transport activities by location

	Location	Non-Transport (*Kl*)	Transport (*Kl*)
1.	Awissawella	21,211.0	85,730.3
2.	Bambalapitiya	2,845.7	156,779.2
3.	Felix	1,294.6	225,025.6
4.	Handapangoda	9,912.3	45,022.1
5.	Havelock	2,115.7	114,154.3
6.	Kelaniya	1,057.0	111,566.9
7.	Madiwela	992.8	112,485.6
8.	Mt. Lavinia	1,057.0	87,968.9
9.	Naiwala	2,746.5	60,593.7
10.	Nalluruwa	27,281.1	65,146.3
11.	Welisara	13,715.2	258,446.4
12.	Wellawatta	31,371.7	63,457.3
13.	Wewaldeniya	7,009.7	125,378.5
14.	Yatadola	19,312.8	89,403.8

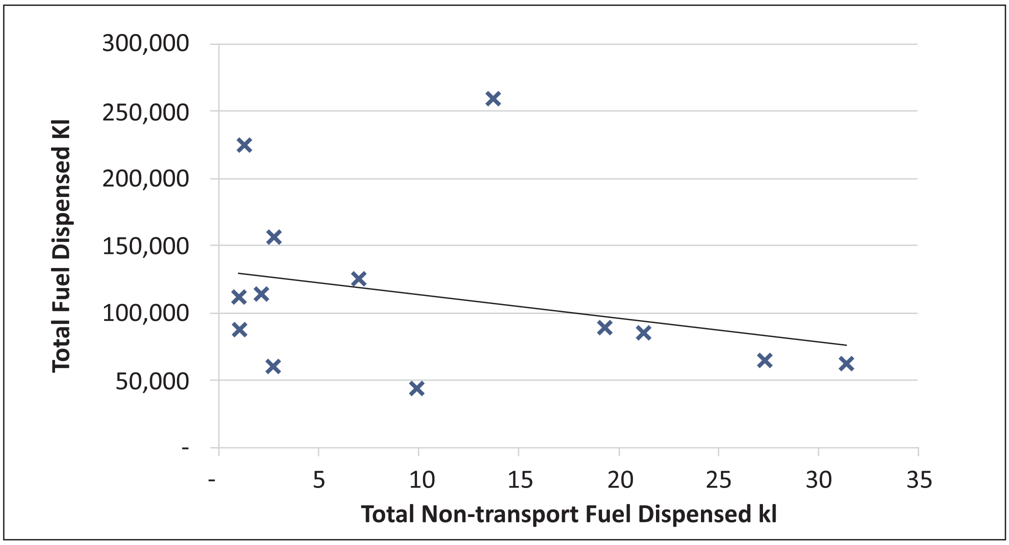


Figure 5-1 : Scatter diagram for total fuel dispensed for transport Vs non-transport activities

Figure 5-1 depicts a weak negative relationship of total fuel dispensed for transport and that of non-transport activities.

Table 5-7 : Distribution of the average amount of fuel issued for Non-Transport activities per station

Hour of the Day	Average amount of issued fuel (*l*)	Cumulative amount (*l*)	Relative Cumulative amount (%)
1.	458.8	458.8	0.7
2.	636.0	1,094.8	1.6
3.	519.6	1,614.4	2.4
4.	1,376.5	2,990.8	4.4
5.	429.6	3,420.4	5.0
6.	2,249.5	5,669.9	8.3
7.	3,326.8	8,996.7	13.2
8.	5,538.5	14,535.2	21.3
9.	7,319.6	21,854.8	32.1
10.	9,125.3	30,980.1	45.4
11.	10,100.5	41,080.6	60.2
12.	3,743.7	44,824.2	65.7
13.	2,870.2	47,694.4	69.9
14.	6,703.7	54,398.2	79.8
15.	4,290.3	58,688.5	86.1
16.	3,093.4	61,781.9	90.6
17.	2,313.3	64,095.2	94.0
18.	2,013.1	66,108.3	97.0
19.	785.9	66,894.2	98.1
20.	438.2	67,332.4	98.8
21.	221.5	67,553.9	99.1
22.	479.9	68,033.8	99.8
23.	22.9	68,056.7	99.8
24.	127.1	68,183.8	100.0

According to Table 5-7, more than 90% of fuel has been issued between 0600-1800hrs. during the day time. Also, there was less than 10% of fuel issued for non-transport activities between1800- 0600 hrs. during the night time. Therefore, it can be recommended to select the data collection period as from 0600 – 1800hrs. to ease the enumeration burden.

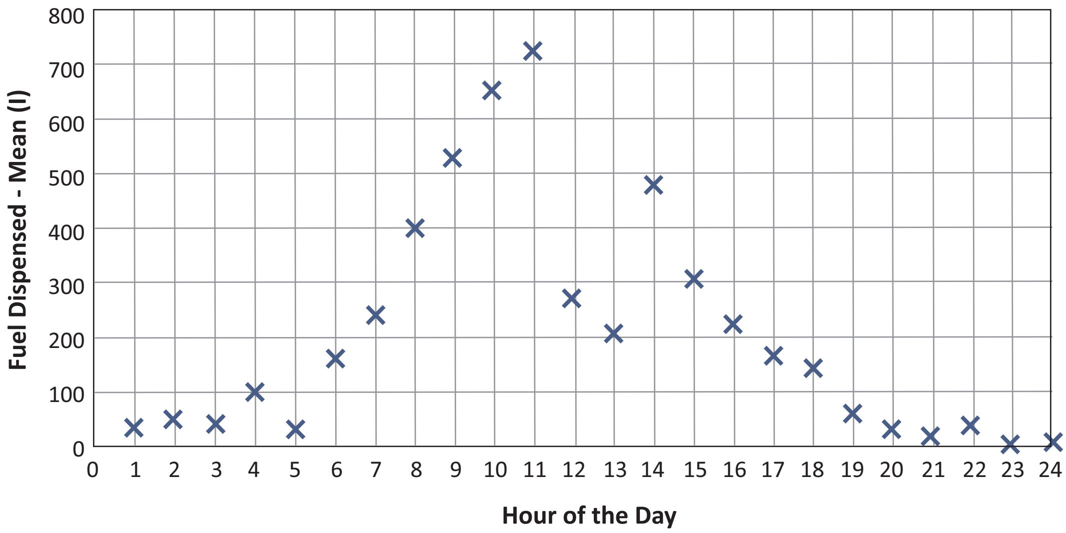


Figure 5-2 : Distribution of the average amount of fuel issued for non-transport activities per station during a day

According to Figure 5-2, major share of fuel has been issued for non-transport activities during the day.

Table 5-8 : Distribution of the daily average amount of fuel issued for non-transport activities per station during a week

Day	Daily average Amount of fuel (l)
Monday	1,016.7
Tuesday	925.0
Wednesday	631.9
Thursday	359.0
Friday	697.7
Saturday	796.0
Sunday	443.8

Testing whether the amount of fuel issued for non-transport activities is independent of the day of the week.

Chi-Square test was carried out. Results are as follows.
Chi-Square statistic = 498.19, p-value = 0.000

Since p-value is very low, (less than 0.01) it can be concluded that there is an association between days of a week on issuing fuels for non-transport activities.

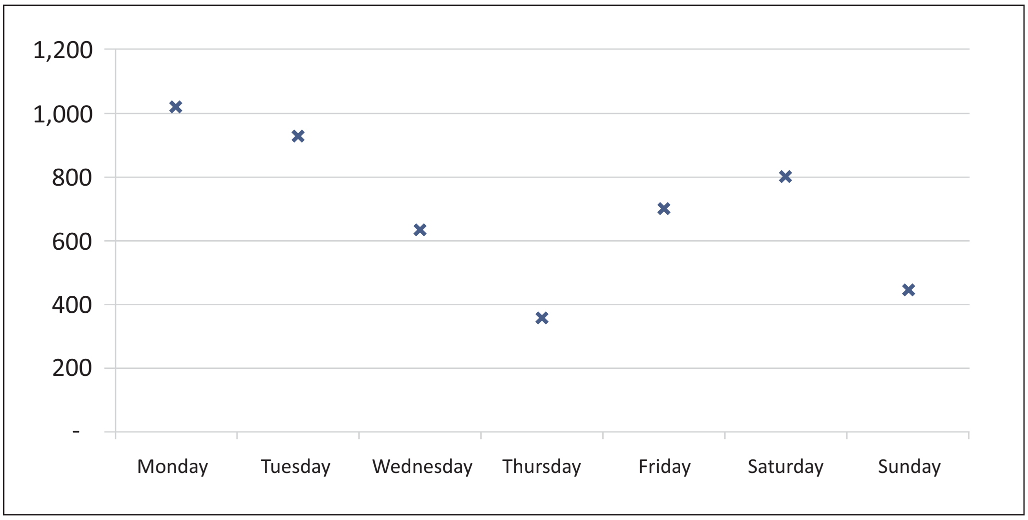


Figure 5-3 : Distribution of the daily average amount of fuel issued for non- transport activities per station during a week

According to Figure 5-3, three clusters of days can be identified considering the similar amount of fuel issued in a particular day of the week.

Cluster 1: Monday, Tuesday
Cluster 2: Wednesday, Friday, Saturday
Cluster 3: Thursday, SundayIt

It is advisable to conduct data collection selecting a day from each cluster. Accordingly, the days Tuesday, Saturday and Sunday are proposed to be selected for enumeration in a future countrywide study.

5.4.2 Period of the day

Given the strenuous workload on the enumerators, it is desirable to have several short periods as the sampling period, spaced apart so that different teams can take over the enumeration. The impact of limiting the sampling period to legs of several hours (compared to the round the clock enumeration of the pilot study) was evaluated.

Table 5-9 : Margin of error (with respect to total fuel dispatch) for each time leg on estimating total fuel dispatch for non-transport activities

Time Leg (hrs.)	Mon	Tue	Wed	Thu	Fri	Sat	Sun	
0700-1200	0.08	0.06	0.05	0.07	0.10	0.08	0.05	Morning Session
0700-1100	0.10	0.08	0.08	0.09	0.13	0.13	0.07	
0700-1000	0.23	0.13	0.14	0.16	0.17	0.37	0.11	
0800-1200	0.10	0.09	0.07	0.09	0.14	0.11	0.08	
0900-1200	0.14	0.14	0.12	0.14	0.22	0.20	0.12	
1000-1200	0.31	0.31	0.31	0.26	0.37	0.32	0.29	
1300-1800	0.07	0.13	0.08	0.08	0.06	0.06	0.05	Evening Session
1300-1700	0.09	0.17	0.11	0.11	0.09	0.09	0.09	
1400-1700	0.15	0.25	0.16	0.15	0.15	0.19	0.15	
1500-1700	0.25	2.78	0.29	0.37	0.25	0.36	0.28	
1400-1600	0.45	0.38	0.27	0.23	0.25	0.48	0.38	
0800-1600	0.04	0.05	0.03	0.03	0.05	0.04	0.04	Day

To ease of interpreting the value of Margin of Error those values were converted in to percentages as in the following table.

Table 5-10 : Margin of error (with respect to total fuel despatch) for each time leg on estimating total fuel dispatch for non-transport activities in %

Time Leg (hrs.)	Mon	Tue	Wed	Thu	Fri	Sat	Sun	
0700-1200	7.78	6.06	5.37	6.73	9.79	8.33	5.18	Morning Session
0700-1100	10.36	7.87	8.40	9.18	12.70	13.07	6.90	
0700-1000	23.19	12.83	13.90	16.06	17.43	36.62	11.32	
0800-1200	9.97	9.06	7.21	9.00	14.13	10.96	7.67	
0900-1200	13.87	13.56	12.15	14.08	22.24	20.16	11.86	
1000-1200	30.90	31.22	30.58	25.61	37.05	31.56	28.66	
1300-1800	6.51	13.30	7.95	8.09	6.49	6.49	5.38	Evening Session
1300-1700	9.26	17.11	11.41	11.05	9.25	8.89	9.19	
1400-1700	15.49	24.51	16.45	15.05	14.67	19.27	15.32	
1500-1700	24.89	278.32	28.81	36.71	24.72	36.43	27.77	
1400-1600	45.39	37.97	26.88	23.45	24.54	47.73	37.99	
0800-1600	4.29	4.67	3.08	3.35	5.16	4.18	3.55	Day

(A) Morning Session: Margin of Error for 0700-1100 = 10.36%

That means, in the morning session of Monday, there is 95 percent confidence that the difference between the estimated and the actual total fuel dispatch is 10.36 percent of the actual total fuel dispatch.

Evening Session : Margin of Error for 1300-1700 = 9.26%

That means, in the evening session of Monday, there is 95 percent confidence that the difference between the estimated and the actual total fuel dispatch is 9.26 percent of the actual total fuel dispatch.

(B) Morning Session: Margin of Error for 0700 to 1200 = 7.78%

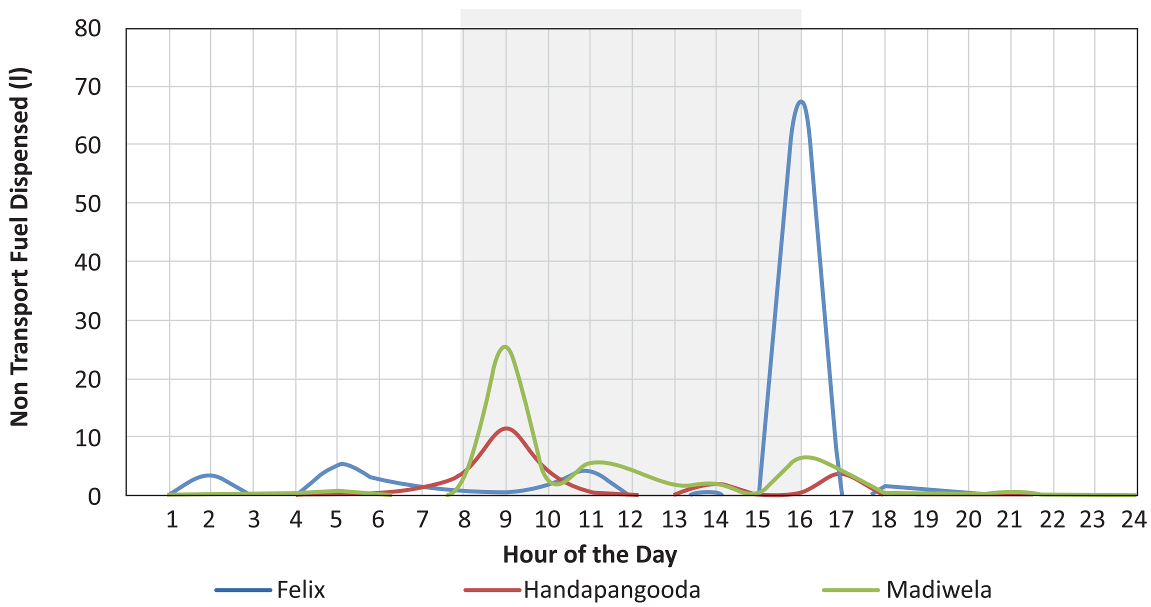
That means, in the morning session of Monday, there is 95 percent confidence that the difference between the estimated and the actual total fuel dispatch is 7.78 percent of the actual total fuel dispatch.

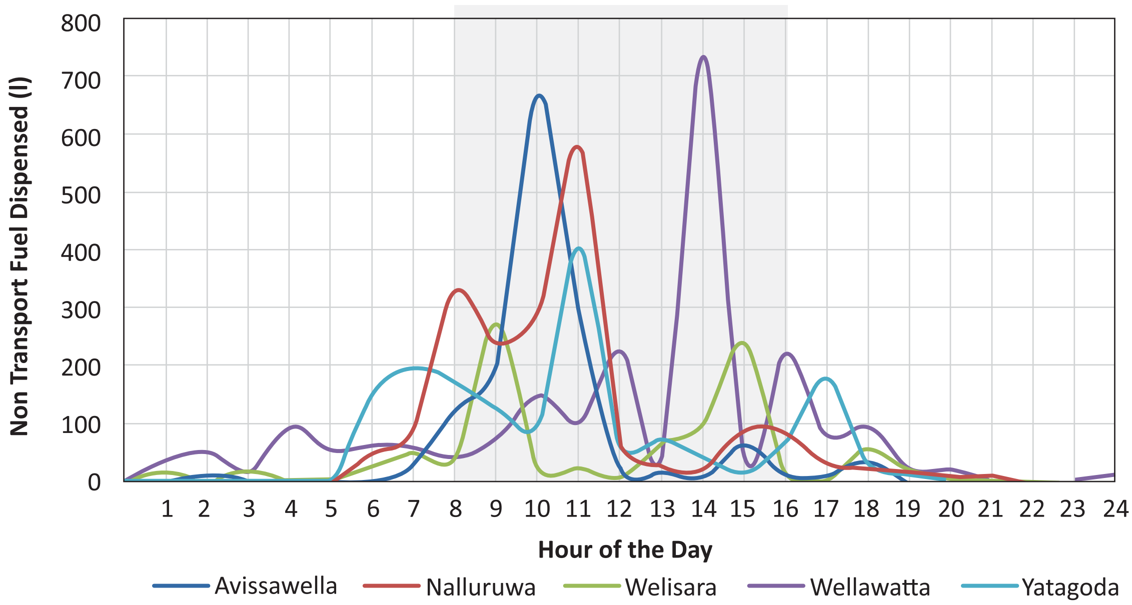
Evening Session: Margin of Error for 1300 to 1800 = 6.51%

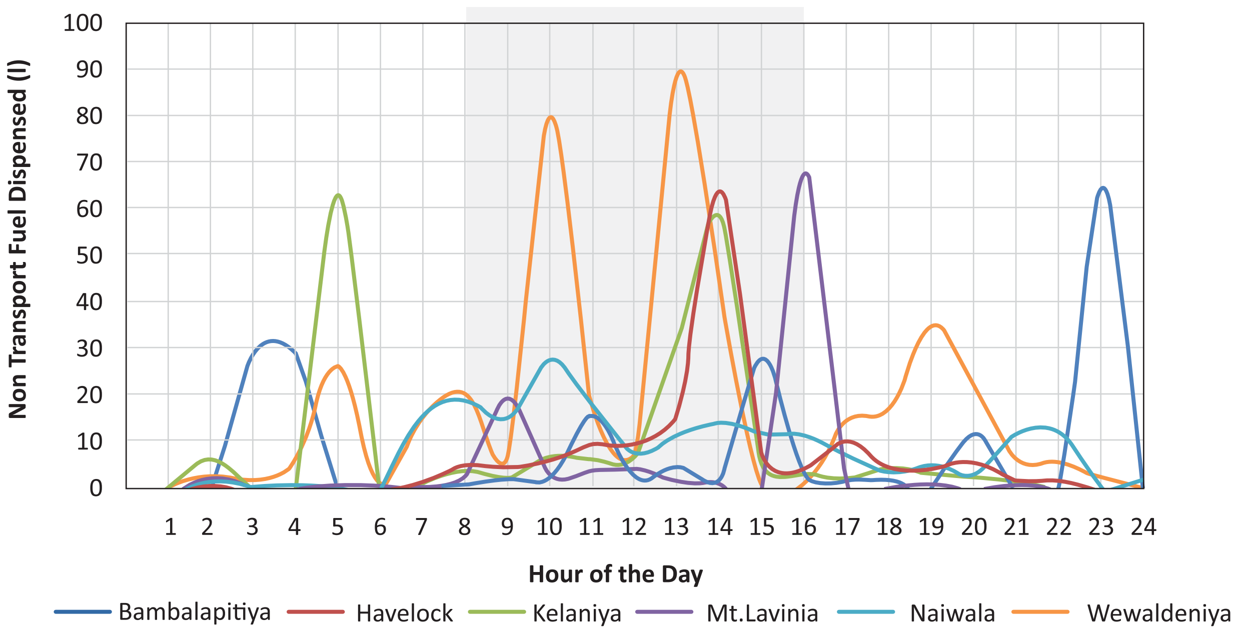
That means, in the evening session of Monday, there is 95 percent confidence that the difference between the estimated and the actual total fuel dispatch is 6.51 percent of the actual total fuel dispatch.

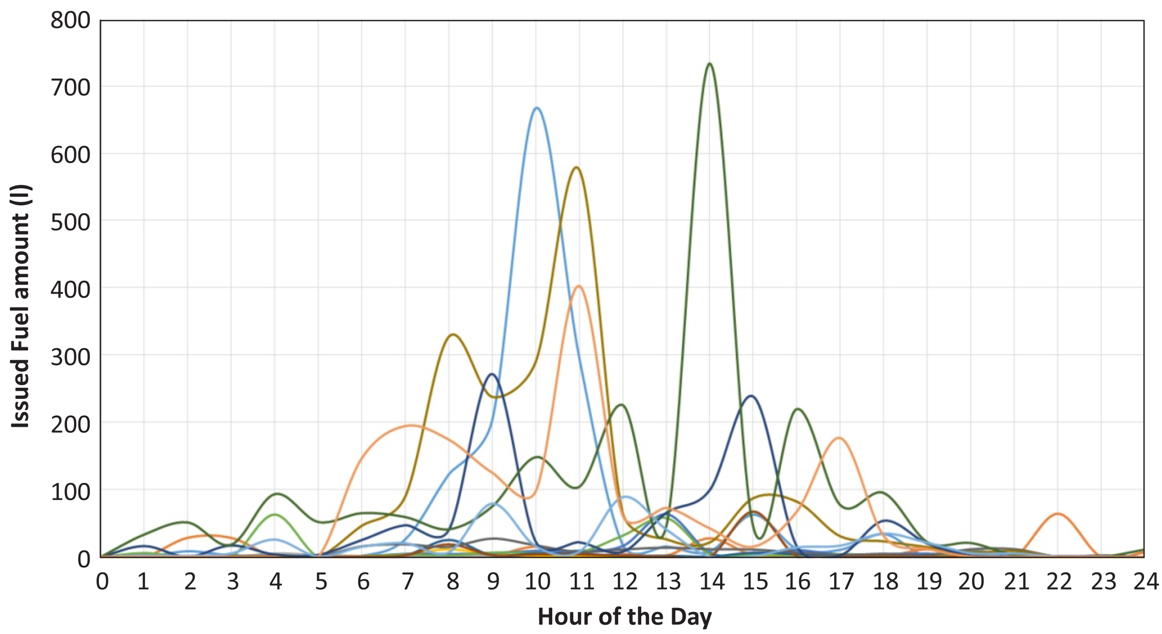
(C) Day: Margin of Error for 0800 to 1600 = 4.29%

That means, on Monday, there is 95 percent confidence that the difference between the estimated and the actual total fuel dispatch throughout a day is 4.29 percent of the actual total fuel dispatch.




Non Transport Fuel Dispensed (l)
Hour of the Day
Avissawella
Nalluruwa
Welisara
Wellawatta
Yatagoda


Non Transport Fuel Dispensed (l)
Hour of the Day
Bambalapitiya
Havelock
Kelaniya
Mt.Lavinia
Naiwala
Wewaldeniya


Issued Fuel amount (l)
Hour of the Day

According to Figure 5-4, approximately similar pattern can be identified among stations with respect to amount of fuel issued for non-transport activities. Two peak time periods which appear to be common to all stations are from 0800 – 1600hrs. of a given day. Hence it is recommended to collect data in a continuous session covering the above periods in a day for better accuracy in estimation of total volumes.

Table 5-11 : Distribution of the hourly average amount of fuel issued for non-transport activities per station during a week

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	31.9	14.1	2.8	1.3	11.9	1.8	1.8
2	7.6	0.2	17.8	1.3	15.5	0.0	48.4
3	1.6	16.1	6.7	1.5	12.5	2.2	33.6
4	1.0	2.5	81.0	0.3	98.8	8.6	4.4
5	13.6	0.3	41.6	0.2	2.3	0.5	2.9
6	83.7	49.1	33.9	6.5	52.0	27.2	69.0
7	31.5	139.8	38.2	20.3	114.3	52.7	78.3
8	71.5	85.7	113.3	46.9	120.9	290.4	62.5
9	414.6	215.7	162.1	41.6	54.8	21.7	135.2
10	262.9	229.8	44.0	112.3	508.3	40.7	105.6
11	542.9	157.6	90.6	71.9	31.9	455.5	92.5
12	84.3	31.5	112.4	26.4	30.5	218.8	30.9
13	70.1	67.1	35.7	11.0	46.3	151.3	28.6
14	14.2	678.4	51.0	127.9	22.4	46.2	17.6
15	28.0	68.2	225.9	138.8	88.8	37.9	25.4
16	93.4	21.5	82.2	64.0	96.7	60.4	23.6
17	125.9	15.1	27.0	8.4	20.9	91.0	42.1
18	45.4	23.2	62.1	31.9	38.2	36.9	49.9
19	28.4	19.9	7.5	0.3	8.8	35.1	12.4
20	3.5	8.6	10.8	1.0	11.1	7.3	20.2
21	8.0	1.0	4.7	2.7	7.8	6.0	1.5
22	64.8	1.3	1.5	0.4	0.3	0.0	0.1
23	0.0	3.1	0.0	0.0	0.0	0.0	0.2
24	4.7	0.1	11.0	0.9	0.4	0.0	1.0
Total	**2,033.5**	**1,850.1**	**1,263.8**	**718.0**	**1,395.4**	**1,592.4**	**887.7**

Table 5-11 was constructed using the data gathered from the pilot study and includes the hourly issuance as a percentage of the daily total.

Table 5-12 : Percentage distribution of the hourly average amount of fuel issued for non-transport activities per station during a week

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	1.6	0.8	0.2	0.2	0.9	0.1	0.2
2	0.4	0.0	1.4	0.2	1.1	0.0	5.5
3	0.1	0.9	0.5	0.2	0.9	0.1	3.8
4	0.0	0.1	6.4	0.0	7.1	0.5	0.5
5	0.7	0.0	3.3	0.0	0.2	0.0	0.3
6	4.1	2.7	2.7	0.9	3.7	1.7	7.8
7	1.5	7.6	3.0	2.8	8.2	3.3	8.8
8	3.5	4.6	9.0	6.5	8.7	18.2	7.0
9	20.4	11.7	12.8	5.8	3.9	1.4	15.2
10	12.9	12.4	3.5	15.6	36.4	2.6	11.9
11	26.7	8.5	7.2	10.0	2.3	28.6	10.4
12	4.1	1.7	8.9	3.7	2.2	13.7	3.5
13	3.4	3.6	2.8	1.5	3.3	9.5	3.2
14	0.7	36.7	4.0	17.8	1.6	2.9	2.0
15	1.4	3.7	17.9	19.3	6.4	2.4	2.9
16	4.6	1.2	6.5	8.9	6.9	3.8	2.7
17	6.2	0.8	2.1	1.2	1.5	5.7	4.7
18	2.2	1.3	4.9	4.4	2.7	2.3	5.6
19	1.4	1.1	0.6	0.0	0.6	2.2	1.4
20	0.2	0.5	0.9	0.1	0.8	0.5	2.3
21	0.4	0.1	0.4	0.4	0.6	0.4	0.2
22	3.2	0.1	0.1	0.1	0.0	0.0	0.0
23	0.0	0.2	0.0	0.0	0.0	0.0	0.0
24	0.2	0.0	0.9	0.1	0.0	0.0	0.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Since all the stations approximately followed the same pattern (Figure 5-4), using the collected data in a particular time slot, daily dispensed amount for non-transport activities can be estimated with the help of Table 5-12. The method is illustrated as follows.

e.g. Suppose data was collected on a Monday from 0800-1000hrs. nd 1500-1700hrs. at a particular station and these amounts were 319.4 and 359.1 litres, respectively;

Step 1: Get the total quantity issued during the two legs:
Here, 319.4+ 335.2= 654.6 *litres*

Step 2: Using Table 5-12, get the total percentage on amount of issued fuel during the two time legs. (Those percentages were shown in shaded cells in Table 5-12)
49.0%

Step 3: Calculate the daily total amount using the figures in Step 1 and 2.

$$\frac{654.6}{49.0} \times 100 = 1{,}336.2$$

Then the estimated total issued amount for non-transport activates from that station in Monday was 1,336.2 litres.

5.5 Future study

Scope and Drat Terms of Reference for a Countrywide Survey

From the results of the pilot study, it can be concluded that results from a sample survey can accurately represent the total number of transactions in a given year. According to the DCS there is no requirement to conduct a census involving all the fuel stations and related transactions. The countrywide study will have the following basic parameters as inputs to study design.

(a) Spatial Domain

It is advisable to have a 50% sample of the fuel stations (approximately 600 locations) spread across the districts for the full study proportion of station to be surveyed will be based on monthly and annual sales at each district.

The sample to be further divided to two sectors, again on the basis of volumes dispensed by stations in (i) main cities and by A class roads and (ii) by B or C class roads away from a main city.

(b) Temporal Domain

The pilot study has calculated that survey of 8 hours (from 0800-1600hrs.) can accurately depict the days dispensing profile. Similarly, the variability based on day of week can be accounted for by conducting the surveys on Tuesday, Saturday and Sunday.

However, DSC has advised that seasonality of demand will have to be captured by conducting the study throughout a calendar year, on two days of a given month. This requires deployment of enumerators on the following schedule>

4 hrs/day x 2 days/month x 12 month/yr x 150 fuel stations Implying 3,600 man days of 4 hrs. work duration

(c) Continuous Monitoring

The countrywide survey will have to obtain dispatch data of all 1,500 fuel stations of a given calendar year. It is proposed to target year 2022 for this purpose.

These data already available to CPC and LIOC are to be collected by SEA on a monthly basis. Along with this data, SEA will maintain a log book at each station throughout the year to monitor electricity use of the station and non-transport demand at each station. This will be necessary to decipher any relationship with the seasonal agricultural activities and any other unknown demand drivers.

This monitoring programme will have to be centrally coordinated and supervised by SEA.

06 Conclusions and Recommendations

The pilot study provided some insights to the petroleum distribution sector. Based on these, following recommendations are made:

(a) It is recommended to conduct an industrial engineering study of fuel station operations, to identify contributors to congestion. This can yield important insights to pump location decisions and other layout decisions.

(b) Considering the severe congestion brought in by private busses and long vehicles to fuel station during busy hours, it is recommended to provide refuelling services to such vehicles using a dedicated station away from busy cities/road ways. Ideally, bus terminals and container terminals will be such candidate locations. Alternatively, these vehicles can be encouraged to pump during off-peak periods by way of time and quantity based discounts etc.

(c) It was also observed that fuel unloading during busy hours cause severe difficulties for vehicle users in smaller fuel stations. If such activities can be carried out during off-peak periods it will be beneficial for all road users and customers visiting fuel stations.

(d) It appeared that motor bicycles and motor tricycles tend to pump very low volumes, leading to queuing and road side stranding of these vehicles after draining the fuel tanks empty. It is recommended to enforce a minimum dispensing volume (e.g. 5 litres or fuel worth LKR 500.00) to prevent these occurrences. Alternatively, a separate service charge, levied per dispensing event can discourage small volume pumping leading to major release of fuel station capacities leading to lesser congestion.

(e) Number of vehicle users who opt for cashless transactions appear to be very low, at 3%. Greater transaction efficiencies can be realised if this is changed to increase the number of cashless card transactions. Introduction of a special fuel vending card on pre-paid basis can be a good initiative.

(f) Opening and closing times of certain fuel stations were found to be non-complaint with the required service levels. This will have to be closely monitored and improved, to offer greater predictability to vehicle users.

(g) Less than desirable service levels were on offer in certain fuel stations during off-peak hours. Some stations refused card transactions during off-peak hours. Similarly, most stations didn't offer tyre inflation services and even in the places where such services were available, required assistance was mostly unavailable.

(h) In several places, no tyre inflation service or rest room facilities were on offer even during peak periods. Some mechanism to monitor and rate these services is recommended to be introduced.

Apart from the recommendations made above for improvement of the ongoing operations, a few more suggestions are made by considering the vast advancement of technology available in other industries. Certain improvements to legal provisions which can add value to the industry are also proposed below:

(i) It is desirable to have disaggregated data on transport energy use. Accordingly, a mechanism to identify at least public transport fuel consumption will help the planning efforts and decision making as a first step.

(ii) New regulations are required to be framed to make using a vehicle without a properly functioning odometer an offence. This will make room to capture accurate passenger km data from all categories of vehicles and also to depict the true utilisation levels of vehicles in use.

(iii) New regulations are also required to be framed to make vehicles stranded due to emptying fuel tank and carrying fuels in vessels offences, so that related issues can be resolved.

(iv) Tyre inflation services will have to be offered at all fuel stations, preferably as a proactive voluntary service by the fuel station operators. The prevalent practices appear to cause severe loss of efficiency, leading to large scale waste of transport energy.

(v) A mobile phone-based user review scheme shall be launched to start a fuel station rating scheme as a crowd supported information portal. Integrating the review scheme with an application such as Google Maps would provide valuable support to all road users. Real time information on availability of particular fuel type or tyre inflation services can also help petroleum distributors to keep close vigil on service levels.

(vi) Similarly, Government can deploy a programme to assist vehicle users with engine tuning and improvement at no cost to vehicle users as an extension to the vehicle emissions test (VET) programme. Such an investment can be easily justified in terms of reduced fuel consumption.

(vii) There appears to be certain remote locations where there is seasonal demand for petroleum fuels presently served by unauthorised vendors. It will be prudent to consider bringing such operations within the legal framework. It may be possible to operate a lower scale vending station only for non-transport use to benefit such users.

(viii) Actions which can automate fuel station transactions can be taken to reduce cash transactions and also to improve data acquisition. Nozzle level vehicle identification, enabled by either through a license plate (the new licence plates are OCR (optical character recognition) capable) based Radio Frequency Identification (RFID) tag or fuel lid based Quick Response (QR) code can generate a vast database of end use data, helping the vehicle users, petroleum supply utilities and vendors in managing their operations.

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