ATTACHMENT TO REPORT: ALTERNATIVE FUEL ANALYSIS FOR COUNCILS PASSENGER CAR FLEET

DISCUSSION PAPER:

**ENVIRONMENTAL & ECONOMICAL SUSTAINABILITY of ALTERNATE FUEL [Energies]
For
PLANT & FLEET**

Aim

This report responds to a brief from the Tweed Shire Council administrators. The report is designed to leave the reader with an unbiased position on the current state of play in the development of an alternative energy source to the current fossil fuel being used in the environment to day.

EXECUTIVE SUMMARY

Ecological Discussion

The Ecological Argument has been taken from the research carried out by the CSIRO and University of Melbourne, Department of Mechanical and Manufacturing Engineering. The research compares fuels on a statistical basis using the mean value and standard deviation for each fuel to address the variability present in emissions data.

In 1998, transport emitted about 22% of the national CO2 emissions of 312.1 Mtonnes, but only 16% of total greenhouse gas emissions of 456.0Mtonnes CO2 equivalents. *"National Greenhouse Gas Inventory Committee, 2000*

For any ecological argument is going to withstand scrutiny it must be based on Life Cycle Analysis (LCA). When the LCA is applied to emissions from the use of transport fuels, both combustion and evaporate emissions are included. Further, the LCA takes into account not only the direct emissions from vehicles (referred to as downstream/tailpipe emissions) but also those associated with the fuels: -

- Extraction
- Production
- Transport
- Processing
- Conversion and
- Distribution

These are basically refereed to as upstream emissions. In this report the term "*exbodied"* emissions are used to refer to the total of the upstream and tailpipe life cycle of emissions (including combustion) associated with fuel.

Given the data presented Low Sulphur (LS) Diesel EURO3 fuel is the most environmentally friendly fuel to use. This fuel is readily available and can be dispensed through current infrastructure.

Insufficient is known about the emissions of air toxics from vehicles, and the appropriate risk-weighted factors that should be used in examining their relative effects on the environment. It is an expectation that these issues will be will be further examined as part of the work on the National Environment Protection Measures (NEPM) on air toxics. When the NEPM work is finalized, the air toxics examined in this report should be revisited.

A sensitivity analysis revealed the importance of escapee emissions in determining whether CNG and LNG are more, or less, climate friendly than diesel fuels. It would be prudent to conduct a further study that combines measurement of fuel used to determine the future levels of emissions.

Many of the gaseous fuel vehicles used in Australia are likely to be converted vehicles or dual fuel vehicles. Consequently it is important to ensure that qualified technicians are used to carry out any such conversions to minimize the risk of leakage.

The analysis in this report has a limited life as the technology used to manufacture Hydrogen, Compressed Air, and Fisher-Tropsch diesel are not operational in Australia at this point in time, and other fuel technologies are changing rapidly. Therefore this study will need to be reviewed in the future to assess the impact of new technology.

Economic Discussion

The economic argument has been taken from the research carried out by the Plant and Material Coordinator of the Tweed Shire Council (TSC). The Net Present Value (NPV) discounted cash flow model development was referenced from "*Fifth Edition Business Finance Graham Peirson, Ron Bird, Rob Brown, Peter Howard"* and *the Second Edition Introduction to Financial Management Clive Wilson, Bruce Keers".*

In the current fleet market the 1.8 litre Toyota Corolla is the cheapest vehicle to own and operate. From a purely economic perspective, this would be the fleet vehicle of choice. However, there are many other considerations that need to be considered in the composition of the fleet, not least of which is the need to ensure that the vehicles provided are suitable for the uses they will be put to.

Balanced Discussion

The balanced argument is based on the notion that while the development of the global economic environment is important it is equally important that such development does not lead to the destruction to the ecological system. Therefore any decision made must ensure balanced results are achieved by considering both environment factors and economic factors.

Fleet management should establish a strategic plan for the procurement and operation of all fleet items consistent with the objectives set by Council.

DISCUSSION

Structure

To ensure that an unbiased view is obtained the data used in this report has been taken from research conducted by the: -
"CSIRO Atmospheric Research",
"CSIRO Environment Risk Network",
"Royal Melbourne Institute of Technology (RMIT) Center for Design",
"Southern Cross Institute of Health Research",
"CSORO Energy Technology",
"University of Melbourne, Department of Mechanical and Manufacturing Engineering"
"Australian Green house Office",
"Australian Fleet Manager Association"
"Small is Beautiful Economics as if People Mattered Prof E F Schumacher 1989"
"NRMA & RACQ Institutes"
"IPWEA Institute National Conference Papers"
"South Eastern QLD Local Government Fleet Managers Group"
"Riverina Local Government Fleet Managers Group"
"Australian Transport Line Magazines"

The report summaries the views and opinions from the research conducted by the above mentioned. Any data that has been or is published for marketing purposes has been ignored as it is considered that such publication are produced with an unconventional conception of the real issues at hand.

The report consists of three main parts:-

Part 1: An ecological discussion on various alternative fuels and blends of fuels that have been put forward as substitutes for fossil.
Part 2: An economical discussion on the use of various fuels in the current market place.
Part 3: A discussion on a balanced view of both arguments discussed in Part 1 and Part 2.

The report summarizes and makes recommendations.

PART 1.

The Ecological Argument:

It should be noted that this argument has been taken from the research carried out by the CSIRO and University of Melbourne, Department of Mechanical and Manufacturing Engineering. The research compares fuels on a statistical basis using the mean value and standard deviation for each fuel to address the variability present in emissions data. The use of standard deviations minimizes the impact of statistical variation inherent in emissions data and provides a greater level of confidence in the findings.

In 1998, transport emitted about 22% of the national CO_2 emissions of 312.1 Mtonnes, but only 16% of total greenhouse gas emissions of 456.0Mtonnes CO_2 equivalents. *"National Greenhouse Gas Inventory Committee, 2000".* It is reasonable to assume that the remaining 78% of the total emissions are emitted from industry in general. It could therefore be argued that success in cleaning of the air lies in industrial technology improvements and in the way authorities regulate industry in general. Having said that the emissions emitted by transport are significant and every effort should be made to reduce them where they can be.

For any ecological argument is going to withstand scrutiny it must be based on Life Cycle Analysis (LCA). A general introduction to Life Cycle Analysis (LCA) can be found in *Graedel & Allenby (1995).* The international standards on LCA are contained in the 14040 series and the International Standards Organization 1998 provides the basic framework in which the LCA can be undertaken. These standards were all adhered to during the referenced research. When the LCA is applied to emissions from the use of transport fuels, both combustion and evaporate emissions are included. Further the LCA takes into account not only the direct emissions from vehicles (referred to as downstream/tailpipe emissions) but also those associated with the fuels:-

- Extraction
- Production
- Transport
- Processing
- Conversion and
- Distribution

These are basically refereed to as upstream emissions. In the context of automobile fuels they are also referred to as pre-combustion emissions.

LCA analysis is often used to determine the amount of upstream energy used to construct a particular object. The use the term "embodied emissions" to cover the full-cycle emissions of gases or pollutants, would be a misnomer, as emissions are emitted, not embodied. Therefore in this report the term "*exbodied"* emissions are used to refer to the total of the upstream and tailpipe life cycle of emissions (including combustion) associated with fuel.

While emissions related to vehicle manufacture, maintenance, disposal, and road building are relevant to total transport emissions they are considered constant for all fuels and subsequently not used. However, the infrastructure associated with refueling varies with the different fuels.

Low Sulfur (LS) diesel was chosen by the Australian Greenhouse Office as the reference fuel against which other fuels are compared because it will be the mandated diesel from 2008 when vehicle designs will be required to meet Euro4 standards of emissions. Figure 1 below displays a summary of the Results from the research carried by the CSIRO.

NOTE: Results are expressed in Kg's of greenhouse gas gases per Km of travel by an average family vehicle using the nominated fuel.

NOTE: It is assumed that the hybrid vehicles used in this analysis are a much smaller vehicle and subsequently have less weight. It could be argued that using hybrid vehicles in the analysis is not a true comparison of similar vehicles. However, it does imply the amount of fuel used or burnt in the combustion process is one of the major contributing factors to the volume of emissions emitted. This is confirmed in Appendices A that displays the breakdown of upstream and tailpipe emissions.

This then raises another question; what is the correct sized vehicle to perform the job criteria? The scope of this report does not cover this issue.

FIGURE 1:
See Figure Sheets at the end of this document.

Diesel Fuels:
The removal of sulfur from diesel produces Low Sulfur (LS) diesel a fuel that emits less important criteria pollutants and air toxins. Tailpipe emissions of particulate matter and hydrocarbons from Ultra Low Sulfur (ULS) diesel are less than LS diesel, and emissions of these pollutants from Fischer-Tropch diesel are less than ULS diesel. While the tailpipe emissions of Oxides of Nitrogen (NOx) are similar with Fischer-Tropsch and ULS diesel they are less than LS diesel. In short ULS diesel burns cleaner than LS diesel however, ULS diesel has more exbodied emissions in the processing process than LS diesel. As displayed in figure 1 LS diesel is 0.84 % more environmental friendly than ULS diesel when used to power a similar sized unit 1 Km.

The greater processing energy involved in the removal of the sulfur from the fuel means that exbodied emissions are similar in LS and ULS diesel. However they are less in Fischer-Tropsch diesel.

Lower sulfurs fuels permit more efficient operation of emission control devices such as exhaust gas recirculation, oxidation catalysts, and particulate traps. Consequently the use of ULS diesel (50ppm sulfur) will lead to improved performance of such devices when compared with LS diesel. Further it is expected that Fischer-Tropsch diesel with its lower sulfur content will perform even better.

It is reasonable to assume that once diesel vehicles routinely use ULS fuels and are equipped with such emission control devices then they will meet EURO4 standards due in 2008.

There is a need to balance the fuel with the appropriate advanced vehicle technology. Combining the advanced technology in the engine and the catalyst only provides the benefits of moving to LS diesel or indeed ULS diesel. The new technology is sensitive is to Sulfur and therefore is inefficient with the LS diesel. It is reasonable to assume that emission from a vehicle with EURO4 on-board diagnostics and particulate trap technology the emissions will be reduced further. This will require advanced training of the technicians who will be required maintain this component of the scheduled maintenance program.

There is substantial evidence indicating that decreasing particle emissions reduces morbidity and reduces hospital admissions as a result of respiratory illness. At present, diesel engines are a major contributor of fine particles -diesel exhaust contributes at a rate of 20 times greater than unleaded petrol (ULP) fueled vehicles. Thus the use of USL diesel and particulate trap technology will produce major benefits to the reduction of emission of particles. Occupation Health and Safety (OH&S) issues are the same for LS and USL diesel fuel *"the reference fuel"*

While it can be argued that the modern western economy is based on petroleum products, of which diesel is one, and that fossil fuel economy is effective and efficient form from ecological perspective it is more difficult that it encourages equity and integrity. In this day and age global warming possess threats of inter-generational equity.

Crude oil supplies are sustainable, in Australia, in the medium term (15 Years), though imports will need to rise as the Victorian oil fields start to dry up. The key issue for sustainability for diesel fuel is the global supply unless new oil fields are found.

Fischer-Tropsch Diesel:
Fischer- Tropsch diesel (FTD) is a synthetic fuel produced from the conversion of natural gas into diesel fuel. The fuel formed is superior to crude-oil based diesel in certain ways, principally the centane number, and zero sulfur content. In some countries it is referred to as “gas to liquid” (GTL) diesel. This process has great relevance to Australia due to the northwest shelf. As this is in its early stages of development in Australia there is not enough data to produce results however it is anticipated that the results will be positive for the environment providing it is used with advanced engine technology.

The Australian Design Rules (ADR) has been based on the use of ULS fuel combined with EURO4 technology. By definition, there should be no potential to compromise vehicles' compliance with gazetted ADR standards.

The advantages of ULS diesel are:-
ULS diesel contains little sulfur and few aromatics. In properly tuned engines this is expected to lead to lower particle exhaust emissions
The low sulfur content means that oxidation catalysts will be more efficient.
The existing diesel infrastructure can be used, unchanged, for ULS diesel
LS diesel can be used in existing diesel engines
Diesel is one of the safest of automotive fuels.

The disadvantages of ULS diesel are: -
The US EPA treats Diesel exhaust (including ULS diesel exhaust) as air toxic.
Because of the extra processing energy, ULS diesel produces more exbodied greenhouse gases than LS diesel.

Biodiesel and Canola Oil:
From a conventional economics perspective Biodiesel / Canola oil is not presently a viable heavy vehicle fuel. In short European research indicates that the price of LS diesel would have to go to approx. $2 per litre before boidiesle /Conola become an economic proposition. Along with the short fall in production costs heavy vehicles engines would have to undergo major alterations.

Biodiesle is a diesel substitution produced from various natural oils including Canola, peanut, coconut, tallow (animal fat) or even fish and chip shop oil. It is currently being produced and sold in small commercial quantities across Australia. The description used to refer to the ratio of biodiesel to petroleum diesel is, for example B100 is 100 % biodiesel, while B5 is 5 % biodiesel and 95 % petroleum diesel. In France the regular pump diesel is actually B5, with the government requiring a 5 % blend.

All forms of biodiesel are more climates friendly than diesel. In other word biodiesel emits less exbodied greenhouse gases than diesel. The emissions involved in upstream activities from biodiesel are less than the emissions involved in diesel combustion and upstream activities.

Biodiesel made from tallow is less climate friendly than biodiesel made from vegetable oil due to the upstream methane emissions from cattle.

Few engine manufactures endorse the use of biodiesel in blends with ratio greater than B10 – the long-term effects of its use in engines are unknown. Unless the fuel complies fully with national fuel standards, quality can be dubious. Fuel tanks and filters can be become clogged with sub-standard fuel, particularly at low operating temperatures. In contrast to the manufactures cautious attitude, the "truck in the park" projects and other road tests have found little difference to engine viability and functionality. However, biodiesel has a lower energy content than diesel and subsequently fuel consumption increases.

Hydrated Ethanol:
Ethanol (C2H5OH) is an alcohol, an oxygenated organic carbon compound. It is the intoxicating component of alcoholic beverages, and is also used in solvent (methylated spirits). By contrast diesel is a mixture of a range of hydrocarbon compounds, none of which contains oxygen. In blended fuels, the mixing of diesel and the oxygen contained in alcohol changes a number of important fuel characteristics. These include changes in combustion properties, energy content, and vaporization potential.

Ethanol will easily blend with gasoline but not with diesel. Alcohol's can be used in diesel engines by either modifying the fuel or making extensive changes to the engine. Hydrated ethanol can be produced from wheat, sugar cane, molasses, and wood. The process is a one-stage process and from the viewpoint of LCA, the upstream emissions for ethanol production are different for each case.

Ethanol can be manufactured from: -

- Biomass via the fermentation of sugar derived from grain starches or sugar crops
- Biomass via the utilization of the non-sugar lignocellulosic fractions of crops
- Petroleum and natural gas via ethylene (reduction or steam cracking of ethane or propane)

As may be expected, the use of a renewable fuel, such as ethanol considerably reduces greenhouse gas emissions due to the greenhouse accounting rule that there are no tailpipe emissions from the combustion of ethanol. However if ethanol is made from fossil fuel then there is more greenhouse emissions emitted than is in the production of LS. In all cases but one there are less particulate matter (PM10) emissions from ethanol are less than LS. The one case is where the ethanol is produced from wheat straw rather than from natural gas.

A third generation fleet of ethanol engines would run with oxidation catalysts. In general, ethanol engines have enlarged holes in the injector nozzles, modified injection timing, and increased fuel pump capacity. Gaskets and filters need to be alcohol-resistant. Additionally the fuel pumps have to use a castor oil as a lubricant, as ethanol tends to dissolve the oil film on greased metal surfaces. Engines using ethanol may need to have vapor pressure controls implemented. Along with these modification is advisable to us an up cylinder lubrication to assist with tendency to dissolve normal lubrication in the top end of the engine. It should be noted that the USA transit authorities experienced high rates of engine failure and poor engine reliability with earlier generation of ethanol buses.

Ethanol upstream emissions of particulate matter and HC range from lower to higher than LS diesel emissions depending on the feedstock. Ethanol tailpipe emissions of particulate matter and HC for all feedstocks are marginally less than LS diesel. Ethanol in solution is hazardous according to worksafe Australia, with high flammability, moderate toxicity, and moderate irritant. While there are difference OH&S issues involved in the production process associated with ethanol compared with LS diesel, no OH&S there are no unique circumstances have been identified.

Ethanol from sugar of wheat has the potential to be a niche fuel however large-scale usage of ethanol will require lino-cellulosic production to be economical. Research has revealed that ethanol could meet 90% of the national oil requirements within 50 years. However, to achieve this the nation would require 19 million hectares of cropland and high rainfall pasture country.

IT is an expectation that ethanol can meet future ADR for pollutants except hydrocarbon which may be slightly above EURO3 and EURO4 standards.

Advantages
As a renewable fuel, ethanol produces fewer fossils CO_2 than conventional fuels.
Other advantages are similar to those mentioned in LS advantages.

Disadvantages
The chemical emulsifiers and advanced ignition technology used to blend ethanol can contain harmful chemicals.
There are higher emissions emitted than from diesel engines.
There may be an odor problem.

Diesohol:
Diesohol is a fuel containing alcohol that comprises a blend of diesel fuel (84.5 %), hydrated ethanol (15 %) and an Australian developed emulsifier (0.5 %). Hydrated ethanol is ethl alcohol that contains approximately 5 % water. The emulsifier is a major component in the preparation of the fuel. This technology was developed in Australia by the APACE research group. It should be noted that ethanol can be made from range of products and different ecological and economic results will be achieved with each individual product.

As would be expected, the addition of 15 % of a renewable fuel, such as ethanol, to diesle reduces greenhouse emissions. As a general statement the research found the following: -

- Particulate matter emissions using diesohoil are lower than LSD
- NOx emissions of dieselohol are lower than the NOx emissions of LSD
- HC emissions of diesohol are comparable with those of LSD.
- Problems will occur with fuel injection equipment and there will be formation of vapour locks. These issues can be addressed by implementing advanced engine technology.
- Diesohol has passed the stability test conducted by Shell
- To date dieselol has been a niche fuel and thus the situation with respect to availability and warranty has not been clarified.
- With the composition of diesohol being 85 % diesel the production and transportation emissions associated with the use of diesohol are considered similar to LSD.
- The flash point and flammability dieseohol are those of alcohol and are therefore has to be handled as gasoline (Petrol) rather than diesel for safety issues.
- It should be noted that appropriate disposal of the refinery waste products is crucial to environmental impacts or benefits

Compressed Natural Gas (CNG)
Natural gas (NG) is a mixture of hydrocarbons, mainly methane (CH4). It is stored on board vehicle in a compressed gaseous state (CNG). Natural Gas is distributed throughout Australia in an extensive pipeline system. A national standard for CNG has been developed. *(Fuel Quality Standards Act 2000)*.

A sensitivity study undertaken by the CSIRO indicated that if fugitive emissions exceed approximately 4 % of supply then exbodied emissions of green house gases exceed those of LS diesel. However, the study revealed that the exbodied emissions of greenhouse gases were lower than LSD. Further particulate emissions emitted from CNG are noticeably lower than those of LSD are.

Due to chronic problems with engines and, in particular, fuel systems components CNG engines have had significantly greater defect than diesel engines. The Longford incident in 1998 halted a large part of Victoria following the disaster created by the vulnerability of the distribution system. There have been major improvements in the distribution technology as a result of the incident

The majority of CNG vehicles in Australia are purchased as new units. There is a growing interest in the conversion of conventionally fueled vehicles to CNG through after market conversions. The emissions performances are unclear, as there is no comprehensive industry-wide data. The CSIRO testing was done on a dedicated CNG unit.

The advantages of CNG are: -
CNG has very low particulate emissions because of its low carbon to hydrogen ratio.
There are negligible evaporative emissions, requiring no relevant control
Due to its low carbon to hydrogen ration, it produces less carbon dioxide per GJ of fuel than diesel.
It has low cold start emissions due to its gaseous state
It has extended flammability limits, allowing stable combustion at leaner mixtures

It has a lower adiabatic flame temperature than diesel, leading to lower NOx emissions
It has much higher ignition temperature than diesel, making it more difficult to auto-ignite, thus safer.
It contains non-toxic components
It is much lighter than air and thus it is safer than spilled diesel
Methane is not a volatile organic compound (VOC)
It has nearly zero sulfur levels and, thus negligible sulfate emissions.

The Disadvantages of CNG are: -
CNG on board a vehicle takes 3 to 4.5 times more volume for storage than diesel.
It requires dedicated catalysts with high loading of active catalytic components to maximize methane oxidation
The composition can vary widely depending on the CNG source, which affects synchronization of air/fuel ratios
Its driving range is limited, as its energy content per volume is relatively low as a result of its gaseous state
It requires special fueling stations
The extra weight of the fuel tank leads to higher fuel consumption or loss of payload
Exhaust emissions of methane, which is a greenhouse gas, are relatively high compared with low sulfur diesel
It can give rise to backfire in the inlet manifold if the ignition system is faulty or fails in use
Relatively small fugitive emissions of methane can have a significant effect on the exbodied greenhouse gas emissions.

Liquefied Natural Gas (LNG):
Natural Gas (NG) is a mixture of hydrocarbons, mainly methane (CH_4); LNG is generally refrigerated to 18 C for liquefaction, and requires vacuum-insulated cryogenic tanks to maintain it in liquid form for storage. NG consumed in Australia is domestically produced from Australian oil and gas fields.

Exbodied emissions of greenhouse gases are lower from LNG than from LSD under all tests carried out by the CSIRO / Melbourne University of Technology's research. The test further indicated that the particulate emissions of LNG are considerably lower than those of LS diesel. In every case, the gaseous fuels have lower hydrocarbon emissions than LS diesel, both upstream and tailpipe basis.

LNG engines have the same reliability and operating cost issues as CNG engines. There have been advances made in the technology of LNG, which could be argued that the technology has addressed some of the issues. Bottom line is that the technology is still in the developing stages and should be viewed in that light. LNG has an advantage of requiring a smaller fuel storage tank. This results in longer range for LNG than CNG for the same capacity tank.

When released to the atmosphere and evaporated LNG is much lighter than air and thus it is safer than diesel when spilled. As a general rule noise levels from natural gas engines are less those of diesel engines. Natural gas is an indigenous fuel that has the potential to replace imported, expensive crude oils.

The advantages of LNG are: -
LNG has very low particulate emissions because of its low carbon to hydrogen ratio.
There are negligible evaporative emissions, requiring no relevant control
Due to its low carbon to hydrogen ration, it produces less carbon dioxide per GJ of fuel than diesel.
It has low cold start emissions due to its gaseous state
It has extended flammability limits, allowing stable combustion at leaner mixtures
It has a lower adiabatic flame temperature than diesel, leading to lower NOx emissions
It has much higher ignition temperature than diesel, making it more difficult to auto-ignite, thus safer.
It contains non-toxic components
When released to the atmosphere and evaporated it is much lighter than air and therefore safer when spilled
Methane is not a volatile organic compound (VOC)
It has nearly zero sulfur levels and, thus negligible sulfate emissions.

The Disadvantages of CNG are: -
There is considerable extra infrastructure involved with gas liquefaction
It requires dedicated catalysts with high loading of active catalytic components to maximize methane oxidation
Its driving range is limited, as its energy content per volume is relatively low as a result of its gaseous state
It requires special fueling stations and handling of a cryogenic liquid making it suitable only for fleet operations.
The energy required to liquefy natural gas, leads to increased greenhouse gas emissions in comparison to CNG.

Exhaust emissions of methane, which is a greenhouse gas, are relatively high compared to LS diesel.
As a general rule refueling times are longer than LS diesel.
It can give rise to backfire in the inlet manifold if the ignition system is faulty or fails in use

Liquefied Petroleum Gas (LPG) – Autogas
Liquefied petroleum gas (LPG) is a protroleum industry by-product, consisting manly of propane, propylene, butane, and butylene in various proportions according to its State of origin. Autogas grade LPG is a mixture of propane and butane in approximately equal ratios. The Australian industry has prepared a set of performance-based specification that is widely seen as a de facto standard. While LPG has particularly low particulate levels, which makes it an attractive fuel for urban environments the levels of particulate matter specified in EURO4 standard is equivalent ULS diesel.

As a general rule emissions of hydrocarbons for gaseous fuels are lower than those emitted from LS diesel. Although it can be argued that pre-combustion emission of emissions of hydrocarbons are higher in LPG as opposed to LS diesel manly due to leakage.

Australian LPG, being primarily sourced from natural gas, is vulnerable to disruption in the gas supply arena. This was evident in the Longford incident in 1998. Presently there are no data on emissions from diesel vehicles converted to use autogs. However, it is expected that the performance of such converted vehicles will be similar to vehicles that have been converted to use propane (LPG-HD5).

Liquefied Petroleum Gas (LPG)-HD5:
LPG-HD5 is essentially liquefied propane gas. Most LPG used on the East Coast of Australia is Autogas. Propane as vehicle fuel id limited to Western Australia. There is very little usage of LPG in Australian heavy vehicles. LPG emits low tailpipe emissions and therefore is an attractive fuel for urban use. However, as diesel particulate emissions reduce to EURO4 levels this advantage will be lost.

Propane (HD5) viability and functionality issues are identical to those of Autogas. The major benefit of propane is that the vehicle compression ratio can be adjusted to make use of the higher-octane fuel and give rise to better fuel consumption.

There has been some recent development in a diesel to LPG fuel substitution conversion kits that was/is being trailed in an articulated vehicle. From the little data available the CSIRO research concluded vehicles appear to have higher tailpipe emissions than those vehicle that are bought as dedicated LPG units. It should be noted that the LPG conversion industry for heavy vehicle is in the very early stages of development.

The advantages of LPG are:-
It has low cold-start emissions due to its gaseous state
It has a lower peak pressure during combustion, which generally reduces noise levels
LPG fuel systems are sealed and evaporative losses are negligible
LPG vehicles do not require special catalysts
It contains negligible toxic components
LPG emits low particulate emissions and has a lower noise level compared with diesel, which make an attractive fuel for urban environments.

The disadvantages of LPG are:-
Although LPG has low tailpipe emissions it has relatively high level of exbodied emissions, which make it approximately 7 % higher than LS diesel in the LCA.
LPG has low energy content per unit of mass, as well as a low energy content per unit volume, which explains why it uses more, litter per one hundred kilometer than LS diesel and requires a larger fuel tank.
A LPG tank is pressure tank and therefore weigh more than diesel tank.
LPG tanks have a higher maintenance factor than diesel tanks.
It is heavier tan air, which requires appropriately handling.
Its vapor flammability limits in the air are wider tan those of petrol, which makes LPG, ignite more easily.
LPG has a high coefficient so that the tank can only be filled to 80% of capacity.

Premium Unleaded Petrol: (PULP)
Premium Unleaded petrol was introduced to the Australian market place in approximately 1995 meeting both the EURO2 specification for unleaded petrol and the fuel specification for PULP as proposed by the Commonwealth and implemented in 2002. The research by the CSIRO assumes no ethanol and is used in a light vehicle as defined by Australian Design Rule (ADR) 79/00 and 79/01

The difference between ULP and PULP is determined by differences in octane ratings. The blend of PULP typically contains larger proportions of high-octane streams such as aromatics, isoparaffins, and naphthenes.

The exbodied LCA analysis emissions from ULP are approximately 33% worse than LS as displayed in Figure 1.

The sustainability of petrol is dependent on the sustainability of the crude oil from which it is refined. With Australian oil reserves on the decline, or soon will be, there is an increased reliance on imported crude oil. It could thus be argued that there is a need to find a substitution form ULP and PULP.

Petrol is refined from crude oil. Spills of crude oil, especially during transport in oil tankers at sea, pose an environmental issue that contaminates marine life and bird life. Further environmental damage from petrol itself can occur, especially from leeks, at filling stations and refueling depots, which usually finishes in the water table.

Anhydrous Ethanol:
Anhydrous ethanol can be use as an additive, or as a pure fuel in its own right. Despite this, as an automotive fuel it is usually fabricated of 85% ethanol with 15% petrol (E85P). The petrol is used or required to ignite the alcohol especially at low temperatures. Ethanol is probably the most widely used alternate automotive fuel in the world. This can be contributed to Brazil's decision to produce fuel alcohol from sugar cane.

The upstream emissions associated with anhydrous ethanol are essentially the same as those associated with hydrated ethanol, with a requirement for extra energy input arising from the extra process step to transform the hydrated ethanol to anhydrous ethanol. The calculations conclude that it takes 30% more energy to complete the transformation of hydrated ethanol to anhydrous ethanol. However, the bottom line is that the exbodied greenhouse gas emissions of E85P are approximately half those of PULP, or less depending on the fuel source provided it is sourced from a renewable material. Ethanol manufactured from fossil fuels emits more greenhouse gases than petrol.

Particulate matter emissions from PULP are generally similar to those from E85D, however if waste (wheat or wood waste) is used as a combustion source (instead of natural gas) then the particulate matter emission from E85P becomes greater than PULP.

There is considerable international experience on the use of ethanol in Brazil where sugar-derived ethanol is used as an automotive fuel. The ethanol used in Brazil is called Alcohol and consists of 93% ethanol by volume. International Energy Agencies (IEA) alternative fuels information services (1996) note, “The techniques for the production and use of methanol and ethanol as a vehicle fuel are unknown. Obstacles that hinder the use of alcohol as a vehicular fuel are relatively high costs of alcohol and the investment necessary to introduce an extra fuel.

Petrohol:
Anhydrous ethanol can be used as an additive in petrol. The term petrohol is used to define a blend of 10%anhydrous ethanol in premium-unleaded petrol. The symbols E10P or E10PULP are also used for this fuel depending on whether it is necessary to specify the type of petrol (P) with which the ethanol is blended.

There has been substantial US interest in the use of ethanol in vehicles. The Californian Government, through their Air Resources Board, requires vehicles to use “reformulated gasoline”. In the begging the Air Resources Board allowed the blending methyl tertiary-butyl ether (MTBE) to make a reformulated fuel. However, it was found that the MTBE contaminated the ground water and was subsequently removed from the allowable blends. Further the removal of MTBE sparked new studies in the US have been commissioned on the environmental and health effects of ethanol in petrol. The use of ethanol produces and oxygenated fuel that satisfies the requirements of the Californian Government.

Oxygenates are added to petrol to improve the ant-knock performance and to reduce emissions. *Reuter et al (1992)* studied European petrol oxygenated with MTBE, and ethanol and found that the tailpipe emissions of oxygenated petrol are independent of the oxygenate that are used to improve anti-knock performance

On May the 8th 2001 the Minister for Environment and Heritage, Senator Hill announced the first national fuel quality standard for petrol and diesel under *Fuel Quality Standards Act 2000.* Senator Hill, in that context, indicated that further assessments were necessary before setting an ethanol limit for petrol. The premier of New South Wales recently (2006) announced that petrol and diesel with a 10 % ethanol blend would be made available on State Contract Supply for all government vehicles.

Limited research on particular types of E10P indicates that there is little difference between, exbodied greenhouse gas emissions, of PULP and E10P.

Motor vehicle emissions data indicates that the use of ethanol results in substantial reductions in air toxics emissions. However, there is contradictory information about the emissions of acetaldehyde tailpipe emissions with some studies showing an increase while other show a decrease compared with petrol. We would be hopeful that further research would clarify the issue.

Having said all that ethanol in solution is hazardous according to Worksafe Australia, with high flammability, moderate toxicity, and a moderate irritant. The flash point of the fuel emulsion becomes that of alcohol when the alcohol content exceeds 5% of the volume. Further ethanol fuels increase permeation on elastomers that are used in automotive application (e.g. rubber hoses, plastic fuel tanks etc). Further research is required to quantify the impacts on ethanol on maintenance. *(Harold Haskew & Associates, 2001)*

Virtually any environment that supports bacterial population is believed to be capable of biodegrading ethanol. Atmospheric degradation is also expected to be rapid. E10P will be more environmentally friendly than petrol on its own.

The advantages of Petrohol are: -
Tailpipe emissions of CO and HC appear to be lower on average
Air Toxic levels decrease as the ethanol concentration increase

The Disadvantages of Petrohol are: -
There are high hydrocarbon evaporative emissions that require adjustment of the vapor pressure of the base petrol to which ethanol is added.
There are problems of phase stability in the petrol mixture if water is present.
The permeation of ethanol on materials used in vehicle manufacture has not yet been defined and therefore associated maintenance increases are yet to be determined.

Hydrogen:
The hydrogen energy content per unit mass is high. Compared to petrol for example, it is three times higher. On a volume basis, the energy content of hydrogen is relatively small. All mixtures of hydrogen and air with volumetric hydrogen content between 4% and 75% are inflammable. When this is compared with petrol and air mixtures it is very wide. Hydrogen can burn in mixtures with air from very lean to very rich.

In my opinion only fuel cell powered vehicles that use hydrogen derived from steam reforming of natural gas cannot be considered as ecologically satiable. It is difficult to see how natural gas reforming to produce hydrogen could be seen an ecologically sustainable development as they use fossil fuel, and considerable energy (thus exbodied greenhouse gases) to manufacture the fuel. The upstream emission of greenhouse gases from hydrogen manufactured from natural gas equates closely to the total exbodied emissions of greenhouse gases from LS diesel.

Whereas production of hydrogen by low-pressure water electrolysis would be an ecologically sustainable method of production, provided the electricity to undertake the electrolysis is based on renewable energy. The hydrogen vehicle produced from reforming of natural gas have virtually no emissions, even NOx, because fuel cells operate at much lower temperatures than internal combustion engines thus NOx is not formed from the nitrogen and oxygen in the air. Theoretically, a hydrogen-fueled fuel cell vehicle emits only water vapor. Further research has revealed that, in all cases but one, emissions of PM10 are less from hydrogen than from LS diesel. Hydrogen has a very low emission of hydrocarbons compared to diesel.

From a health perspective there are practically no air pollutants or greenhouse gas emissions during operation with only one that may be of concern occurs during pre-combustion.

As hydrogen rises when it is released to the air its safety is similar to that of conventional fuels. To avoid explosion, evaporating hydrogen is extracted during the refueling process. Further to improve the safety of hydrogen during vehicle collisions designs incorporate leak proof hydride tanks and place them inside a safety cage in the vehicle so as to reduce the risk of damage. No results of collision testing with hydrogen vehicles could be found in the current research.

Currently there are plans for hydrogen to be generated from steam reforming of natural gas in the Northwest Shelf. Although there are large amounts of natural gas available this can only be seen as a sideways shift from an ecological perspective as the exbodied in the production of natural gas are similar to LS diesel. However, there is light at the end of the tunnel for hydrogen as there has been a proposal bought forward based on using tidal power to dissociate hydrogen from fossil fuel and thus run a hydrogen economy. The theoretical potential is there for great environmental benefits provided the technology could be implemented

The advantages of Hydrogen vehicles are: -
High energy efficiency because the efficiency is not limited to maximum efficiency of thermal energy process
Low emissions during operation
Low noise in production

The disadvantages of Hydrogen vehicles are: -
Fuel cell vehicles are much more expensive than internal combustion vehicle
Fuel cell vehicles are large and heavy per kW output.
The refueling time can be up to ten times the refueling time of fossil fuel vehicles.

Compressed Air Technology Cars:
Moteur Development International (MDI) has developed a high performance compressed air technology. When it is compared to traditional fossil fuel powered engines, MDI's engine is in terms of energy used and thermodynamics.

The technology that MDI vehicles use is not new, in fact it has been around for years. Compressed air technology allows for engines that are both non-polluting (ergonomically) and economical. One could the best of both worlds. After ten years of research and development, MDI is now prepared to introduce its clean air vehicles into the market place. Unlike electric or hydrogen powered vehicles, MDI vehicles are not expensive and do not have a limited driving range. MDI cars are affordable and have a performance rate that meets current standards.

MDI have developed two technologies for the different environments.
Single energy compressed air engines
Dual energy compressed air plus fuel engines.

The single have been conceived for city use, where the maximum speed is 50 km/h and where it is thought that polluting will soon be prohibited. This is a reality in London, where if you want to enter the city center with a gasoline-powered vehicle you must pay a fee.

The duel energy engine, on the other hand, has been designed as much for the city as the open road. The engine works exclusively on compressed air while running under 50 km-h in urban areas. However when vehicle precedes over 50 km-h the engine switches to, to fuel mode. The internal combustion engine has been designed to run ULP gas oil, bio-diesel, LS diesel, liquid gas, ecological fuel alcohol, etc etc.

This technology is now being further developed to other fields, such as electric cogeneration and energy accumulations. The French Government has recoginised this technology development by awarding MDI the *"la Palma de Orode la Academis nacional para el Fomento de la Creatividad Industrial, Artesana y Artistica"* (08-02-05 – Asamblea Nacional)

Tests by MDI have claimed that the single engine vehicle runs for a cost of less than one euro for every 100 km. In short this is approximately 10 times less than a gasoline-powered unit. The vehicle is approximately twice that of most advanced electric cars. (From 200 to 300 km or 8 hrs of circulation) This is considered as very appropriate as 80% of city driver's travel less than 60 km a day. The recharging of the car will be done at service stations once the market has been developed. It is anticipated that the air tank will be filled in about 2 to 3 minutes for a price of 1.5 euros. The vehicle has a small compressor that can be plugged into an electrical network and recharge the tank completely in 3 to 4 minutes. As the engine does not burn fuel the car's oil (1 litre of vegetable oil) requires changing every 50,000-km. Further the temperature of the air expulsed from the exhaust pipe is between 0 and 15 degrees below zero and can therefore channeled and use for air conditioning in the interior of the car.

While this technology was not included in the CSIRO research and I was unable to find any Comparisons it would be fair and reasonable to assume that it would have similar results to those of the fuel cell vehicle.

In my opinion only compressed air powered vehicles that use compressed air derived from fossil fuel electric power stations or fossil-fueled engines cannot be considered as ecologically satiable. It is difficult to see how fossil fueled power stations or fossil fuel production could be seen an ecologically sustainable development as the upstream pollutant are constant with those of the use fossil fuel, and considerable energy (thus exbodied greenhouse gases) to manufacture the compressed air. The upstream emission of greenhouse gases from the manufacture of compressed air would equate closely to the total exbodied emissions of greenhouse gases from LS diesel.

There has been much written over the years that suggests that solar energy, directed via satellites to collector on the planet, will be used to fire the power station to generate electricity. Should this become a reality than in my opinion the compressed air technology is more likely to be the technology used in mobile vehicle/plant industry.

Summary:
Given the data presented LS diesel EURO3 fuel is the most environmentally friendly fuel to use. This fuel is readily available and can be dispensed through current infrastructure. However the sustainability of the fuel is in question and therefore we must look for an alternative fuel for future generations. Further the issue of emissions emitted is directly linked to the methodology of the production of the fuel and as well as to the volume of fuel used/burnt to produce the required amount of energy to complete the task at hand.

Insufficient is known about the emissions of air toxics from vehicles, and the appropriate risk-weighted factors that should be used in examining their relative effects on the environment. It is an expectation that these issues will be will be further examined as part of the work on the National Environment Protection Measures (NEPM) on air toxics. When the NEPM work is finalized, the air toxics examined in this report should be revisited.

A sensitivity analysis revealed the importance of escapee emissions in determining whether CNG and LNG are more, or less, climate friendly than diesel fuels. It would be prudent to conduct a further study that combines measurement of fuel used to determine the future levels of emissions.

Many of the gaseous fuel vehicles used in Australia are likely to be converted vehicles or dual fuel vehicles. Consequently it is important to ensure that qualified technicians are used to carry out any such conversions thus ensuring the emissions are minimized and do not finish at a higher level than they were before the conversion. There the monitoring of compliance with emission standards is important.

The testing of all vehicle emissions, with regards to the fuel used should become mandatory as part of road worthy inspection annually.

It follows that if the data produced herein are to be used in guiding initiatives that lead to alternative fuels implementation the data should be revisited periodically. The analysis in this report has a limited life as the technology used to manufacture Hydrogen; Compressed Air and Fisher-Tropsch diesel are not operational in Australia at this point in time. As there is an expectation that operational plant will be in place within the next few years the study will need to be repeated so that the reevaluation includes actual production process emissions that are emitted concurrently.

It therefore follows that due to the non-definitive of the future alternative fuel it would be prudent management to stay with the current fuels used [diesel and unleaded petrol] and ensure compliance with the statutory requirements as they are implemented.

Hydrogen and compressed air technology should not be put on the back shelf, as a non-happening identity, as the probability for success is high at this point in time of their development.

PART 2.
The Economic Argument:
Uncertainties

It should be noted that this argument has been taken from the research carried out by the Plant and Material Coordinator of the Tweed Shire Council (TSC). The data used has been taken from the Tweed Shire Council's (TSC) fleet management system and other Council of similar size that have fleet management systems both New South Wales and South East Queensland. Projected Sale values are taken from Glasses Guide, Red Book and State Government Auctions (NSW & QLD) results.

The study uses a model that the TSC Plant and Material Coordinator developed at the Charles Stuart University while completing a Master in International Business Management (MBA). The model is designed in such away that it allows the user to evaluate best value for money based the total life costs of a project/asset. (Where the model can be criticized it is do in the body of the report.) This is achieved by using the Net Present Value (NPV) discounted cash flows model to determine the projected cost to own and operate the unit, and then allowing weighted averages for the other chosen criteria areas to be applied to the final total result. The NPV discounted cash flow model development was referenced from "*Fifth Edition Business Finance Graham Peirson, Ron Bird, Rob Brown, Peter Howard"* and *the Second Edition Introduction to Financial Management Clive Wilson, Bruce Keers.*

Figure 2 below portrays the results of sixteen (16) units that are commonly used in the TSC fleet. They have been selected at random to give the reader a picture of the cost to own and operate a particular style of unit rather than a particular make and model even though make and models have been identified.

Figure 2:
The cost to own and run a particular unit of a period of 3 years 90,000 km

See Figure Sheet at the end of this document.

Figure 2 is listed in ascending order irrespective of the different body styles, engine capacity and drive wheels. These are three areas that should be considered when selecting the type of unit suitable for a particular job.

Figure 3:
The Cost to own and operate sorted by body style and cost $ per km

See Figure Sheet at the end of this document.

Figure 3 has been displayed to emphasize the need to look at cost in various categories rather than just straight costs. Quite clearly if the only need is to transport 4 people then the Toyota Seca Corolla would the preferred option of the vehicle under evaluation. However, if the need were to transport 5 people then the 2.4 Litre Toyota Camry would be the preferred option of the vehicle under evaluation.

NPV Model:
Assumptions

1. That a study has been done resulting in a decision that the organisation requires the unit/asset for the long term.
2. That the unit will be replaced with the same style unit in a new model at the end of its economic life
3. That the unit has been subjected to the dominant sale point methodology and will be replaced at the most effective and efficient time in its life cycle.
4. That the subsequent replacement units will increase at a constant rate
5. That the current residual percentage will remain constant in the market place at the dominant sale point.
6. That the cost to operate will rise in accordance with a set inflation rate.
7. That the consistency rules are applied. All values for each individual unit are taken from the same source and applied to all units under evaluation.

NOTE: It should be noted that this model has been designed to project what will happen. The model has been developed using managerial accounting principles, which take experiences from the past and project forward to the future.

The values and parameters applied in this model are:-

Sale Policy:
3 years and or 93,750 km have been used. TSC currently averages 31,250 Km per annum in the categories of units under evaluation. This average was used as the same policy is applied to all units under evaluation

Available Booked Hours:
2,000 hours per annum. [5days a week x 52 weeks – 10 public Holidays x 8 hours per day = 2,000 hours P/A]

Utilisation:
100% as TSC charges these categories of unit to the users on a monthly rate [internal cost recovery].

Appreciation %:
3 % per annum has been used as a reasonable average price rise.

Inflation Rate:
2% used.

<u>EXPENSES:</u>
Capital:
The capital calculation commences with TSC purchase price as negotiated under the State Government Supply 653 Acquisition of Motor Vehicle Contract. It assumes that the initial Capital is available for use or the money is borrowed under an interest only loan. If the Capital is borrowed on the an interest only basis then the opportunity cost rate should be set at the rate that the Capital is borrowed at.

Appreciation: The model calculates the replacement cost of the new unit at the nominated sale point.

Depreciation: The model calculates the sale residual for the unit based the same models purchase price and to-days sale value. This establishes the residual percentage, which is, applied the replacement cost to determine the sale value of the unit at the end of its economic life. From these two calculations the model then calculates the amount of money required to be placed with the sale value to replace the old unit with a new unit. [Change over cost]
The change over cost is then divided by the Km traveled to arrive at a cost per km.

Opportunity Cost: The model allows a percentage value to be applied to the initial purchase price, which produces a cost for the use of the money. Needles to say the higher the purchase price the higher the opportunity cost.

Fuel:
The model allows the user to set a dollar value per litre of fuel and the number of litres per 100 Km for each individual unit.

In this case the value of ULP and Diesel have been taken from the current cost to TSC as at 03-03-06. The costs LPG from the average retail price from 3 retail outlets in Murwillumbah and Tweed heads on the 03-03-06. The retail price for the LPG has been used, as TSC has not facilities to store and dispense LPG. It is assumed that the cost of such infrastructure is included in the retail price as it would be an additional cost to TSC if the decision were to use the product.

Prices per litre used are
ULP $0.99
Diesel $1.09
LPG $0.635

Fuel consumption in litres per 100 Km for each individual unit has been taken from the greenhouse web site using the town travel figures for consistency

Service and Repair Costs:
The model calls for Councils buy price for the commonly spare parts in the life of the unit. [e.g., oil filter, fuel filter, air filter, brake linings etc] The cost of this parcel is then totaled and the subsequent cost is then taken as a percentage increase of the cheapest parcel.

The workshop labour cost used is $51.35 per hour full cost recovery.

Service [(Number of services [total life] x the time to service)/ the number of years of ownership]

Repairs [Number of hours to do repairs (total life) / the number of years of ownership]

Annual Inspection [Number of hours to carry out an annual inspection]

Insurance Repairs [Number of hours used to do repairs that would normally be covered by a comprehensive insurance policy however, are not because of the insurance excess set by TSC policy.]

Operator maintenance [The number of hours the operator is involved in the service or repairs of the unit] In this case I have zero for all unit other than the hybrids as they have to be taken back to the dealer for service.

In short what all this means is that if a units spare price is 20% dearer than another than the cost to service that unit is, [assuming the hours to services the unit are the same], will be charged in the model at 10% more to service.

Registration:
The registration charge is the standard charges that the Roads and Traffic Authority (RTA) of New South Wales applies. This cost is based on weight and therefore varies with the Tare weight of the individual unit.

Insurance Premium:
The same for all units.

Fringe Benefits Tax: (FBT)
The model presented uses a scenario where the employee contributes zero for the private use of the vehicle as this highlight the increase in FBT due to the Purchase price.

Tyres/Tracks:
The life expectancy for the tyres has been taken from past experiences both at TSC and other Council fleet management systems.

From the above values being applied the various formula an expense cash flow is determined on a yearly basis. The purchase is charged in year 0 and the sale value credited back in the final year.

REVENUE:
A revenue stream is then applied the booked hours increasing the rate until a zero balance with the expenses is achieved. This balance includes the necessary funds to replace the unit and subsequently taken over the total economic life of the unit.
The internal rate of return percentage is then adjusted to establish a zero Net Present Value. The internal rate of return is the rate of the interest, which equates to the present value of the future flows with the original cash outlay. In short when future net cash flows are discounted at the internal rate of return, the NPV will be zero. At this point the model has established a projected break-even cost structure for the particular unit. In other words it has determined what the charge out for the vehicle must be set at to produce a zero result at the end of the units economic life and allow the organisation to renew the asset for further use. The model then compares and contrasts each unit under evaluation showing a percentage dearer than the cheapest unit in the group.
As the assumption is of no profit or loss on the project the decision rule indicates that you accept the lowest internal rate and the lowest charge out rate per booked as being the best mutually exclusive project or vehicle in this case.

The model has an analysis sheet, which give results on most aspects of the cost of owning and operating the various units. The results are displayed in Figure 4 & 5 below:-

The figures are presented in Dollars ($) per kilometre travelled and then as a percentage of the total cost to own and operate.

Summary of Economic Argument

This discussion and the results presented are a snapshot of the current fleet market.

The true economist would suggest that the 1.8 litre Toyota Corolla is the cheapest to own and operate and therefore it would be prudent to have a fleet of them. However, one must bring some logic to the economic view and suggest that there must be a correlation between the work required and the design limits of the unit.

While the scope of this report does not cover the correlation it is fair and reasonable to say that until the relationship is established and a subsequent set of minimum requirements for the unit to perform the job effectively and efficiently are established the best economic decision cannot be taken.

Figure 3 segregates the units by the number of passenger seat required and suggest that if you require 5 people to travel at the one time the 2.4 Litre Toyota Camry is the unit to purchase. This is just one of many criteria that must be considered before economic analysis can have any credibility.

Figure 4: First Half of Net Present Value Model

See Figure Sheet at the end of this document.

Figure 5: Second Half of Net Present Value Model

See Figure Sheet at the end of this document.

PART 3:
Balanced Argument:
This argument is based on the notion that while the development of the global economic environment is important it is equally important that such development does not lead to the destruction to the ecological system. Therefore when any decision is made, consideration must be given to both systems and if necessary compromise must be accepted to ensure balanced results are achieved

To find the answer to this question we must first look at the way in which the transport operation is structured, ask, and seek answers to the questions:-

1. Is the way in which we are approaching the management of the transportation of Council resources [plant, materials, and people] giving consideration to both the economic and ecological factors?
2. Are we giving consideration to the type of fuel we are using?
3. Are we giving consideration to the coordination to the design limits of the units and the requirements of the unit to perform the job criteria?
4. Are we considering the people who use and maintain the units?
5. Are we being responsible and accountable for our decisions with regards to costs [budgets and budget constraints]

Question 1:
Is the way in which we are approaching the management of the transportation of Council resources [plant, materials, and people] giving consideration to both the economic and ecological factors?
The intent is to raise awareness of the some of the criteria that should be addressed in the management process.

Factors that could be considered however not limited to could be: -

- Net Present Value of the cash flows of the units over the total life.
- The operator evaluation or market choice
- The exbodied greenhouse gas emission emitted to the atmosphere
- The safety of the unit or risk evaluation
- The maintenance evaluation

The model that the TSC currently uses allows for 4 different criteria, but can be expanded.

For the Vehicle evaluation TSC currently use the following Criteria and weightings.

Criteria	**Weighting**
NPV	70 %
Market Choice	15 %
Maintenance	10 %
Risk	5 %

Question 2:
Are we giving consideration to the type of fuel we are using?

Question 2 raises issues around the type of fuel Council chooses to use.

The ecological discussion indicated that Low Sulfur diesel was the cleanest burning option. On the other hand the data collected for the NPV model indicated that the LPG was the cheapest to purchase. However, figure 4 & 5 display that

Toyota Prius (ULP) has a fuel cost of $0.044 per Km
VW Golf has (Diesel) has a fuel cost of $0.0645 per Km
Ford Falcon (ULP) has a cost of $0.1161 per Km
Ford Falcon (LPG) has a cost of $0.1198 per Km
Holden Commodore (ULP) has a cost of $0.1121 per Km
Holden Commodore (LPG) has a cost of $0.1198 per Km

It should be noted that while the cost per litre of the fuel is important to the equation equally important is the volume of fuel used to produce the required energy. Exbodied green house gas emission should carry equal importance.

The European marketplace obviously sees the LS diesel as being dominant in the market place as they are rapidly developing small diesel engines that perform equal to some of the ULP engines from the USA marketplace. It should be noted that the Japanese engineers see the hybrid technology as being the way forward with plan to have them in the Camry range by the end of 2006 and in their small truck fleet by 2010.

On Monday 28 November 2005 the NSW premier announced a mandatory Biofuel Policy. "*Premier media release 28 November 2005".*

The next NSW Government fuel contract will call for tenders to come from suppliers who can provide biofuels such as ethanol-blended petrol and biodesel. The document suggested that the ethanol/biofuel mix would be equivalent to E10.

Question 3:
Are we giving consideration to the coordination to the design limits of the units and the requirements of the unit to perform the job criteria?

Question 3 is about the suitability of the vehicle type for the purpose to which it is applied.

All engines have an optimum torque range, which is general plus or minus 20% or the revs per minute that the peak torque is developed. It is within this range that the engine will provide the best fuel consumption. Thus the minimum amount of tail pipe emissions emitted to the atmosphere.

Question 4:
Are we considering the people who use and maintain the units?

There has been and there will be much more debate between operators over which is the correct vehicle for them to drive. Maintenance technicians have similar debates.

At TSC this issue is solved by adopting a similar fleet composition to the total Australian vehicle sales composition

Question 5:
Are we being responsible and accountable for our decisions with regards to costs? [budgets and budget constraints]

As noted in Question 1 above, TSC considers market choice, maintenance and risk (safety) in addition to cost (NPV). The purpose of this report is to add to these factors fuel use and emissions.

Summary of the Balanced Discussion:
The balanced discussion has been basically around a methodology that can be used to achieve a balanced economical and ecological view of TSC transport operation. The discussion has focused on issues raised in Part 1 [economical argument] and Part 2 [ecological argument] of this paper.

To achieve the balanced economical and ecological satiable environment there are a number question/issue that must be addressed. Some of these issues have been discussed in this part of the discussion.

Fleet management should establish a strategic plan for the procurement and operation of all fleet plant and equipment. The strategy should ensure that TSC would get the best value for money within the bounds of the economic and ecological objectives set by Council.

FIGURE 1:

Summary of Exbodied Emissions of Greenhouse Gas/Gases from Average Family-Sized Vehicles

Results Expressed as Kg's - Per/Km	LS Diesel EURO3 Per Km	XLS Diesel EURO3 Per Km	ULP EURO3 [ADR37] Per Km	PULP EURO4 Per Km	LPG Autogas 2nd Gen Per Km	LPG Propane 2nd Gen Per Km	LPG Autogas 3rd Gen Per Km	LPG Propane 3rd Gen Per Km	CNG LV Per Km	PULP Hybrid [Standard vehicle] Per Km	LS Diesel Hybrid Per Km
Total Upstream and Tailpipe Greenhouse Gas/Gases	0.2325	0.2345	0.3491	0.2892	0.3013	0.3021	0.2509	0.2506	0.2613	0.1589	0.1278
% Worse than the Best	-.45.05%	-45.51%	-63.40%	-55.82%	-57.59%	-57.70%	-49.08%	-49.01%	-51.10%	-19.57%	0.00%
% Worse than the Best (No Hybib's)	0.00%	-0.84%	-33.39%	-19.61%	-22.83%	-23.03%	-7.34%	-7.22%	-11.01%		

FIGURE 2:

The cost to own and run a particular unit of a period of 3 years 90,000km

Make, Model	**Body Style**	**Drive Wheels**	**Engine Capacity**	**Fuel Type**	**Cost $ Per Km**	**% Dearer Than Cheapest**
Toyota Seca Corolla	4 Seat Sedan	Front 2WD	1.8 Litre	ULP	$0.3703	0.00%
Toyota Camry 4 Cyl	5 Seat Sedan	Front 2WD	2.4 Litre	ULP	$0.3930	6.13%
Holden Astra	4 Seat Sedan	Front 2WD	2.2 Litre	ULP	$0.4005	8.15%
Toyota Camry V6	5 Seat Sedan	Front 2WD	3.0 Litre	ULP	$0.4295	15.97%
VW Golf 1.9	4 Seat Sedan	Front 2WD	1.9 Litre	Diesel	$0.4375	18.15%
Toyota Hilux	5 Seat L-Com	Rear 2WD	3.0 Litre	Diesel	$0.4463	20.51%
Holden Commodore VZ	5 Seat Sedan	Rear 2WD	3.6 Litre	ULP	$0.4651	25.60%
VW Golf 1.6	4 Seat Sedan	Front 2WD	1.6 Litre	ULP	$0.4664	25.94%
Toyota Hilux	5 Seat L-Com	Rear 2WD	2.7 Litre	ULP	$0.4696	26.80%
Ford Falcon BA	5 Seat Sedan	Rear 2WD	4.0 Litre	ULP	$0.4705	27.05%
Ford Falcon BA	5 Seat Sedan	Rear 2WD	4.0 Litre	LPG	$0.4963	34.01%
Toyota Prius	4 Seat Sedan	Front 2WD	1.5 Litre	ULP	$0.4994	34.84%
Holden Commodore VZ	5 Seat Sedan	Rear 2WD	3.6 Litre	LPG	$0.5351	44.49%
Honda Civic	4 Seat Sedan	Front 2WD	1.5 Litre	ULP	$0.5647	52.48%
Toyota Hilux	5 Seat L-Com	All 4WD	3.0 Litre	Diesel	$0.5879	58.76%
Toyota Hilux V6	5 Seat L-Com	All 4WD	3.0 Litre	ULP	$0.6211	67.73%

FIGURE 3
The cost to own and operate sorted by style and cost per km

Make, Model	Body Style	Drive Wheels	Engine Capacity	Fuel Type	Cost $ Per Km	% Dearer Than Cheapest
Toyota Seca Corolla	4 Seat Sedan	Front 2WD	1.8 Litre	ULP	$0.3703	0.00%
Holden Astra	4 Seat Sedan	Front 2WD	2.2 Litre	ULP	$0.4005	8.15%
VW Golf 1.9	4 Seat Sedan	Front 2WD	1.9 Litre	Diesel	$0.4375	18.15%
VW Golf 1.6	4 Seat Sedan	Front 2WD	1.6 Litre	ULP	$0.4664	25.94%
Toyota Prius	4 Seat Sedan	Front 2WD	1.5 Litre	ULP	$0.4994	34.84%
Honda Civic	4 Seat Sedan	Front 2WD	1.5 Litre	ULP	$0.5647	52.48%
Toyota Camry 4 Cyl	5 Seat Sedan	Front 2WD	2.4 Litre	ULP	$0.3930	0.00%
Toyota Camry V6	5 Seat Sedan	Front 2WD	3.0 Litre	ULP	$0.4295	9.27%
Holden Commodore VZ	5 Seat Sedan	Rear 2WD	3.6 Litre	ULP	$0.4651	18.34%
Ford Falcon BA	5 Seat Sedan	Rear 2WD	4.0 Litre	ULP	$0.4705	19.71%
Ford Falcon BA	5 Seat Sedan	Rear 2WD	4.0 Litre	LPG	$0.4963	26.27%
Holden Commodore VZ	5 Seat Sedan	Rear 2WD	3.6 Litre	LPG	$0.5351	36.14%
Toyota Hilux	5 Seat L-Com	Rear 2WD	3.0 Litre	Diesel	$0.4463	13.55%
Toyota Hilux	5 Seat L-Com	Rear 2WD	2.7 Litre	ULP	$0.4696	19.48%
Toyota Hilux	5 Seat L-Com	All 4WD	3.0 Litre	Diesel	$0.5879	49.59%
Toyota Hilux V6	5 Seat L-Com	All 4WD	3.0 Litre	ULP	$0.6211	58.03%

FIGURE 4: First Half of Net Present Value Model

Make or Model	Toyota Seca Corolla 1.8 Litre (ULP)	Toyota Camry 4 Cyl 2.4 Litre (ULP)	Holden Astra 2.2 Litre (ULP)	Toyota Camry V6 3.0 Litre (ULP)	VW Golf 1.9 Litre Turbo (Diesel)	Toyota 3 Litre 2WD Double Cab (Diesel)	Holden Commodore VZ (ULP)	VW Golf 1.6 Litre (ULP)
Operational Cost Dollars $ Per Kilometre or $ Per Machine hour								
Capital Exp (Depreciation)	0.0798	0.0897	0.0807	0.0979	0.1051	0.0946	0.1268	0.1425
Opportunity Cost	0.0313	0.0331	0.0307	0.0367	0.0440	0.0417	0.0394	0.0344
Net Capital Cost	0.1111	0.1227	0.1114	0.1346	0.1491	0.1363	0.1662	0.1768
Fuel	0.0818	0.0990	0.0879	0.1131	0.0645	0.0945	0.1121	0.0747
Service P/A (grease & oil)	0.0131	0.0106	0.0188	0.0108	0.0155	0.0140	0.0109	0.0155
Major Repair $P/A	0.0145	0.0116	0.0207	0.0119	0.0171	0.0154	0.0120	0.0171
Annual Inspection $ P/A	0.0088	0.0070	0.0125	0.0072	0.0103	0.0094	0.0034	0.0103
Insurance Repair $ P/A	0.0145	0.0116	0.0207	0.0119	0.0171	0.9140	0.0120	0.0171
Operator Maintenance $ P/A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Registration $ P/A	0.0137	0.0150	0.0137	0.0150	0.0137	0.0213	0.0167	0.0137
Insurance Premium $ P/A	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114
Fringe Benefits Tax $ P/A	0.0799	0.0843	0.0782	0.0936	0.1122	0.1064	0.1007	0.1030
Tyres $ P/A	0.0215	0.0198	0.0251	0.0198	0.0266	0.0235	0.0198	0.0266
Total Cost P/Km orP/Mh Over Total Life	**$0.3703**	**$0.3930**	**$0.4005**	**$0.4295**	**$0.4375**	**$0.4463**	**$0.4651**	**$0.4664**

Expense Analysis as a % of the Total

Make or Model	**Toyota Seca Corolla 1.8 Litre (ULP)**	**Toyota Camry 4 Cyl 2.4 Litre (ULP)**	**Holden Astra 2.2 Litre (ULP)**	**Toyota Camry V6 3.0 Litre (ULP)**	**VW Golf 1.9 Litre Turbo (Diesel)**	**Toyota 3 Litre 2WD Double Cab (Diesel)**	**Holden Commodore VZ (ULP)**	**VW Golf 1.6 Litre (ULP)**
Capital Exp (Depreciation)	21.55	22.81	20.16	22.80	24.02	21.19	27.25	30.54
Opportunity Cost	8.46	8.41	7.66	8.55	10.06	9.35	8.47	7.37
Net Capital Cost	30.01	31.23	27.82	31.35	34.08	30.54	35.72	37.91
Fuel	22.09	25.18	21.94	26.34	14.74	21.18	24.10	16.02
Service P/A (grease & oil)	3.55	2.68	4.70	2.52	3.55	3.14	2.34	3.33
Major Repair $P/A	3.91	2.95	5.17	2.77	3.90	3.46	2.58	3.66
Annual Inspection $ P/A	2.37	1.79	3.13	1.68	2.36	2.10	0.72	2.22
Insurance Repair $ P/A	3.91	2.95	5.17	2.77	3.90	3.14	2.58	3.66
Operator Maintenance $ P/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Registration $ P/A	3.70	3.82	3.42	3.50	3.13	4.78	3.6	2.94
Insurance Premium $ P/A	3.09	2.91	2.85	2.66	2.61	2.56	2.46	2.45
Fringe Benefits Tax $ P/A	21.57	21.45	19.54	21.80	25.64	23.83	21.64	22.10
Tyres $ P/A	5.81	5.03	6.27	4.60	6.09	5.27	4.25	5.71
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Total Litres of Fuel Used Total Life	**7,594**	**9,188**	**8,156**	**10,500**	**5,438**	**7,969**	**10,406**	**6,938**

FIGURE 5: Second Half of Net Present Value Model

Make or Model	**Toyota Hilux 2.7 Litre 2WD Double Cab (ULP)**	**Ford Falcon BA (ULP)**	**Ford Falcon BA (ULP)**	**Toyota Prius 1.5 Litre (Hybrid)**	**Holden Commodore VZ (LPG)**	**Honda Civic 1.5 Litre (Hybrid)**	**Toyota 4WD 3 Litre Turbo Double Cab (Diesel)**	**Toyota Hilux V6 3.00 Litre 4WD Double Cab (ULP)**
Operational Cost Dollar $ Per Kilometre or $ Per Machine hour								
Capital Exp (Depreciation)	0.1128	0.1249	0.1411	0.1647	0.1680	0.2208	0.1852	0.1977
Opportunity Cost	0.0336	0.0394	0.0400	0.0511	0.0413	0.0512	0.0523	0.0487
Net Capital Cost	0.1464	0.1643	0.1811	0.2158	0.2093	0.2720	0.2375	0.2464
Fuel	0.1313	0.1161	0.1198	0.0444	0.1198	0.0525	0.0945	0.1313
Service P/A (grease & oil)	0.0132	0.0101	0.0101	0.0131	0.0109	0.0131	0.0149	0.0140
Major Repair $ P/A	0.0146	0.0111	0.0117	0.0044	0.0127	0.0044	0.0198	0.0187
Annual Inspection $ P/A	0.0088	0.0034	0.0000	0.0066	0.0073	0.0066	0.0099	0.0094
Insurance Repair $ P/A	0.0132	0.0111	0.0111	0.0145	0.0120	0.0145	0.0149	0.0140
Operator Maintenance $P/A	0.0000	0.0000	0.0000	0.0202	0.0000	0.0263	0.0000	0.0000
Registration $ P/A	0.0213	0.0167	0.0167	0.0137	0.0167	0.0137	0.0224	0.0224
Insurance Premium $ P/A	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114
Fringe Benefits Tax $ P/A	0.0857	0.1004	0.1050	0.1302	0.1151	0.1305	0.1333	0.1242
Tyres $ P/A	0.0235	0.0260	0.0260	0.0251	0.0198	0.0196	0.0292	0.0292
Total Cost P/Km or P/Mh Over Total Life	**$0.4696**	**$0.4705**	**$0.4963**	**$0.4994**	**$0.5351**	**$0.5647**	**$0.5879**	**$0.6211**

Expense Analysis as a % of the Total

Make or Model	**Toyota Hilux 2.7 Litre 2WD Double Cab (ULP)**	**Ford Falcon BA (ULP)**	**Ford Falcon BA (ULP)**	**Toyota Prius 1.5 Litre (Hybrid)**	**Holden Commodore VZ (LPG)**	**Honda Civic 1.5 Litre (Hybrid)**	**Toyota 4WD 3 Litre Turbo Double Cab (Diesel)**	**Toyota Hilux V6 3.00 Litre 4WD Double Cab (ULP)**
Capital Exp (Depreciation)	24.02	26.55	28.43	32.99	31.39	39.10	31.50	31.83
Opportunity Cost	7.16	8.37	8.06	10.22	7.72	9.07	8.89	7.84
Net Capital Cost	31.18	34.92	36.49	43.21	39.11	48.17	40.40	39.67
Fuel	27.96	24.69	24.15	8.90	22.40	9.30	16.08	21.14
Service P/A (grease & oil)	2.82	2.14	2.03	2.63	2.04	2.33	2.53	2.26
Major Repair $ P/A	3.10	2.35	2.36	0.88	2.38	0.78	3.37	3.01
Annual Inspection $ P/A	1.88	0.71	0.68	1.32	1.36	1.16	1.69	1.51
Insurance Repair $ P/A	2.82	2.35	2.23	2.90	2.24	2.56	2.53	2.26
Operator Maintenance $P/A	0.00	0.00	0.00	4.04	0.00	4.66	0.00	0.00
Registration $ P/A	4.55	3.56	3.37	2.75	3.13	2.43	3.82	3.61
Insurance Premium $ P/A	2.43	2.43	2.30	2.29	2.14	2.02	1.94	1.84
Fringe Benefits Tax $ P/A	18.26	21.33	21.16	26.06	21.52	23.12	22.67	19.99
Tyres $ P/A	5.01	5.52	5.23	5.03	3.70	3.48	4.97	4.71
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Total Litres of Fuel Used Total Life	**12,188**	**10,781**	**17,344**	**4,125**	**17,344**	**4,875**	**7,969**	**12,188**