7. IMPROVEMENTS TO AUTOMATIC TRANSMISSIONS

7.1 ENGINEERING DESCRIPTION

Improvements to current automatic transmissions can occur in the following areas:

- o Increased penetration of torque converter lock-up.
- o Reduction in flow losses in the torque converter.
- o Increase in the ratio spread between top and first gear.
- o Increase in the number of gear steps between the available limits.
- o Electronic control of transmission shift points and torque converter lockup.

Current automatic transmissions use a hydraulic systems to transmit the engine power to the drivetrain. There is no direct mechanical linkage of the engine to the transmission; instead power is transferred by a torque converter. They flywheel, which is attached directly to the engine's crankshaft, also is bolted directly to a part of the torque converter termed the impeller.

The impeller fan sets up a motion of the hydraulic fluid (transmission oil) and this in turn spins a centrifugal fan, which is not mechanically connected to the impeller.

During periods of acceleration, this hydraulic system allows the driven member (centrifugal fan) to turn more slowly than the driving member (impeller). This process is termed slip, but it also leads to torque multiplication.

Although torque multiplication is useful during acceleration, the fuel economy of this system is degraded during cruise conditions when the torque converter begins to slip. This slippage causes a loss in fuel economy because, during constant speed conditions, it is more fuel efficient for both members to revolve at the same rate. In order to rectify this situation, automobile manufacturers have developed a system to mechanically link the driving members during cruise periods. This system, termed a torque converter lockup, eliminates slippage and consequent fuel economy losses.

The fuel economy of manual and automatic transmissions can be improved by increasing the ratio spread between the lowest and highest gears. A larger ratio spread also needs to provide more intermediate gear steps to prevent excessive shift shock and poor driveability when gears are shifted.

In addition, the lowered road load aerodynamic horsepower requirement from low aerodynamic drag designs also demand a larger ratio spread to provide better matching between load and engine operating point. At any operating condition, the vehicle demands a certain horsepower from the engine, and horsepower is the product of torque x engine speed. If fuel economy were the only concern, the optimum point to operate under any load condition is by maximizing torque and minimizing engine speed (RPM).

This leads to reduced throttling loss and reduced friction loss. However, there must be sufficient reserve power at any operating point so that modest changes in road load horsepower do not require a downshift. In addition, operation at too low an RPM causes excessive driveline harshness and poor accelerator response. As a result, the choice of operating points is constrained.

To maximize fuel economy and driveability, the drivetrain parameters of engine size, axle ratio, gear ratios and number of gears must be matched carefully. Table 7.1 shows the typical ratio spreads in U.S. domestic car transmissions used in 1988-1990. The Continuously Variable Transmission (CVT) can be visualized as the logical limit of increased number of gear steps, and it permits operation closer to the theoretical optimum.

Mercedes has offered 4-speed automatic transmissions since the early 1970's, but domestic manufacturers first introduced them in the early 1980's. As of 1988, 4-speed automatics are widely used in all domestic large and midsize cars but most domestic compacts and subcompacts use 3-speed automatics. Five speed manual transmission have completely replaced four-speed units, which are currently offered only in a special low price Escort. Torque converter lock-up (TCLU) clutches are also widely used in most, but not all, transmissions. In fact, TCLU penetration declined slightly from the mid-1980's to 1988.

In the 1990's, further increases in ratio spreads and number of gears are likely. Mercedes-Benz and Nissan have recently introduced a 5-speed automatic transmission, while GM has introduced a 6-speed manual transmission. Product plans reveal that such transmissions are likely to be more widely adopted in the post-1995 timeframe. CVT's have been introduced in Europe and Japan, and in one car model in the U.S.

Electronic transmission control is also likely to become more widespread as a tool for optimizing the TCLU's lock-up speeds and the transmission's shift points. However, engineers believe that the current hydraulic system is well tailored to the FTP, so that electronic controls will be more effective in real-world conditions where non-FTP modes are encountered.

7.2 TORQUE CONVERTER LOCK-UP

Torque converter lockup clutches result in driveline vibrations being transmitted to the body. The locking-unlocking action can also be annoying because of the slight jerk to the vehicle. Thus, their use in small diesels or gasoline engines with fewer than 4-cylinders -- engines that have inherently high vibration levels -- are likely to cause more customer complaints than in a vehicle equipped with larger, smoother engines.

TABLE 7.1: TYPICAL RATIO SPREADS FOR TRANSMISSIONS IN 1988

	Automatic		Manual	
	3 speed	4 speed	4 speed	5 speed
Chrysler	2.69	4.12	N/A	4.57
Ford (FWD)	2.84	4.01	4.12	4.80
Ford (RWD)	N/A	3.58	N/A	4.52
GM (FWD)	2.84	4.29	N/A	5.04
GM (RWD)	N/A	4.09	N/A	4.69

N/A - Transmission not used.

RWD - Rear wheel drive.

FWD - Front wheel drive.

In fact, in recent years TCLU's have been removed in some vehicles with 4-cylinder engines. However, reductions in 4-cylinder engine vibration levels and electronic control of lock-up can reverse this trend.

The fuel economy benefits of TCLU have been extensively studied by the automanufacturers in careful "back-to-back" tests with the TCLU engaged and disengaged on the same vehicle. Chrysler had provided data[1] on their first torque converter lock up clutch in 1978, where lock-up was applied in third gear only.

Results showed a six percent improvement in the highway cycle and a two percent improvement on the city cycle for a net improvements of 3 percent. Ford introduced its automatic overdrive with lock-up in gears 3 and 4 in 1980. More recently, Ford's front-wheel drive four-speed transmission (called AXOD) has lock-up in gears 2, 3, and 4. The actual fuel economy benefit was found to depend on:

- The efficiency of the open converter;
- The actual lockup speeds encountered in the city cycle.

A review of the confidential submissions by the automanufacturers to DOT suggests that increased benefit of lock-up in gear 2 is partially offset by the increased open converter efficiency. The benefits may be slightly lower for four cylinder engines due to requirements for vibration and noise control. DOT has suggested a range of 3 to 5 percent benefit, and EEA's 3 percent estimate appears conservative in this light.

The design of the torque converter itself is being improved. Toyota[2] has introduced a new "Super Flow" converter in its Lexus LS400 vehicle. The new converter was computer designed to optimize impeller blade angle and blade shape to reduce loss of oil flow. In addition, the new manufacturing tech- niques were developed for the impeller to increase rigidity.

As a result, Toyota claims the converter efficiency is the world's best, and is 3 to 5 percent higher than other torque converters. Such an improvement is expected to provide a 0.5 percent benefit in composite fuel economy.

7.3 FOUR/FIVE SPEED AUTOMATIC TRANSMISSION

The effects of increased number of gears in a transmission is dependent on several variables that define the transmission. The increased number of gears can be utilized to provide a wider ratio spread between first and top gears, or else to increase the number of steps with a constant ratio spread for improved driveability and reduced shift shock.

In addition, the wider ratio spread can be utilized to provide higher performance in the first few gears while keeping the ratio of engine speed to car speed in top gear constant, or else to keep performance in the first few gears constant and reduce engine speed in top gear. Since the manufacturer is able to select among these tradeoffs, different manufacturers have chosen different strategies in selecting gear ratios.

An overdrive transmission (manual or automatic) needs careful matching to engine characteristics and axle ratio to provide optimum fuel economy gains. In general, the use of overdrive results in lower engine speeds on the highway which, in turn, decreases noise and vibration levels. However, performance in overdrive also suffers and downshifts are required to negotiate gradients or provide highway passing performance. In city driving, overdrive is of little value, since vehicle speeds are never high enough to spend any substantial portion of urban mileage in overdrive.

In keeping with the constant performance criterion, EEA has examined fuel economy differences between 3 and 4 speed automatic transmissions where the performance in the first three gears is nearly identical. In examining the available 3-speed and 4-speed transmissions for domestic automobiles, we have found that the first three gear ratios are nearly identical between the two transmission types, while the 4th gear is usually an overdrive with a ratio of 0.66 to 0.75.

Among the earliest studies on the effects of number of gears and ratio spread was a theoretical study by Chana, Fedewa and Mahoney[3] from GM. In this study, engine size and axle ratios were optimized for maximum fuel economy, as was the shift pattern. In real life, these choices are not unconstrained, and other parameters related to vehicle driveability and comfort limit the number of shifts during normal driving. Hence, the study can be considered as an upper bound to the benefits obtained. The study compared a 3-speed automatic with 2.84 ratio spread to a 4-speed automatic with 4.22 spread. These values are very similar to the actual values in transmissions available today. The 4-speed unit was found to provide 14.3% benefit in composite fuel economy over the 3-speed unit when evaluated at constant performance as defined by the 0-60 mph acceleration time. In practice such values have not been attained.

Since both 4-speed and 3-speed automatic transmissions are already sold widely in the U.S., a comparison of vehicles featuring these transmissions is possible. Unfortunately, both transmissions are rarely available in the same carline/engine combination. A "matched pair" is required so that vehicle differences and performance differences are factored out of the comparison.

Only GM and Toyota have offered both transmissions with the same carline/ engine in the 1986-1989 period. The GM transmissions have nearly identical ratios for the first three gears, but the 4-speed features on overdrive gear with 0.70 ratio. In the Toyota, the 4-speed transmissions first gear has a 2.45 ratio versus 2.91 for the 3-speed transmissions. The shift schedule is an uncontrolled variable in these comparisons. In addition, the axle ratios also differ slightly. In all cases, the "constant performance" criterion is only approximately valid. In addition, measurement variability can cause errors of q2% of the actual (true) value.

As can be seen from Table 7.2 the available comparisons show a range of 3 to 7.8 percent benefit for the 4-speed over the 3-speed. Conversations with transmission engineers suggest that 4.5 percent is an acceptable median value for a constant performance comparison. A more recent EPA "matched pair" comparison[4] has come to a similar conclusion.

Five speed automatic transmissions have only recently been commercialized in Japan and Europe. Nissan has provided a comprehensive analysis of the effect of numbers of gears and choice of first gear and top gear ratios on fuel economy[5]. They found declining benefits with increasing number of gears, with little or no benefit above six gears. With a first gear ratio of 3.0 (similar to that of current automatics) they found no benefits in fuel economy in using overdrive ratios lower than about 0.7.

However, increasing the first gear ratio to about 4 provided better standing start performance. This production Nissan 5-speed transmission uses a 3.85 first gear ratio and a 0.69 overdrive ratio for a 5.56 ratio spread. At constant performance, Nissan showed fuel economy gains in the 3 percent range. Mercedes, the only other manufacturer to have introduced a 5-speed automatic, confirmed that the fuel economy benefit over a 4-speed automatic was in the 2 to 3 percent range.

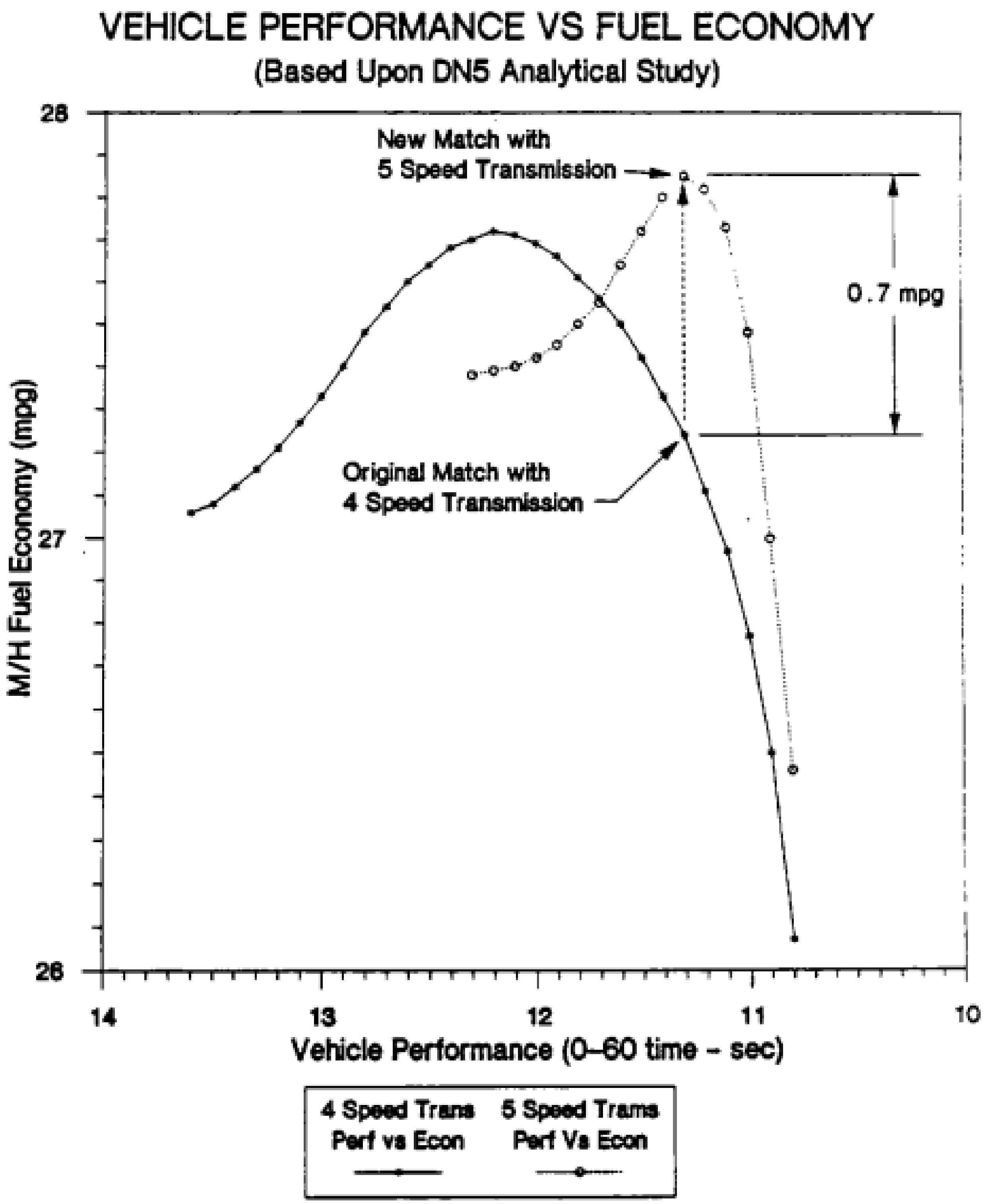
Ford also submitted data on their planned 5-speed automatic transmission. Although the specific gear ratios were not provided, Ford provided simulated data on the 4-speed and 5-speed transmissions. They found the benefits to be closely related to the absolute performance level at which the comparison was made.

As shown in Figure 7.1, Ford estimated that the 5-speed automatic would provide a 2.5 percent at current performance levels, but could have much smaller benefits at other levels. It is possible that the ratio spreads between the two transmissions did not differ much in this comparison.

TABLE 7.2: MATCHED PAIR COMPARISONS OF FUEL ECONOMY WITH THREE AND FOUR-SPEED AUTOMATIC TRANSMISSIONS

Model	Engine CID	Test Weight (lb)	3-Speed Auto		4-Speed Auto		% F/E Increase
			Axle	F/E	Axle	F/E	
Chevy Celebrity	173 V-6 (2-bbl)	3250	2.84	25.5	3.06	26.5	3.9
Olds Cutlass	173 V-6 (FI)	3250	2.84	24.2	3.06	26.1	7.9
Chevy Caprice	262 V-6 (FI)	4000	2.56	21.7	2.56	22.7	4.6
Chevy Caprice	262 V-6 (FI)	3875	2.56	23.2	2.56	23.9	3.0
Toyota Corolla	97 I-4 (FI)	2750	3.33	33.1	2.82	34.9	5.4

FIGURE 7.1: VEHICLE PERFORMANCE VS FUEL ECONOMY



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Powertrain Systems Analysis Department

EEA has selected 2.5 percent fuel economy benefit as a representative figure for the fuel economy benefit of a 5-speed automatic over a 4-speed automatic.

7.4 ELECTRONIC TRANSMISSION CONTROL

Electronic Transmission Control (ETC) systems can replace the hydraulic controls used in most transmissions. The electronic system can be used to control shift schedules and torque converter lock-up such systems were first introduced in Toyota's A43DE transmission in 1982. As of 1988, the domestic manufacturers did not have electronically controlled transmissions although several have been introduced in 1989 and 1990.

The benefit of the ETC system lies in the potential to maximize fuel economy by tailoring shifts and lock-up to the driving schedule. In the analysis of Toyota's 4-speed transmission in 1982_6, the benefits of the electronic transmission control in "normal" setting offered a 3.1 percent in fuel economy or the Japan 10-mode city cycle. Benefits on highway driving schedules are much smaller, simply because there are fewer gearshifts. Toyota also found that in an "economy" setting, the benefit increased to 6.2%.

DOT has published estimates of 3 to 5 percent benefit in fuel economy for the ETC system.

Domestic automanufacturers, however, claim that these benefits are unrepresentative since most modern non-electronic transmissions have been optimized for the FTP test cycle, and the available benefits of ETC are much smaller. Although several electronically controlled transmissions are already available, "paired sample" comparisons are not possible as no example of the same car/engine combination is available with non-electronic and electronic transmissions.

However, studies across different models of similar weight and performance do not show any significant advantages for the electronic transmission. In the absence of carefully controlled test data, we have accepted the manufacturer's claim that the benefit is only 0.5 percent. However, it appears there is potential for greater improvement with some loss of smoothness or "feel".

7.5 CONTINUOUSLY VARIABLE TRANSMISSIONS

Current transmissions feature a discrete number of gear ratios (usually 3 to 5) that determine the ratio of engine to vehicle speed. This results in some loss of flexibility in matching the engine speed/load condition to vehicle requirements. A continuously variable transmission (CVT) offers a infinite choice of ratios between fixed limits, allowing optimization of engine operating conditions to maximize fuel economy.

Currently, Subaru is the only manufacturer offering a CVT in a small car. Although there are several designs being tested, the CVT that is in production features two conical pulleys driven by metal belts. The position of the belts on the conical pulleys determine the gear ratio between input and output shafts. Under steady state conditions, the metal belt system can be less efficient than a conventional system, but the fuel used over a complete driving cycle is decreased because of the optimized speed/load conditions for the engine.

Current CVT's are designed as replacements for conventional automatic transmissions and are generally not more efficient than a wide ratio 5-speed manual transmission or an advanced overdrive five speed automatic transmission. The CVT is expected to find application only in small cars because:

1) CVT's are inherently torque limited due to the metal belt design and are, thus, not compatible with engines over 2 liters (120 CID) in displacement; and
2) CVT's are attractive for small front-wheel drive cars because they are easier to "package" than a four-speed or five-speed automatic transmission.

The performance, cost and fuel economy gains are discussed below.

Several major suppliers are experimenting with CVT's, and Ford and GM are known to be testing the CVT for possible introduction in the mid-1990's in the subcompact and minicompact class of cars. Ford offers a CVT in its European Fiesta as of 1990.

Performance of the CVT should be equal to or somewhat better than conventional automatic transmissions. However, a CVT can produce unexpected changes in engine speed -- i.e., engine speed dropping while the vehicle speed is increasing -- which may deter consumer acceptance. Developments in the metal belt system coupled with weight reduction of future cars are expected to enhance the availability of the CVT for use in the compact size classes of cars in the 2000 time frame.

In the early 1980's, CVT's were expected to provide substantial fuel economy benefits over 3-speed automatic transmissions. Researchers from Ford[7] showed that an Escort with a CVT of 82 percent efficiency would have a fuel economy 14 percent higher than the fuel economy with a 3-speed automatic; at a CVT efficiency of 91 percent, the fuel economy benefit was computed to be 27 percent. (91 percent was considered as an upper bound of potential efficiency).

Similarly, Gates Corporation[8] installed a CVT in a Plymouth Horizon and found a fuel economy improvement of 15.5 percent over a conventional 3-speed automatic with lock-up at almost identical performance levels. However, design compromises for driveability, as well as improvements to the base three speed automatic since the time these papers were published (1982) has resulted in lowered expectations of benefits.

The current consensus among automanufacturers is that the CVT will be 8 to 10% more efficient than current 3-speed automatics with lock-up, and EEA has utilized 8 percent as a conservative figure. This figure is consistent with the measured results from the Subaru Justy CVT sold in the U.S. Note that the 8 percent figures includes the benefits of electronics control which is required to maximize CVT benefits.

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8. DIESEL ENGINES AND TWO-STROKE ENGINES

8.1 DIESEL ENGINES

The diesel engine uses a fundamentally different combustion process than the spark-ignition (gasoline) engine. In the diesel, intake air is heated by compression to a temperature sufficient to ignite the fuel. Diesel fuel is then injected as a spray at very high pressure, with combustion taking place at the air-fuel interface of the spray droplets. (In spark-ignition engines, air and vaporized fuel are pre-mixed, and the homogenous mixture is ignited by a spark).

The diesel inherently is more efficient than spark-ignition engines as a power plant for motor vehicles. First, the diesel has a greater thermodynamic efficiency because it operates at much higher compression ratios than a gasoline engine (22:1 versus 8:1). Second, current diesels are unthrottled and achieve part-load operation by reducing the rate of fuel injection, therefore leaning the air-fuel ratio.

In contrast, gasoline engines throttle the intake during part-load operation, incurring pumping losses associated with airflow pass the throttle plate, and maintain approximately constant air-fuel ratios across the operating range. Diesels therefore, offer particularly efficient operation during idle and low-load conditions, which are very common in urban driving patterns.

Since the diesel combustion process is controlled by the rate of fueling, performance of the injection system is critical. All of the current passenger car diesels feature a pre-chamber design in which the air and fuel spray are partially mixed and ignited before combustion spreads to the main chamber. This design limits the rapid pressure rise which occurs in a direct-injection diesel (found in medium and heavy-duty trucks), with attendant reductions in noise, vibration, and NOx emissions.

The prechamber design also makes the combustion process less sensitive to the performance of the fuel injection system and allows the use of a less expensive rotary injection pump. However, the lower rate of pressure rise and the additional heat transfer of the prechamber design results in lower specific fuel economy than in the direct injection diesel.

Diesel engine performance traditionally has been a deterrent to its widespread acceptance. The principal disadvantages of the diesel compared to gasoline engines are:

- Poor acceleration
- Increased noise and vibration
- Cold start performance
- Exhaust smoke and odour

Performance advantages for the diesel include reduced maintenance and better throttle response which eliminates stumbling and hesitation in any weather.

Acceleration performance has been poor because diesels have significantly lower peak power output than gasoline engines of equal size (displacement), due to the higher internal friction of the diesel engine as well as limitations on the diesel combustion process. In particular, smoke production increases at high fueling rates due to incomplete combustion of the injected fuel droplets.

The engine design must therefore limit peak power to control smoke to acceptable levels. A diesel engine is also heavier than an equivalent gasoline engine to withstand the higher stresses of the increased compression ratio, with a resulting adverse impact on power/weight ratios. Diesel performance can be increased by using a larger engine or by turbocharging, although with price and fuel economy penalties. During times of high fuel prices, however, consumers have been willing to accept reductions in traditional performance in return for increased fuel economy.

Although diesels have increased noise and vibration levels, insulation and rubber engine mounts have successfully minimized these problems in current cars so that the average driver cannot differentiate between gasoline and diesel engines. Slow cold start and warm-up performance of diesels have been improved through the use of EGR.

GM already has developed a "fast-start" glow plug system that allows the diesel to start in 60 seconds in 0 degree weather. Exhaust smoke and odour are problems that are less readily solved, but it appears that particulate traps (addressed elsewhere in this section) will provide control of both.

Although diesels traditionally are thought to be 25 percent more efficient than gasoline engines, comparisons from currently available models show that the fuel economy gain can range from 15 to 55 percent, depending on the type of comparison being made[1]. (Equal engine size, equal performance, or model to model comparisons produce very different results.)

One problem with comparing diesel to gasoline fuel economy is that diesel and gasoline versions of the same car rarely exhibit similar performance characteristics, while comparisons between different models can reflect manufacturer and drivetrain differences. The limited number of diesel models available also make accurate comparisons difficult.

Current diesels show 30 percent improvement in fuel economy on average, reflecting the performance difference between average gasoline and diesel cars. In a "best-to-best" comparison which (approximately) equalizes performance, the fuel economy improvement over gasoline engines is 20 percent for a naturally aspirated diesel and 30 percent for a turbocharged diesel.

In addition, diesels have much lower fuel economy shortfall (difference between real-world and EPA fuel economy), than gasoline engines. This difference in shortfall ranges from 6 percent (for low fuel economy cars) to 25 percent for high fuel economy cars. Diesels especially show fuel economy advantages in city traffic, as they use very little fuel during idle, and in comparison to gasoline engines, also use much less fuel during the cold start and warm-up phase. In real world economy, therefore, the diesel can provide up to 50 percent improvement over gasoline engines in an "average-to-average" comparison.

As explained previously, all of today's passenger car and light truck diesels are of the prechamber type. Conversion to direction injection results in an additional 15 percent fuel economy benefit over an equal displacement pre- chamber design. This large benefit has resulted in considerable interest in applying direct-injection to cars and light trucks, and there are several experimental models currently undergoing development. Much of the work is being performed in Europe by AVL, BMW, VW and $MAN_{2/3}$.

The direct injection diesel has suffered from the problems of increased noise and vibration as well as higher particulate emissions. The key to control of these problems lies in the fuel injection system. The use of electronic control and more advanced injection pumps has resulted in improved potential for the direct injection diesel. The status of current research shows that direct injection diesels are very close to meeting all applicable U.S. emission standards, while noise and vibration levels are competitive with current prechamber engines.

It appears that direct injection diesels will be introduced in the early 1990's by several foreign manufacturers and, perhaps, by domestic manufacturers in their luxury cars.

8.2 TWO-STROKE ENGINES

The two-stroke engine has recently made a reappearance, largely due to the success of an Australian firm, Orbital Engine Company. Historically, two- stroke engines had high specific output, low weight and were simple in design, but had poor thermodynamic efficiency and very high emission levels. Orbital has largely solved the problems by using a direct injection, stratified charge combustion system to reduce emissions and raise fuel efficiency.

According to information publicly available from $Orbital_4$, a 1.2L engine has been developed fully to meet even the stringent 1994 U.S. emission standards of 0.25 HC/3.4 CO/0.41 NO_x g/mile, although only in a lightweight vehicle.

The Orbital engine has an output of 90 BHP and a torque of 130 N-m, roughly comparable to a 1.6L 2-valve OHC engine. Orbital claims that its principal advantages in fuel efficiency lies in decreased pumping losses and reduced mechanical friction. The thermodynamic advantages of direct-injection stratified charge engine arises from the lean burn concept used, but this is partially offset by the reduced effective compression ratio of the engine (~8).

In comparisons with the 1.6L OHC engine, Orbital has claimed a bsfc advantage of 12 percent. In addition, the engine has an output advantage of 120 lb and is reportedly smoother than the 4-cylinder 4-stroke engine. The size of the engine is also significantly smaller, and Orbital has claimed potential aerodynamic advantages of the engine.

Even if this is discounted, the Orbital engine appears capable of providing a 16 to 17 percent fuel economy advantage in a 2500 lb. inertia weight subcompact. The engine may be cost competitive with OHC 2- valve 4-stroke engines, although there is an initial tooling cost associated with conversion that may be significant. The Orbital claims have been verified by established automanufacturers, but they have issued no independent confirmation of these claims.

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9. POWER BOOSTING

9.1 TURBOCHARGING

9.1.1 Engineering Description

Internal combustion engines, both gasoline and diesel, reject 25 to 50 percent of the fuel energy into the exhaust. A turbocharger recovers some of this wasted energy, thereby increasing the power rating of the engine. The turbocharger consists of a turbine placed in the exhaust path which drives a compressor in the intake manifold, compressing incoming air to the engine. The higher pressure of the intake manifold results in more air being forced into the engine, thus generating more power.

The turbocharger can be used to improve performance or fuel economy. Its use as a performance device is obvious. As a fuel economy device, the turbocharger allows the use of a smaller, lighter engine without a performance sacrifice. Smaller engines with turbochargers have lower fuel consumption during idle and cruise conditions that larger, naturally aspirated engines of equal power. Depending on the choice of engine and turbocharger, performance can be traded off against fuel economy.

9.1.2 Application

Turbochargers function more effectively with diesel engines than with gasoline engines for two reasons. First, since the turbocharger compresses intake air, its effects on combustion are similar to that of an engine operating at increased compression ratio. Gasoline engines are compression limited by "knock" and the pressure boost delivered by the turbocharger must be carefully controlled to a low value (5-7 psi) to prevent knock. No such limitation exists for diesel engines, and turbocharger boost is only a function of engine material limitations. Second, gasoline engines throttle the intake air at part load conditions, whereas diesel engines reduce only the fuel delivered.

Intake air throttling renders a turbocharger ineffectual and hence, the turbocharger is utilized only under relatively infrequent wide-open throttle conditions in gasoline engines.

There are a number of problems associated with turbochargers, some of which are a result of natural laws governing the performance of turbines. For example, the complex interrelationship between boost pressure, airflow and turbocharger speed (RPM), results in a turbocharger providing little or not boost at low engine speeds and a very rapid rise in boost at high engine speeds.

The conflict between boost and engine speed requires careful matching between turbocharger size and engine RPM to maximize mpg and performance benefits. The turbocharger's performance, cost and fuel economy gains are sensitive to the conflict between boost and engine speed design tradeoffs. The tradeoffs are discussed below, and the performance and fuel economy issues are highlighted.

As manufactures phase out the large V-8 engines, they have begun offering turbocharged gasoline engines to satisfy customers requiring performance. Both GM and Ford have offered turbocharged engines for over 10 years, and a number of European importers (Audi, Saab, Porsche) have offered them in expensive high performance cars. Turbocharged diesel engines are currently offered by Mercedes, Peugeot and Toyota. Total market penetration of turbocharged engines has been very small (2 percent in 1988). The reasons for the turbocharger's limited penetration are considered below.

9.1.3 Performance and Fuel Economy

The acceleration characteristics and fuel economy gains are dependent on how the turbocharger is "matched" to the engine. If the turbocharger is sized to provide boost at moderate engine speed (2000 to 3000 RPM) but sacrifice some maximum power at higher engine speeds, the engine will provide good performance in the 40 to 70 mph range. At the very low RPM range (for example, a hard acceleration from a stop sign), the engine behaves like a normally aspirated engine of identical size.

After the vehicle exceeds 25 to 30 mph, it behaves like a larger normally aspirated engine. The EPA fuel economy gain is approximately 5 percent over the larger normally aspirated engine of the same power. Mid-range boost offers the best compromise between fuel economy and performance. However, the turbocharger in combination with 4-valve engines exacerbates the low RPM torque problem. As a result, EEA does not believe that the turbocharger/4-valve engine combination will be used for fuel economy.

If all the boost is concentrated on the high end of the engine RPM range to optimize for maximum power, there is no gain in either performance or EPA economy during normal driving in comparison to a naturally aspirated engine of equal displacement. All the performance improvement is available only for high RPM gear shifting, and the turbocharger appeals to a performance oriented group of buyers. For example, the behaviour of the now discontinued Mustang Turbo at low to moderate engine speeds resembles that of the naturally aspirated engine from which it was derived. Although fuel economy comparison with a V-8 shows a 10 percent gain, there are considerable differences in low speed acceleration between the two.

It is clear that for gasoline engines the characteristics of the turbocharger appeal only to those buyers interested in maintaining high performance. For such customers, the turbocharger provides a 10 percent fuel economy benefit over a V-8, albeit at the expense of poor performance over a significant portion of the engine's speed range. Some 4- valve engine, such as the Toyota Celica 4WD engine, feature turbocharging to provide very high peak power.

Diesel turbocharging results in a price impact very similar to that for gasoline engines for modest maximum boost pressures (10-12 psi). At a higher boost pressure, piston cooling requirements and strengthening of internal engine parts as well as cooling system improvements may raise the price significantly. High boost pressures allow diesels to be competitive in acceleration performance with gasoline engines and the price is illustrative of the cost/performance tradeoff that customers will face in the future. For example, Peugeot has chosen the modest boost path, while BMW has chosen to use high boost to maximize performance. On average, EEA estimates that a turbocharger will provide a 10 percent benefit in fuel economy for diesels.

9.1.4 Environmental Constraints

The effect of turbocharging on emissions is dependent on the application. For gasoline engines, turbocharging can increase emissions for two reasons. First, the thermal mass of the turbine wheel in the exhaust delays catalyst warm-up, increasing HC and CO emissions.

Second, if a smaller, more highly loaded engine is used (i.e., the turbocharger is used as a fuel economy device), NOx emissions will increase. If the engine is not more highly loaded (i.e., the turbocharger is used to provide extra performance only), the turbocharger does not affect emissions on the EPA test cycle as there are no "wide open" throttle driving regimes during the test.

For diesel engines, the use of the turbocharger as a combination fuel economy/performance device typically results in decreased HC and particulate emissions due to the extra air available for combustion. NOx emissions may increase, but only by a small percentage. Thus, in general, the use of turbochargers on diesels result in more favourable emission characteristics.

9.2 OTHER SUPERCHARGING TECHNOLOGIES

Although the turbocharger is the most widely used form of supercharger, several other supercharging technologies are being researched. The most important technologies are:
- Comprex
- Roots blowers
- Positive displacement pumps

These technologies are being investigated to eliminate the turbocharger's problems of poor low end torque and difficulty of matching with piston engine requirements.

9.2.1 Comprex

Comprex superchargers have been investigated for decades in Europe, principally by Brown-Boveri and MAN. They utilize the pressure pulsations in the exhaust manifold to compress intake air in a rotating device that actually places the intake and exhaust gases in contact with each other. This also results in some mixing of exhaust gases with the intake air. Although the Comprex has worked in diesel engine applications, it has been difficult to control and has proven expensive. EEA is of the opinion that it is likely to be available in the post-1990 time frame, with some diesel models from Europe.

9.2.2 Roots Blowers

Roots blowers have been in use in aircraft engines since World War II and in limited production automobiles (such as Bentley and Mercedes) in the early 1930's. There has been renewed interest in this device recently, and Ford has introduced this technology into the market in 1990. The Roots blower is similar to a gear pump in operation, and consists of two lobe rotors geared together and enclosed in a housing.

The rotors are connected to the engine crankshaft via a toothed belt and their rotation provides compression of intake air. Roots blowers are considerably bulkier than turbochargers and require precision castings and pressure seals for proper operation. However, they provide constant boost over much of the engine operating range, except at very low speeds where air leakage past the rotors results in very low boost.

9.2.3 Positive Displacement Pumps

Positive displacement pumps are similar to air pumps used in current vehicles for emission control. Supplier companies have been developing these pumps (vanetype) for use on superchargers. As with Roots blowers, they are bulky and need to be driven off the crankshaft. They are cheaper to produce than Roots blowers and produce somewhat higher low-speed torque. However, their durability characteristics are inferior to Roots blowers.

9.2.4 Application

Competition between Roots blowers and vane pumps for the gasoline supercharger market is likely. Since their size increases linearly with engine size, they become much too bulky for use with large engines. In addition, since they are driven off the crankshaft, the drive system becomes too complex to transmit the high power required.

For these reasons, EEA believes that superchargers (either Roots or vane-type pumps) may be used in small and compact cars as well as small LDT's. In both categories the application of superchargers can be combined with engine downsizing/axle ratio reduction to provide increases in fuel economy. Ford is using superchargers with a large V-6 (3.8L) engine, and the results have been mixed.

Unlike turbochargers, these supercharging technologies are more compatible with gasoline engines since diesels have much higher airflow at the same power, requiring greater power input to the supercharger. EEA estimates that superchargers can provide a 5 percent gain in fuel economy for gasoline engines for constant performance comparisons. However, superchargers may be offered as an option to increase performance, and reduce this benefit.

As stated earlier, their application will be restricted to small engines in cars. Consumer prices for the supercharger are likely to be $250 to $300 depending on application. The Roots blower is likely to be more expensive but offers greater durability and quieter operation. The cost and complexity of supercharging will result in these technologies being used as a limited high performance option, rather than as a fuel economy device.

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WORKING PAPER NO. 3

PRODUCTION AND MARKETING FACTORS AFFECTING THE INTRODUCTION OF FUEL EFFICIENT TECHNOLOGY

PREPARED FOR:

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

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T A B L E   O F   C O N T E N T S

L I S T   O F   T A B L E S

CONTEXT

Within the context of developing a comprehensive policy response to the Government's planning target to reduce greenhouse gas emission, the Department of Transport and Communications acting in concert with a number of other government agencies commissioned Nelson English, Loxton and Andrews Pty. Ltd. (NELA) to assess the potential to reduce fuel consumption by new passenger cars sold in Australia.

Interim information is being presented to the Steering Committee by way of a series of seven Working Papers as follows:

Working Paper No.	Title
1	Available Options for Fuel Efficient Technology
2	Documentation of Technologies Available to Improve Vehicle Fuel Economy
3	**PRODUCTION AND MARKETING FACTORS AFFECTING THE INTRODUCTION OF FUEL EFFICIENT TECHNOLOGY**
4	Population, Passenger Car Stocks and Fuel Consumption Performance
5	Report on International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, Berlin, 25-28 March, 1991
6	Review of Policy Instruments Available to Governments
7	Definitions, Process and Procedures.

1. INTRODUCTION

1.1 BACKGROUND

The Australian motor vehicle industry is small by world standards and has experienced difficulties achieving the economies of scale of the larger manufacturers. The small size of the domestic market also constrained the activities of the motor vehicle manufacturing industry in respect of R&D and other developments that might have facilitated the adoption of new technology directly impacting on vehicle fuel economy.

Under the Government's motor vehicle policy (Button Plan), announced in 1984, the industry is to be restructured and modernised by the early 1990's to increase its profitability, efficiency and competitiveness. By that time vehicle manufacturers are expected to be achieving increasing economies of scale through the reduced number of models being made locally and co-operation between manufacturers on standardised components and common technical standards.

1.2 OBJECTIVES

The objective of this Working Paper 3 is to examine the issues surrounding the production of new vehicles in Australia, and the feasibility of introducing technical options into the Australian marketplace.

Dimensions of this include:
- o the factors affecting the cost of manufacture of new vehicles in Australia;
- o the factors affecting new vehicle purchase decisions in Australia.

1.3 APPROACH

The first part of this Paper concentrates on the sources of development and manufacturing costs of technical options in Australia.

The results were obtained from a review of the Industry Commission (1990) report on The Automotive Industry, supplemented by meetings with the engineering, product planning and government relations staff at the five Product Plan Manufacturers' plants in Victoria and South Australia. during early April, 1991. These discussions produced an appreciation of their productive capacity, attitude to manufacturing in Australia and the culture of the "Australian Car".

This information was supplemented by information from the Berlin Conference on The Clean and Fuel Efficient Motor Vehicle and the experience and judgement of EEA and Jack Kelly.

The second part addresses the culture of the automotive industry and addresses factors affecting the purchase of new vehicles in Australia and hence the sources of consumer surplus. This information was obtained from discussions with manufacturers, supplemented (in the absence of documentary evidence from manufacturers) by the findings of Artcraft Research (1988) and econometric studies by the ITS.

These matters provide the basis for estimating the extent to which candidate policy instruments (such as mandatory fuel economy goals, vehicle labelling, fuel price, sales tax, purchase price increments, etc.) impact on the policy options considered in WP6.

2. TECHNICAL FEASIBILITY OF INTRODUCING NEW TECHNOLOGY

With few exceptions, all of the cars sold in Australia were designed in Europe, Japan and the U.S.A. Australia is too small a market to carry its own design and manufacture operation, although it cannot be denied that Australians participating in the industry have some achievements to their credit. The Ford Falcon and the Holden Commodore are essentially "Australian" vehicles (the Falcon engine, for example, being unique), Mitsubishi Australia is exporting Magna station wagons to Japan and Henderson Springs exports its products to Mercedes.

However, these are particular circumstances and the general proposition holds that the automotive industry in Australia is very dependent on its overseas owners, all of whom are global manufacturers.

Those global manufacturers always have the option to meet Australia-specific fuel economy standards by restricting products, and supplementing that policy with a few modest design improvements to a handful of products, rather than spend the billions necessary to redesign vehicles just for Australia.

2.1 ENGINES AND TRANSMISSION MANUFACTURE

The majority of engines built in Australia are designed overseas with some local modifications for Australian Design Rules e.g. General Motors Holden, Toyota, Nissan and Mitsubishi.

The exception is Ford who have designed the 6 cyl. OHC engine independent of USA. This is expected to continue.

The manufacturing status (on a value basis) of engines sold in Australia is provided in Table 2.1, by Plan Producer and engine size.

TABLE 2.1: MANUFACTURING STATUS OF ENGINES ASSEMBLED IN AUSTRALIA

		FORD	GMH	TOYOTA	NISSAN	MITSUBISHI
V-8 Engines		Imported	95% Local	N/A	N/A	N/A
1-6 Engines		90% Local		N/A	N/A	N/A
V-6 Engines			Assembly Only	N/A	N/A	N/A
1-4 Engines		Imported				
	1.6L		Local Exported	80% Local		
	1.8L		Local			
	2.0L		Local Exported	80% Local	70% Local	
	2.6L					80% Local
Manual Exmission		100% Local	Imp.	Imp.	Imp.	Imp.
Auto Exmission	3 Speed	N/A				
	4 Speed	100% Local	Imp.	Imp.	Imp.	Imp.

Some of the engine plants are long established - e.g. GMH Family II at Fisherman's Bend is quite old. However, some are equipped with modern plant, e.g. the Ford engine plant at Geelong.

Local transmission production is at BTR in Albury.

2.2 OTHER AUTOMOTIVE COMPONENTS

There are a large number of Australian components manufacturers, producing engine, chassis, transmission, drive line and rear axle components.

It was considered that this subsector has only an indirect effect on fuel economy, and the Study did not examine the characteristics of this industry except to note the comments made by the Industry Commission (1990), that some contraction is inevitable.

This would affect the capability of the automotive industry to manufacture new technology locally unless those components have an export potential.

For a large export potential to exist, it seems likely that exports would have to be channelled through the five global manufacturers which assemble in Australia, and hence the design of vehicles manufactured in Australia would have to be compatible with the global product of those manufacturers.

2.3 RESEARCH AND DEVELOPMENT FACILITIES IN AUSTRALIA

Most Australian suppliers have access to R&D facilities overseas via their parent company or by licensing agreements with overseas firms. This is particularly so for critical items including pistons, electricals, bearings and seals.

All local manufacturers have R+D facilities, but generally these are only used for auditing and process improvement, because the five automotive companies generally use overseas prints or specifications for the types of products that are purchased locally.

However, Australian automotive manufacturers and others have built up a capability for research and development.

Ford Motor Company

Ford Australia recently introduced the EA-26 6 cyl 3.9 litre OHC engine, which was completely designed in Australia. They also designed the current model, Falcon and the Capri convertible.

They have extensive R+D facilities plus world class test track and emission laboratories.

General Motors Holden

GMH has extensive R+D facilities including test track and emission laboratories, but in the last decade have relied on imported design.

Orbital Engine Company

This company has designed a 3 cyl 2 stroke automotive engine, a single cylinder motor scooter engine and a V-6 2 stroke engine, and has sold prototype engines to most automotive companies under licensing agreements. Their engine has met USA rules for emissions and fuel economy proposed for years from 2000.

They have one of the best independent R+D establishments for internal combustion engines in the world. Manufactured in Michigan in 1992.

C.S.I.R.O./Universities

They have extensive R+D facilities but limited automotive.

Oil Companies

All have extensive facilities for R+D in fuel and lubricants.

2.4 CAPABILITY TO RESPOND TO NEW REQUIREMENTS

There are long lags in introducing new motor vehicle technologies. After initial laboratory work, production planning and engineering takes 3 to 5 years; from engineering to initial production takes another 3 - 5 years; while building up production rates can take a further 4 years. Hence a decision on new motor vehicle technology can take 15 to 20 years (or even longer) before it becomes the dominant technology on the road.

Uncertainties affect the propensity of manufacturers to invest. In a business environment where there is significant Government intervention, and manufacturers are less likely to be willing to invest in plant which cannot be amortised quickly. Rather, they will undertake assembly by manual techniques and import or buy in components.

The Industry Commission (1990) examined the factors affecting the resilience of the automotive industry in far greater detail than is possible by this Study. The IC clearly envisages a reduction in the number of Plan Producers, which is not an issue for debate within the Terms of Reference for this Study.

However, production practices were discussed with Plan Producers, and estimates made of the amount of additional investment required in Australia to bring the Maximum Technology Scenario to fruition. These estimates are made on the basis of the new vehicle volumes forecast in WP4, and on the assumption that either all five Plan Producers will be retained, or at least any industry rationalisation will not adversely affect production practices and costs.

It is recognised that this last is a very large assumption. However, it is necessary to provide a consistent basis for policy evaluation discussed in WP7 and the main report.

2.4.1 Effect of Labour Costs

The Study has noted Industry Commission (1991,p.210) concern about the cost of labour in Australian automotive manufacturing compared with overseas firms. The following assessment is based on information obtained from manufacturers and Jack Kelly's knowledge of the industry.

Additional labour costs arise not necessarily because of labour rates/hr which are lower in Australia than in the U.S.A., but wages overhead and work practices including hours worked, penalty rates, compulsory superannuation, absenteeism, leave loading, staff turnover, Workcare, payroll tax and restrictions on discipline.

Typical work patterns in the US versus Australia were assessed as follows:

	U.S.A.	AUSTRALIA
Days/Year	365	365
- Week ends	104	104
- Paid Holidays	5	10
Paid Days	256	250
Paid Vacation	10	20
Working Days	246	231
Rostered	NIL	11
TOTAL	246	221

This result is similar to the IC finding that Australian workers input fewer hours per year than their US or Japanese counterparts. However for the US at least, this is compensated by a lower hourly rate ($8/hr Australian to ($/c US/0.74) = $13.50 Australian). Using IC results, the comparison is as follows:

	AUSTRALIA	USA	JAPAN
Hours per year	1657	1852	2360
Payroll Yearly Salary (Automotive Ind. Report)	$20000	$30000	A$50000 (1)
+ 45% for Penalty rates Payroll Tax, Holiday Loading, Workcare:	9000	3000	NIL
TOTAL	29000	33000	50000
Hourly Cost	$A17.5	$A17.8	$A21.18

Note: 1. Includes Bonus.
2. Source: Industry Commission (1991).

This suggests that the basic direct labour costs are not significantly different between the US and Australia, and about 20 percent lower than in Japan. Discussions with individual manufacturers indicates that for particular plants, the differentials may be even smaller than those shown.

It is considered that the cause of total production cost differentials may lie with the choice of mass production versus lean production techniques (Womack et al:1990), and the plethora of Government charges and work practices which have grown up around the industry and those which service it.

It should be noted that Plan Producers already have extensive employee relations programmes in place, for implementation of cost savings and quality improvement.

2.4.2 Ease of Introduction of New Technology

This question can only be assessed subjectively, because a judgement depends on a wide range of factors including whether a manufacturer adopts mass production or lean production techniques, capability of component suppliers and penalties applicable to imported components, and the microeconomic environment imposed by industrial relations matters and systems of Government supervision, taxes and charges.

Based on discussions with manufacturers, Table 2.2 indicates the Consultants' perceptions of the ease of implementation of the feasible technical options discussed in WP1, by Plan Producer.

TABLE 2.2 EASE OF IMPLEMENTATION OF FEASIBLE TECHNICAL OPTIONS BY PLAN PRODUCER

	FORD	GM	TOYOTA	NISSAN	MITSUBISHI
Front Wheel Drive	X	X	Y	Y	Y
Weight Reduction	P	P	P	P	P
Drag Reduction	P	P	P	P	P
2 Stroke Engines	X	X	IMP	IMP	IMP
4 Valve Engine OHC/DOHC	X	IMP	IMP	IMP	IMP
Const. Veloc Xmission	na	na	IMP	IMP	IMP
5 SP Automission	X	IMP	IMP	IMP	IMP
Variable valve timing	X	IMP	IMP	IMP	IMP
Engine friction redn.	Y	IMP	P	P	P
Electric Power STG	na	na	IMP	IMP	IMP
Imp Tyres and Lubricants	P	P	P	P	P

LEGEND

X = investment to implement
Y = implemented
P = in process
IMP = imported

It is noted that Plan Producers have already embarked on programmes of reducing weight and drag, and improving tyres and lubricants. The status of progress depends largely on manufacturer concerned.

Changes to current design rules can affect vehicle costs in the short term, and particularly so if the rules exceed what has been previously established in other countries, especially the U.S.A. However, new Australian safety and emissions requirements likely to be introduced during the planning period are unlikely to be more stringent than the proposed US 1994 requirement, and this can be accommodated.

2.4.3 Investment Requirements

It is the case that all Plan Producers are involved in an ongoing capital investment programme which, although confidential to each firm, is necessary to introduce the technology anticipated by the NAFC forecast prepared by the FCAI and envisaged by the Product Plan scenario. This appears to be about $500m annually in 1988 dollars (EIU:1991,p.84).

The Product Plan references most or all of the technical options discussed in WP1. The Maximum Technology Scenario represents an early introduction of some technical options, and either an accelerated investment programme or alternatively import of a large proportion of necessary components. However, some can and will be manufactured in Australia subject to capital availability and volume restrictions.

Table 2.3 summarises the estimated additional investment required in Australia to place the local industry in a position to introduce the technology discussed in WP1 into the Product Plan and the Maximum Technology Scenario at 2005. Very largely, this additional expenditure would not occur before 1995, because manufacturers plans are mostly fixed up to that date.

TABLE 2.3: ESTIMATED PLAN PRODUCERS' AUSTRALIAN INVESTMENT REQUIREMENT BY TECHNOLOGY TYPE

Technology	Plan Producers Involved	Capital Reqt. ($m)
Front Wheel Drive	2	350
Weight Reduction	5	390
Drag Reduction	5	140
Four Valve Engines	2	370
5 Speed Automatic	1	100
Variable Valve Timing	2	370
TOTAL		1720

Note: 1988 $A

This amount represents the additional cost of land and buildings, plant and equipment, tooling and labour expended on capital items. It allows for import of a range of parts in accordance to the structure indicated by Table 2.2.

One issue arises in respect to the improved two stroke engine, because Orbital Engine Company is an Australian company. It may be expected that these items could be manufactured in Australia. However, discussions with Orbital Engine Company indicated that there are no current intentions to manufacture in Australia. Rather, the company sees itself as a purveyor of intellectual property to global manufacturers and appears to have had some success with this strategy (The Age:24/5/91,p.19). Decisions about plants and point of manufacture are in the manufacturers' hands rather than Orbital's.

Consequently, it was assumed for the purpose of these estimates that such engines would be imported.

Estimating the extent to which this programme is likely to be brought forward by the Maximum Technology Scenario is much more difficult. However, based on the relative penetration required as documented in WP1, it was concluded that the Maximum Technology Scenario would require that investment be brought forward by five years.

Assuming real interest rates for risky investments at 10 percent, and that investment which would be made between 2000 and 2010 under the Product Plan is brought forward to the period 1995-2005 for the Maximum Technology Scenario, it was estimated that the additional cost of the Maximum Technology Scenario would be about $200m in 1988 dollars.

2.5 WEIGHT AND COST PENALTIES OF NEW TECHNOLOGY

The modelling process required an assessment of the increments to weight and cost which would arise as a result of introducing technical options according to the Product Plan and Maximum Technology Scenarios. The estimated penalty for each vehicle class at each target year took into account all technology improvements applicable at a given target year, the penetration of those improvements and the unit weight or cost increment.

Weight penalties are a function of technical specifications and an average weighted increment was provided by EEA. The weighting was undertaken in line with the market penetration of each technology into sales for each class of vehicle at each target year. This penetration is included within the definition of each Scenario.

Cost increments due to the introduction of particular technologies into each make/model are confidential because they relate to patent access arrangements and manufacturing cost structures in Australia and overseas. In addition, the cost picture is confused by changes to currency values and tariff rates, as well as the propensity for Plan Producers to import a large range of components.

However, the Consultants gained access to sufficient information from various sources to be able to broadly assess the average weighted cost (in constant 1988 $A) of technology improvements by vehicle class and year.

A piece cost for each technology was estimated by EEA in 1998 $US and Jack Kelly in 1991 $A. The components of piece cost includes the direct costs of materials and labour, amortisation, applicable taxes (except sales taxes) and retail markup. A uniform percentage was used for retail markup, although it is recognised that product pricing involves a large number of factors other than the costs of manufacture and Government charges.

Thus piece prices were estimated to include amortisation of capital, except the cost of bringing capital programmes forward, which was treated separately.

While there was some variation between the results, the numerical result was more or less similar for each estimate, after correcting the latter to 1988 $A.

This may be surprising given the large difference in retail prices of new vehicles sold in Australia versus overseas, but is quite consistent with the differences in labour costs pertaining to the US versus and Australia. An early conclusion of the Study was that Australian assembly costs are adversely impacted much more by small volume and Government charges than by differences in labour and plant costs. Doubtless there is also some cost penalty arising from tariff protection.

Piece costs were grossed up on the basis of the penetration of each technical device, for the Product Plan and the Maximum Technology Scenario. The process took into account the fact that some components would be imported, and locally produced components would be made behind a tariff barrier.

However it was considered that for whatever reason, the marginal retail price of fuel economy in the early years would be substantially greater than the piece costs. Accordingly, it was decided to increase the piece estimates abovementioned by factors to account for Australian sales taxes and tariff protection under the Car Plan. Tables 2.4 and 2.5 provide a summary of the weight and cost penalties applicable to each class and year for the Product Plan and Maximum Technology Scenarios respectively.

2.6 CONCLUSION

Technology improvements addressed to fuel economy will reference bodywork, engines, transmission, accessories and options.

It is typical of automotive manufacturing that there be a large difference in efficiency between plants, depending on whether mass production or lean production methods are used. However, Australian unit labour costs are not greatly different from those in similar plants overseas, on a plant for plant basis.

Volume and Government charges are the main factors affecting the cost efficiency of automotive manufacturing in Australia, although the effects of tariff protection are undoubtedly significant albeit indirect.

Plan Producers mostly but not exclusively use flexible manufacturing processes on assembly lines, and these are marginally more consuming of human resources than lines which are dedicated to manufacture of a single vehicle model.

TABLE 2.4: VEHICLE PENALTIES - PRODUCT PLAN

	1990	1995	2000	2005
Mini				
Weight	870	882	860	838
Power	72	75	75	73.5
Price	0	108	259	421
Small				
Weight	1030	1055	1027	998
Power	94	103	98	93
Price	0	250	421	616
Sports				
Weight	1200	1212	1180	1151
Power	125	129	125	120
Price	0	107	277	458
Medium				
Weight	1250	1295	1258	1220
Power	172	181	181	111.5
Price	0	169	389	620
Upper Medium				
Weight	1420	1425	1404	1383
Power	172	181	181	181
Price	0	223	472	743
Luxury				
Weight	1355	1355	1307	1259
Power	175	177	170	163
Price	0	228	748	1268

Note:
1. Weight in kg, Power in HP, Price in 1988 $A.
2. Does not include the affect of 1994 US emission/safety standards, which require an additional 30kg weight.

Changes to body materials (e.g. introducing more plastic components) or to body shape (to reduce C_D) would improve fuel economy but could substantially increase costs of panels. Volume increase and reduced complexity are two items that can help reduce the cost of engine manufacture.

Flexible machining practices with good engineering should reduce capital and tooling investment over a period of time, thus reducing piece cost.

Transmissions, accessories and options are mostly supplied by components manufacturers, although many are imported. Again, volume is the key to keeping Australian components manufacturers viable.

TABLE 2.5: VEHICLE PENALTIES - MAXIMUM TECHNOLOGY

	1990	1995[3]	2000	2005
Mini				
Weight	872	882	840	795
Power	72	75	72	67.5
Price	0	108	329	586
Small				
Weight	1030	1055	1007	945
Power	94	103	95	86.4
Price	0	250	498	773
Sports				
Weight	1200	1212	1151	1090
Power	125	129	122	116
Price	0	107	455	817
Medium				
Weight	1250	1295	1230	1165
Power	114	125	119	113
Price	0	169	522	892
Upper Medium				
Weight	1420	1425	1344	1263
Power	172	181	175	165
Price	0	223	1133	1514
Luxury				
Weight	1355	1355	1269	1182
Power	175	177	168	159
Price	0	230	1083	2256

Note:

1. Weight in kg, Power in HP, Price in 1988 $A.
2. Does not include the affect of 1994 US emission/safety standards, which require an additional 30kg weight.
3. Assumes that calibrating cars to best U.S. practice has no price effect.

On the basis of the above review, it was considered that if Government were to implement policies aimed at improving fuel economy in Australia at the levels envisaged by the Maximum Technology Scenario, then manufacturers could respond despite the economic environment currently being imposed on the industry. Indeed, some manufacturers are well on the way to delivering fuel economy commensurate with overseas expectations already.

Estimates of cost increments per vehicle under the Product Plan Scenario at 2005 range from $421 to $1268 (constant 1988 $A) depending on the vehicle class, with the upper luxury class being the more expensive. For the Maximum Technology Scenario, the range is from $586 to $2256 per vehicle. In these estimates, the last two digits are not significant.

3. FACTORS AFFECTING PURCHASE OF PASSENGER CARS

3.1 FACTORS DRIVING MANUFACTURER'S DESIGNS

Because the motor car has been part of western society for 100 years, it is largely part of the Australian culture. Other interests such as housing, the work ethic, social and recreational activity, etc. all are directly affected by the convenience afforded by the motor vehicle and the mobility dimension directly affects decisions taken in those areas.

When considering the automotive industry in Australia, it is necessary to understand the culture of an underdeveloped road system, the rural ethic and the outdoor lifestyle which defined the stereotype of Australians right up to the 1970s (however misleading that stereotype may be).

3.1.1 The Automotive Tradition

The attitudes which drive the design of cars sold in Australia are essentially based in overseas markets, although there is some "Australianisation" as discussed below. There are two parallel streams driving these designs:

- o the tradition of the family car pioneered in the US by Henry Ford;
- o auto racing, which has been the cradle of automotive performance research throughout the world. The great auto races have always been in Europe (although the Indianapolis 500 is not to be discounted).

From the early part of this century, Ford, GM and other US manufacturers produced large powerful vehicles which were (and still are) observable in that market, especially up to the mid-1970s.

Over the last 20 years, the US car ownership has risen from 0.42 cars and personal light trucks (Schipper et al:1991) to 0.554 cars per person (OECD:1991). That passenger fleet includes the largest cars in the world.

Light commercial vehicles first found their way onto the market in the mid-1930s, when a Geelong farmer convinced Ford to create a vehicle which could be used for both social purposes (going to church) and for carrying farm produce.

The utility truck grew rapidly in popularity and today, sales of new passenger vehicles in the US is shared between passenger cars (65 percent) and light commercial derivatives (35 percent); i.e. large and small utilities and/or vans converted to passenger use. These derivatives are used for recreational purposes as well as the utilitarian ones as originally conceived.

The breakdown of US new car sales for 1989 reveals the specialist nature of that market which has developed from the early 1970s (Womack et al:1991,p 122):

TYPE	SIZE	PERCENT
Passenger Motor Vehicle	Luxury	5
	Large	8
	Intermediate	14
	Compact	30
	Subcompact	7
	Subtotal	65
Light Commercial Derivative	Large Utility Van	15
	Mini van	5
	Small Utility	15
	Subtotal	35
	Total	100

US vehicles were developed for use on very high quality roads, pioneered in California and represented by the extensive Interstate System which was built by the US during the 1950s and 1960s. In the US, a tradition of power developed not only from the need to drive the large vehicles, but also because it was not unusual in the early 1970s for US drivers to travel 700 miles or more in a single day.

These long hours at the wheel required a degree of comfort, leading to the "armchair ride" which is characteristic of US vehicles and which is delivered by soft suspensions and power steering. Comfortable cornering ability was not required because the roads were built with large radius curves (although US cars can corner surprisingly well if pushed and one ignores the screaming tyres and adverse cant).

Gasoline was plentiful and cheap, with prices before about 1975 held below world parity by price controls on American oil producers. Thus fuel economy considerations were irrelevant to the "gas guzzlers" before the first oil shock in the early 1970s.

In Europe, the Autobahn developed in Germany during the 1930s set down a tradition of speed unlimited which exists to the present day. Even in 1991, the high speed roads in Europe carry no speed limit, and the fastest cars in the world are manufactured in that market (Porsche, Ferrari, Mercedes, BMW). and the size and power of engines has increased steadily. In Europe, specific power output per litre of engine capacity increased about 50 percent to the ten years to 1989 (Anman:1989) and in Germany, installed engine power has nearly doubled in the last 20 years (Flenker:1991,p.3).

European population centres and the Autobahn feature on-road drive cycles which are characterised by short trips, traffic delays, high accelerations and high speeds, all of which lead to sharp increases in fuel consumption. However, all fuel (gasoline or diesel) was imported and the combination of transport cost and import duties made European fuel as expensive as most countries anywhere and this pressure flowed through to fuel efficiency in engine design, up to 15 percent diesel power and a higher proportion of smaller and medium size vehicles than in the US.

Many European countries (e.g. south of France, Spain, UK) did not see high speed roads until well into the 1970s. It was necessary for European manufacturers to develop handling capabilities for fast cars to manage the tight curves and narrow roads with a measure of safety. Out of this tradition came the "European feel" which is characterised by stiff suspension, flat cornering and direct steering.

Overseas consumer research suggests that today, new car buyers consider a range of attributes - brand, safety, interior volume, size of boot, handling characteristics, price, reliability and so on (Ledbetter:1991).

However, the tradition of "smarter, bigger, faster" has grown rather than diminished with increasing world affluence through the 1970's and 1980's. By 1986, 40 percent of all new cars in Britain were capable of exceeding 190kph (although the speed limit was only 110kph; over half could accelerate to 100kph in less than 10 seconds (Petter and Hughes, 1990, cited by Fergusson:1991).

The OECD (1991,p.66) found that early improvements in fuel consumption of new motor vehicles have been offset by the growth in the size and intensity of use of the vehicle fleet in the various countries. In addition, efficiency improvements have been adversely affected by the trend towards heavier and more powerful vehicles, particularly in the passenger car sub-sector. It concluded that such shifts in consumer preference have had a strong effect, along with the increase in the number of vehicles in use, on the sustained growth of fuel demand experienced by the road transport. These overseas precedents are believed to have influenced automobile development in Australia.

3.1.2 Adapting the tradition to Australia

Manufacturers such as General Motors (Chevrolet, Pontiac, Buick), Ford (Lincoln Continental) and Chrysler were the basis of the industry which fathered Australian automotive manufacturing in the 1940s and 1950s.

Before World War II, US and European (particularly UK) cars imported to Australia brought with them the Ford tradition of interior space (reinforced by American cars disposed after World War II) and the "European feel" as represented largely by British Motor Corporation vehicles. There were also a small number of Japanese cars from about 1934.

Although there has been Commonwealth road funding since the 1920s, the road system was relatively undeveloped at that time. Before 1970, less than 20 per cent of Australian roads were sealed (CRB:1973) Early Australian road programmes had concentrated on delivering sealed farm to market roads. Rural arterials were commonly unsealed, especially in western NSW and Queensland and in SA and WA, these being largely the responsibility of the States. There were virtually no urban road programmes, and city streets were rough.

The image of "Australian conditions" inherited by the automotive manufacturers after World War II lies with the famous Redex trials of the 1960s. This can be described as in terms of a need for vehicles to be able to cope with extremes of heat and dust, and to negotiate streams without becoming bogged or "bottoming" in gibber country and damaging underfloor equipment (crank case, transmission).

In general, strong suspensions and high clearances were needed to cope. Tyre strengthening programmes were pursued by tyre and automotive manufacturers in consultation.

Car ownership was not high by American standards, and few Australian households were expected to own more than one car. Thus the same vehicle was required to perform both a town and recreational function. Australian distances were large (800-1000km between capital cities) and interior space could not be compromised.

Australian consumers took a holistic approach to their purchases, and variously sought a mix of vehicle attributes including:

- large interior and boot space provision, to accommodate nuclear families, especially on social visits and holidays;
- torque characteristics which placed high performance at the high revs end. This gave maximum speeds under 140kph (which was about the best the roads could accommodate) but good acceleration performance which allowed overtaking on narrow two lane roads;
- stiffer suspensions and direct steering to accommodate tight curves and deliver good road holding capability;
- sufficient strength, clearances, tyres, accessories (cooling system) and dust sealing to cope with reasonably regular use on rough country roads.

There also evolved a large demand for towing capacity due to:

- recreational demands arising from the good weather;
- rubbish disposal from backyard gardening;
- the large rural market (horse floats, etc.)

The required mix of attributes was unavailable in any car made overseas. The imports did not translate well to Australia and when GM and Ford were established after World War II, a considerable effort was made to "Australianise" automotive designs.

GMH and Ford Australia were established under a regime of strong economic regulation which has persisted in various forms to the present day. Such regimes are to be found in all developing countries, and in many developed ones as well. Tariff barriers in Australia reached nearly 60 percent by 1970.

Manufacturers were able to accommodate the necessary R&D expenditure, and investment in product lines, and automobile and component manufacturing industry became one of the largest industries in the country, with over one million jobs.

There was substantial market intervention through sales taxes on motor vehicles, various ownership charges (registration charges, etc.) and fuel taxes. Motor vehicles in Australia have always been more expensive than in most OECD countries (a trend which is increasing), and this has held car ownership to levels below the US but ahead of some European countries.

Especially the Holden, but also the Ford companies went to considerable lengths to differentiate an "Australian car" featuring the consumer demand vehicle attributes described above, and they still meet that specification very well.

During the 1960s, Japanese vehicles again began to appear on the Australian market. These were originally designed for overseas conditions and the early imports experienced the same difficulties as the early European and US designs.

However, Japanese cars are now imported both by Plan Producers and Japanese firms, and fully imported Japanese cars represented almost 18 percent of sales in 1990. 77 percent of these are mini, small and medium classes, and nearly 12 percent in sports.

Although there had been petrol rationing during World War II, the election of the Menzies government in 1947 brought with it a perception that rationing was no longer needed, and the issue of fuel consumption has only been high on the public agenda during the oil shock of the 1970's and to a lesser extent during the Gulf War.

Fuel prices in Australia are second lowest in the OECD countries; only the U.S. has lower prices. This is despite world party pricing of crude oil and substantial fuel taxes which receive political attention from time to time.

Certainly fuel prices in Australia have never had the impact on automobile attributes as has been the case in Europe and Japan, and new cars sold on the Australian market provide a broad shandy of almost all vehicles sold throughout the world. (Some advanced models and Central European cars being the exception).

3.1.3 An Interpretation of the Manufacturers' Perspective

At the outset, it is necessary to keep in mind that all Plan Producers have overseas owners and, when considering those influences on the design of vehicles sold in Australia, it should be remembered that few manufacturers think nationally; there are international pressures brought on by world trade and tourism that local manufacturers in any country ignore at their peril (Orfeuil:1991,p.12).

Not the least of these pressures is the outlook for the world market, which may grow during the period of this Study from about 500 million to about 800 million - 1100 million vehicles (Walsh:1991). While some of this growth will continue in the major markets of the U.S., Western Europe and Japan, the major proportion of new registrations will be into developing countries where price and fuel economy will be important imperatives.

It is to be expected that manufacturers' global strategies will not only continue the development of fuel efficient small cars, but they will also press for harmonisation of compliance and a commonality in vehicle attributes among markets.

In other words, there is a strong incentive for the global manufacturers to ensure that markets in particular countries (such as Australia) are supply driven.

However, it is to be expected that manufacturers and their retail distributors will try to understand the reasons that different passenger vehicle models have different market shares. This requires a knowledge (quantitatively or qualitatively) of local consumer demands or tastes for vehicle attributes (price, fuel economy, styling, performance, reliability etc.) and the constraints which limit the translation of unconstrained tastes into actual purchase decisions.

Although no manufacturer was prepared to document its perspective of the determinants of consumer choice in motor vehicle purchase, the issue was discussed at length with representatives.

The manufacturers' perception of the new car market appears to lie very much with the culture described in previous Sections. The Australian market is seen to be low volume by world standards, with a demand for a wide range of choice from large luxury cars to minis.

This means that investment costs are high relative to production volumes of specific models, and this leads to perceptions of higher unit costs and long model life cycles among some manufacturers.

However, there was no agreement on this point. Some manufacturers have adopted flexible (lean) production practices analogous to those prevailing in Japan (Womack et al:1990, Chap. 4). The influence of overseas ownership and the place of the Australian arm in the owner's global strategy seems for some to be of greater relevance than the specific characteristics of the Australian market.

There is a perspective among Australian manufacturers that customers have and will continue to demand increases in comfort, drivability, luxury and aesthetics (OECD/IEA:1990,p.6). In addition, they believe Australian consumers insist on a towing capability and that it is difficult to break these current consumer demand trends in a free society.

Very largely, the vision of "smarter, larger, faster" cars appears to be led by the manufacturers of luxury and sports vehicles, particularly European models but more recently those Japanese firms which have entered into competition with the Europeans.

Several manufacturers emphasised the large proportion of unsealed roads in Australia, and the harsh environment which gives rise to a need for manufacturers to counter problems arising from dust and high temperatures.

All manufacturers agreed that Australian passenger cars needed a towing capability, and be able to cope with long trips (i.e. interstate or intercapital) with heavy loads for families on vacation. Some have gone to considerable lengths to ensure that their front wheel drive products are competitive with the rear wheel drive market leaders in towing capacity.

The issue of towing capacity needs to be addressed with some care, and the discussions with manufacturers were inconclusive. On the one hand, it is not unlikely that the reason Holden and Falcon cars still feature rear wheel drive has more to do with the costs of changing production lines then with a need to retain a towing capability. On the other hand, those manufacturers claim that their towing capacity is restraining the penetration of CV derivatives into the Australian market.

Manufacturers claim that the advent of CAFE standards in the US reduced less powerful vehicles and customers who need towing capacity simply shifted to utilities, panel vans and four wheel drive vehicles. On the US market, CV derivatives command 35 percent of light vehicles sold for passenger use.

This may be the case in part; however NELA believes that a second factor is at work, viz. segmentation of the market as car ownership increases towards and beyond 0.5 cars per person. Enquiry in the US indicated that US light truck sales doubled between 1972 and 1978, which was prior to the introduction of CAFE in 1978 and coincident with the oil shocks of the 1970s.

On balance, the Consultant concluded that growth in CV derivatives is more a feature of the product specialisation which comes with high car ownership (approaching 0.5 cars per person). The forecasts in WP4 suggest that new light passenger vehicles sold in Australia could include 18 percent of CV derivatives by 2005.

It may be that the manufacturers' vision of the family car as a tow truck is reinforced by US precedent, and a concern to retain market share of the upper medium class vehicles which are the bulk of Australian product.

However, their point that a high proportion of CV derivatives has consequences for fuel consumption is well taken.

With one exception, manufacturers did not put a high emphasis on fuel economy, although it was not ignored in the mix of product features.

Market Segmentation

When considering the market faced by manufacturers, it must be remembered that it is significantly different from that occupied by an ordinary Australian, who mostly buys second hand vehicles. This also applies to some businesses such as taxis.

For manufacturers, over half of all new vehicles purchased are acquired by companies and Government. These need to be thought of in three segments:

- o vehicles for senior and lower level management (referred to

as "management vehicles";
- o vehicles for fleets and car pools;
- o vehicles bought for household businesses (i.e. "one man" firms such as agents, doctors, plumbers, etc who work from home).

Of these, about half of the purchases are thought to be driven by the requirements of senior management, who are concerned with issues such as company status, comfort, space and use of a company car for family purposes. Household business purchases are thought to be driven by similar criteria.

Fuel economy is important for company fleet purchases only.

As shown by Table 3.1, virtually no companies provide medium vehicles to their senior or second level executives, and less than 20 percent of companies issue sales representatives with these vehicle classes.

TABLE 3.1: PERCENTAGE OF COMPANIES ISSUING CARDS TO EXECUTIVES BY LEVEL OF EXECUTIVE AND MODEL OF VEHICLE

	Percentage of Issuing Companies		
Car type	**Senior Executives**	**Second Level Executives**	**Sales Executives**
Mercedes 560, BMW 750	2	2	
Jaguar/Daimler	3		
Mercedes 300, BMW 635/535	2		
BMW 525	2		
Ford LTD, BMW 320, Honda Legend, Volvo 740	32	5	
Fairlane, Fairmont Ghia, BMW 318, Cressida	49	22	2
Falcon GL, Commodore SS, Berlina, Skyline	6	56	8
Falcon S	2	3	13
Falcon GL, Commodore Exec, Pintar	2	10	58
Telstar, Camry		2	19

Source: Cullen Egan Dell 1991

Table 3.5 of WP4 estimates shows that in 1988, businesses purchased 43377 medium and 26358 mini/small vehicles, which represents 39 percent of all vehicles registered by businesses. There is no way of determining the business sector (i.e. household, management or fleet to which these vehicles were allocated, but if the figures are examined in the context of Table 3.3 of WP4, it can be surmised that the bulk of the mini/small classes are bought by household businesses, and the medium cars are allocated to sales executives and fleets.

Thus from a manufacturer's perspective, nearly half the new car market cannot be won over by emphasising fuel economy.

Competition Reinforces the Trends

For Car Plan manufacturers, product competition is intense among both local products and imports, and significantly influences their behaviour.

From a community perspective, luxury and performance attributes appear to be led slowly upward without limit, with the upper luxury and sports cars exhibiting quite startling performance characteristics (acceleration 0-100kph in 5 seconds; maximum speed 270kph!!), well beyond the capability of the road system to accommodate them safely.

There is no reason to expect that this culture will change, with European manufacturers' vehicles being produced for a road system which has no speed limits.

Incremental change is a necessary consequence of the small market and mature technology; it can be expected that they will resist rapid change (such as is envisaged for fuel economy under the Brief) unless there are clear signals sent to them from the market place.

Manufacturers are also aware that consumer tastes can be moulded to some extent by supply-side considerations, although it is a brave manufacturer who attempts to go against the general technological trend of the industry as a whole. For them, a knowledge of industry-wide trends is sufficient to guide likely scenarios of incremental change on an annual basis in vehicle design with respect to style, technology, performance and luxury.

Consequently, they will tend to continue to introduce new vehicles through marginal changes to the critical attributes influencing perceived consumer demand.

The typical product cycle starts with a new model introduced into the small car class, and then progressively upgraded in size and performance until it arrives into the large or even luxury class. As it moves up a class, its place in the lower class is taken by a new product. At the end of its cycle, the model name will be dropped and not returned for many years, if ever.

In interfirm competition, manufacturers view power and internal space as powerful weapons in the battle for market share and to ignore them in favour of fuel economy would be seen as a risk strategy.

The luxury manufacturers support their position to some extent by emphasising safety attributes; but the treadmill of competition among manufacturers of lower priced cars ensures that, unless someone moves to significantly change the culture, increases in size and performance will continue without limit and fuel economy will continue to be increasingly irrelevant. If one manufacturer does not supply performance attributes, then the next one will.

It is clear that if Government wants to bring fuel economy near to the top of manufacturers' agenda, some intervention is necessary to break the cycle. This probably means changing public perception of the merit of large and powerful vehicles and placing a cap on the upward trend in performance.

3.2 TODAY'S MOTORING ENVIRONMENT

In this Section, we argue that the factors under which the Australian motoring culture evolved have changed during the late 1980s and 1990s, except possibly for the real price of fuel. We need to consider today's environment if we are to identify the optimum form of intervention needed for improved fuel economy.

In considering the following discussion, remember that it focuses on private sales, which comprise only about 50 percent of new vehicle sales. However, about 65 percent of company cars are bought for use by managers, who have a substantial say in the choice of vehicle. To the extent that they value interior volume, and pay (or are at least aware of) FBT, it was assumed that their determinants of choice would be closely allied to those they would use if the decision was a private one, but the car was priced significantly lower. It was estimated that the following discussion may be relevant to at least 70 percent of the new passenger car market.

3.2.1 What the Consumers Are Saying - An Overview

Evidence about the determinants of consumer choice is not robust, but some information is available from Artcraft Research (1988), econometric modelling by ITS and discussions with manufacturers.

Table 3.2 summarises the reasons cited by a sample of some 900 private purchasers of new motor vehicles in three Capital cities during 1984 and again in 1987-88.

The Table shows that there are many factors which influence a private consumer's decision on which model to buy. Price, size, brand loyalty, appearance, recommendation, engine size and reliability were cited before fuel economy for selecting a particular model.

As is the case in overseas markets, Australians have little or no opportunity to buy fuel economy in a vehicle by spending more money. This suggests that neither consumers nor manufacturers are interested in fuel economy as a vehicle attribute.

1985 surveys of private buyers in Sydney supported by econometric modelling allowed the ITS to focus on competition among passenger vehicle models, based on consumer's demands for vehicle attributes and their choices among vehicle models.

The auto type choice model is described in more detail in Appendix B to WP7. A multinominal logic model was estimated for 2138 passenger vehicles in 1172 households. The model is estimated at the vehicle level taking into account household-level constraints. Each vehicle is evaluated in a choice set comprising the household's chosen vehicle and a random sample of 19 other vehicles from the universal set of all passenger vehicles. The choice sets are unranked, hence the parameter estimates are all generic with no alternative-specific constants.

TABLE 3.2: UNAIDED REASONS FOR SELECTING A PARTICULAR MAKE AND MODEL OF VEHICLE - 1984 AND 1988

	THE MAIN REASON		ALL REASONS	
	1984 TOTAL PERCENT	1987-88 TOTAL PERCENT	1984 TOTAL PERCENT	1987-88 TOTAL PERCENT
PRICE. Value, Good deal Trade in value	20	24	32	40
SIZE CONSIDERATIONS. Needed bigger car, Smaller car	11	11	26	30
OWNED SAME MAKE PREVIOUSLY. Loyal to brand	22	22	26	26
APPEARANCE. Style, Looks, Colour	9	10	21	25
RELIABILITY. Reputation, Mechanical reliability	5	7	15	19
FUEL CONSUMPTION. Good petrol consumption	6	4	17	16
RECOMMENDATION. Car of the year. Friend's advice	7	6	14	11
ENGINE SIZE. Power. Can tow boat. Fuel injected. Turbo	4	5	7	10
COMFORT. Quiet ride. Smooth on road	2	2	8	10
EXTRAS. Air conditioned. Power steering	2	2	8	10
HANDLING. Braking. Steering. Cornering	*	2	5	8
PERFORMANCE. Acceleration. Zip	2	2	7	6
REQUIRED SPECIFIC VEHICLE. Hatchback. Wagon, 4WD	4	2	9	4
OTHER MINOR REASONS: After sales service. Easy to get spares. Imported model. Australian made, assembled.				
Unsure	1	1	1	1

Notes: 1. Table ordered in terms of the last column
2. All Reasons columns add to over 100% as some people gave more one reason.

Source: Artcraft Research (1988)

The ITS results suggest that there are a number of factors which affect the purchasing decision which are also relevant to the eventual fuel consumption of the vehicle. These include:

- vehicle price;
- vehicle size index (based on length, width, height)
- vehicle weight;
- fuel economy;
- engine size, based on number of cylinders;
- max. net power (kwh) output;
  - transmission;
  - max. torque; - percent foreign mfg.
  - engine capacity;
- carburation type; and possibly
- compression ratio;
- fuel system.

The correlation between the two sets of research is apparent.

If we are developing policies which seek to reduce NAFC and latterly FAFC, these results set the agenda. The following sections consider them in the context of the Australian new vehicle market environment to point up discrepancies between facts and culture, and to address those attributes on which new technology and government policies are most likely to be effective in reducing fuel consumption.

3.2.2 Price

For private and company buyers, price includes a consideration of trade in value at end of a vehicle's service. In addition, manufacturers indicated that fleet buyers were concerned about fuel consumption (in the sense of calculating a net present value of the vehicle over its life).

However, Artcraft (1988,p.15) found that private buyers regard fuel costs as just one of the many costs of ownership and use of the vehicle, and one without great leverage on the purchase decision.

The ITS has recognised that changes in the prices of new vehicles will have an impact both within the new vehicle market (i.e. class share changes due to changes in the quantity of model lines demanded) and within the used car market.

Hensher et.al. (1991) has a scrappage model with price as a determinant. The implied mean elasticity of scrappage rate with respect to vehicle price is -0.66. Thus if we increase the price of a new vehicle by 10% this will reduce the mean scrappage rate of used vehicles by 6.6%. In 1988 this is equivalent to a reduction at the mean from 3% to 2.8%.

Evidence on the switch out of new vehicles in response to new price increases is limited because of the lack of econometric models for new vehicle which explicitly model the demand for used vehicles. Further, given that the scrappage rate is now about 3 percent, there is little scope for it to fall much further.

A Canadian study in the later seventies (Blomqvist and Haessel 1978) provides evidence to suggest that an increase in the price of new large cars tends to cause fairly substantial shifts in demand towards new small cars and possibly old cars.

An increase in the price of new small cars on the other hand shifts demand mainly towards old cars, but not towards new large cars. The implied elasticity of demand for used cars with respect to new prices of large and small cars are respectively 0.02 and 0.90.

A recent time series study by Hensher and Ho (1991) using annual data over the period 1961 to 1988 and a suitable lagged structure to account for the long-term impact of vehicle price changes gave a mean new vehicle price elasticity of demand of -0.6.

In recent years, the price of passenger cars has increased significantly in real terms, and whether this will continue is uncertain. Nominally, the progressively reducing tariff will reduce the retail price of cars. However, a fall in the value of the Australian dollar over the planning period may well offset this effect.

On this basis, one would expect changes to sales tax as envisaged by the Brief to be most useful if they operate on the larger and more powerful vehicles. They are less likely to cause a major reduction in vehicle sales.

However, discussions with Product Plan manufacturers about their recent experience with the luxury car tax indicated that they perceived no increase to small car sales as a consequence of the dropoff in sales of luxury cars. Rather, their impressions were that consumers kept their luxury vehicles for a longer period until eventually the tax was removed.

3.2.3 Size, Specific Vehicle

Consumers do not view the issue of size in terms of "bigger is better". Rather, consumers tend to consider a range of factors, including fuel economy, household life stage, garaging and parking arrangements, etc., and select a size of vehicle which is appropriate to their particular needs.

It is believed that this decision is often made before a prospective purchaser visits the showroom, and may involve fuel economy of a vehicle class.

Once the size decision is made, fuel economy becomes much less relevant.
Examination of the sales statistics suggests a strong preference in Australia for medium and large cars; consumers appear willing to trade-off economy for size and performance. Medium, large and luxury cars make up nearly three quarters of all sales of both Car Plan manufacturers and importers.

However, it is to be noted that the interior space delivered by Product Plan medium and large vehicles is similar, insofar that five seats are provided comfortably (note however, that Holden and Falcon tend to have slightly more shoulder room than others).

It is not impossible that this consistency in size is a function of manufacturers' marketing strategies including manipulation of price differentials between products. Discussions with industry representatives and manufacturers indicates that manufacturers' pricing of individual vehicles is not cost related.

International evidence indicates that the costs of manufacture are primarily a function of manufacturing techniques. Given consistency and efficiency of manufacturing process, the real difference between "mass" produced and "craft" produced cars (such as Japanese vs European) is thickness of steel in panels, insulation, luxury add-ons and the like (Womack et al:1990,p.88).

Thus costs of manufacture of vehicles within the same plan, but of different size class but equivalent equipment are not substantially different.

Australians also appear to be moving away from the stage where a single family car has to perform all the functions of commuting, social and recreational travel, towing, and so on.

Car ownership has risen to about 0.46 cars per person, which is close to the "knee" of the typical logistic curve which has been overseas experience. As described in WP4, the urban household car availability curve is likely to asymptote to 0.55 cars per person over the next 20 years.

Consumers very largely have their first car, and it is to be expected that specialist features and price will become more important determinants of vehicle purchase than those which prevailed in earlier years.

The ITS research evaluated a long list of passenger-carrying characteristics, with special emphasis given to internal dimensions and their interaction with household size and composition. Absolute variables such as total seating capacity or total interior volume were consistently non-significant.

Front legroom and rear volume were significant influences on vehicle type choice. Excess capacity (the difference between seating capacity and household size) is a significant source of relative utility. Luggage carrying capacity conditioned on the presence of multiple children in a household has a positive influence on vehicle choice.

Thus downsizing the fleet of new vehicles through intervention in pursuance of fuel economy, may drive families more and more into old cars, and reinforce the increasing trend for new cars to be purchased by companies and couples over 50.

3.2.4 Appearance, Luxury

This is manifested by vehicle styling, colour, accessories such as air conditioning, and options such as sound systems, etc.

Artcraft found that these attributes are relevant to choices made by over 10 percent of customers, and manufacturers report that the demand is increasing.

These accessories and options adversely affect fuel economy because they add weight to the vehicle and also consume up to 10 percent of engine power.

WP4 shows that the Australian consumer has a wide choice (nearly 150 models, which is greater than many other countries and may reflect a growing demand for specialisation of attributes including luxury appointments and "image".

Country of manufacture represents a myriad of country specific biases that are inherent in consumer preferences of the Australian population. European vehicles have become stereotyped as the epitome of luxury in passenger cars, although in recent years competition from Japan has become apparent. There is virtually no competition from the United States.

On the other hand, the image of the Japanese car is that while it is smaller, it is equipped with more options (sound gear, air conditioning, etc).

These imports are comparably fuel efficient on a vehicle class comparison basis, and intervention which pushes manufacturers toward additional costs in search of fuel economy, or downsizing of the fleet, is likely to enhance their competitive position in the Australian market.

3.2.5 Fuel Consumption

A broad review of overseas markets tends to suggest that the smallest cars are found in those countries with the highest fuel prices.

In Australia, Artcraft (CCEM:1988, p.15) found that about 70% of fleet and private buyers considered fuel consumption very or quite important. Thus, it seems that fuel efficiency is a reasonably high priority for both private and business buyers in typical market conditions, although fuel efficiency is seen as closely linked to vehicle size.

The ITS found that fuel efficiency per se was not a direct source of influence on automobile type choice but was highly correlated with vehicle price, through the weight of a vehicle. This is consistent with manufacturers' impressions that a desire to reduce fuel expenses does not greatly motivate consumers to choose a particular car.

The real price of fuel is one of the few parameters which has not changed substantially for many years. Refer WP4, which suggests that, without Government intervention to change one or more of the various fuel taxes, the price of fuel will remain largely at its present level throughout the planning period.

Fuel taxation is a very sensitive issue, but a consensus is emerging which appears to regard high fuel prices as a policy tool available for environmental management and discouraging the amount of travel, particularly in urban areas.

3.2.6 Power and Performance

The relevant attributes here relate to acceleration performance or "zip", high cruising speed and towing capacity.

The traditional performance statistics quoted by manufacturers are power/weight ratio and the number of seconds required to accelerate from 0 to 100kph.

In this regard, power/weight ratio is an important determinant of choice.

Acceleration Performance

Manufacturers believe that there are two distinct reasons why performance is valued by consumers:
- o a market demand for vehicles to deliver "launch feel", which essentially translates to a drive train and torque characteristic which will provide high acceleration at speeds below 20kph. This appears to be valued in urban situations at traffic signals and when joining a traffic stream from a side street;
- o a safety requirement for high acceleration performance to accommodate overtaking situations on two lane rural roads.

Manufacturers will also argue that more powerful engines will reduce test fuel consumption by about 25 percent (Flenker:1991, p.3) because of lower throttle openings needed to maintain the test drive cycle. This applies to both Otto and Diesel cycle cars.

However, in a practical on road situation acceleration performance is very consuming of fuel and these criteria require careful consideration.

Discussions with manufacturers indicates that by manipulating the engine management system to deliver a flat torque characteristic, and providing a low gearing ratio up to 20kph, it is possible to deliver launch feel in small vehicles which do not have a high top speed.

No manufacturer appears to have considered the issue of overtaking quite so specifically, but did not disagree that the "0-100 criterion" was not helpful in addressing the safety aspects associated with two lane rural roads. However, no representative interviewed appeared to accept that it was in a customer's interest to limit performance, so that additional engine efficiency could be applied to fuel economy.

It was NELA's view that the acceleration performance already being delivered by most vehicles exceeds the minimum safety requirements incorporated into road design standards, or even if one includes B-Doubles in the consideration.

An investigation was mounted to see if minimum acceleration performance requirement could be determined on safety grounds; and a maximum performance criterion devised above which there is no great safety benefit to be gained from additional performance capability.

Troutbeck (1981) provided statistics on the gaps accepted by drivers overtaking other vehicles on two lane rural roads.

Troutbeck assumes the overtaking manoeuvre to consist of three sections, the first of which is relevant. In that section, a car which is trailing a truck accelerates until the rear of the overtaking vehicle is alongside the rear of the overtaken vehicle. This is the section where the most dramatic acceleration is required.

Troutbeck's empirical studies showed that cars which accept gaps to overtake would increase speed from 70kph to just under 90kph in a mean time of 4.26 seconds with a standard deviation of 1.04 seconds.

Adapting behavioural theory, this Study would argue that if a driver sought to execute this section in a time less than one standard deviation from the average (i.e. 5.30 seconds), it would be reasonable to regard that as deviant behaviour. There would be every reason for the community to regard that driver as a leadfoot who simply wastes fuel.

If those leadfoots were penalised in some way, nearly 70 percent of all overtaking drivers would be unaffected.

The community could, for example, move to apply a "excess performance tax" on all vehicles which have a capability to accelerate from 70kph to 90kph in three seconds or less.

In a similar vein, it is possible to identify a minimum performance criterion by looking at the time the least powerful vehicles take to execute the same manoeuvre. In this case, it would be usual to take the 85th percentile vehicle; and if a vehicle could not perform the manoeuvre in (4.26 + 2.08 =) 6.34 seconds, it would be deemed to be unsafe and should be sent for maintenance, irrespective of its fuel economy capability.

It is a fact that the automotive market culture and some manufacturers would regard such vehicles as underpowered. The Study would not agree. The ITS modelling found that vehicle acceleration from 0 to 100 kms per hour is a consistently positive and significant influence on auto type choice. This positive sign suggests that consumers attach less utility to "zippy" vehicles. This finding is supported by previous evidence in Manski and Sherman (1980) and Mannering and Winston (1985).

Before recommending such a measure, it would be desirable to discuss the concept with State Road Authorities, and manufacturers. Either or both of those groups would doubtless wish to comment on the proposal. Presumably this would be done after this Study is completed.

For this Study, it should be sufficient to identify the effect on

NAFC of tax instruments which encourage the replacement of high performance engines with smaller ones.

High Maximum Speed

As discussed earlier, European cars imported to Australia are built for an environment where many major roads have no speed limits, and one can experience the culture of auto racing simply by driving on the public road system.

Australian manufacturers have little option but to compete with these imports on the basis of "smarter, larger, faster". This penchant for higher speeds is consuming of fuel in an on-road situation. The proposition that more powerful cars use less fuel because of low throttle openings (ref.) appears to avoid the realities of the market and consumer characteristics.

It is noted that the Berlin Conference included at least two speakers (Orfeuil:1991; Al:1991) who advocated both speed limits of 110kph on rural freeways (Autobahn) and speed limiters (160-200kph) on passenger cars.

Such measures seem entirely appropriate for Australia.

Accidents

In 1988, eighty two out of 2051 fatal accidents were due to overtaking. Table 3.3 details all fatal accidents by road type for 1988. High engine performance and light weight has an accumulative effect on safety. Speed kills; and lighter vehicles are typically less protective in event of a crash.

Towing Capability

There is a consensus that Australian consumers need a vehicle which can deliver towing capability, with a towed/towing vehicle capacity in the ratio 1.0 to 1.5. This can be accommodated by appropriate selection of drive train, and there are a range of equalising devices available which are recommended by manufacturers, even those which manufacture front wheel drive vehicles.

These attributes relate to a smooth ride, minimum noise and vibration, good braking, steering and cornering. They affect the choice in about 5 percent of purchases only.

It is interesting that this is the attribute for which manufacturers have expended a great deal of effort in developing the "Australian car".

However, discussions revealed no consensus among manufacturers about whether it is still necessary to include peculiarly Australian attributes in automotive design. Some stick strongly to the Australian tradition as described above, while others believe that this has been overtaken by a tendency towards a "world car".

TABLE 3.3 FATAL CRASHES BY ACCIDENT CLASSIFICATION AND ROAD TYPE, AUSTRALIA, 1988.

ACCIDENT CLASSIFICATION	National Highway	State Highway	Other Rural	Major Metropolitan	Other Urban	Unknown	TOTAL	Percent. of Total
Pedestrian	29	41	45	186	220	2	523	20.4
Vehicles from adjacent directions	13	30	55	55	83	0	236	9.2
Vehicles from opposing directions.	80	140	119	82	104	1	526	20.5
Vehicles from same direction	22	16	19	35	30	1	123	4.8
Manoeuvring	4	6	11	11	24	0	56	2.2
Overtaking	10	25	24	5	18	0	82	3.2
On path	5	7	16	18	15	0	61	2.4
Off path straight road	49	95	156	39	84	2	425	16.6
Off path curved road	24	89	232	49	89	0	483	18.9
Passengers and miscellaneous	4	5	12	2	9	0	32	1.2
Other	0	3	3	2	1	0	9	0.4
Unknown	0	1	1	1	1	1	5	0.2
TOTAL	240	458	693	485	678	7	2561	
Percentage of total	9.4	17.9	27.1	18.9	26.5	0.3		

SOURCE: Federal Office of Road Safety, Fatal file 1988.

3.2.7 Comfort and Handling

There are two reasons why this attribute may no longer be significant.

Firstly, the typical Australian now drives on much improved roads. True, and as shown by WP4, nearly two thirds of Australia's road system remains unsealed. However, this represents a reduction of 15 percent since 1970 and such an aggregate perspective belies the typical motoring environment.

Today, most of the long lengths of unsealed road are well away from centres of population and typically carry less than 100 vehicles per day, compared with volumes up to 30,000vpd on rural highways and 90,000 vpd on some urban arterials.

During the late 1970s and 1980s, there were significant improvements to Australian roads through the National Roads and other urban and rural programmes. Roads are sealed along all intercapital routes and to Cairns; and there has been a small freeway programme in most capitals. Nearly all recreational areas are served by sealed roads. Very many of these programmes adopted best Californian practice, although the extent of the network is nowhere near that in the United States.

The *SMVU* (1988) has shown that 73 percent of passenger vehicle km is performed in capital and major provincial cities (WP5, Table 5.1) and, when it is recognised that most of the rural veh km are performed on rural arterials (which are mostly sealed), it is easy to appreciate that unsealed roads carry only about 2 percent of passenger car travel (NAASRA:1984).

Secondly, some manufacturers reported that their parent companies had adopted some Australian characteristics into their world car. In those cases, there appears to be a convergence of size, strength and power attributes, and cooling systems and oils used overseas cope with conditions similar to those encountered in Australia.

There are great similarities in road quality among the most trafficked roads in OECD countries at least. There are pressures in Europe for imposition of road speed limits of about 110 kph, and for speed limitation on cars at about 160kph (Orfeuil:1991,p.6).

On balance, it was concluded that it may not be inappropriate if policy instruments in pursuance of fuel economy place pressures on those manufacturers which currently pursue an "Australian car", provided that this was generally in line with the intent of the Car Plan.

3.3 TOMORROW'S MARKET ENVIRONMENT

The challenge for this Study is to provide information which will allow Australia to identify a package of policies which encourage fuel economy in new vehicles sold in Australia, yet operate sensibly within the market and policy environment being faced by manufacturers and importers.

The package should encourage manufacturers to design, produce and bring to the domestic and export market a range of automotive products and services relevant to fuel efficient passenger cars.

Some of the dimensions relevant to the market outlook which is relevant to formulation of those policies are:

1. Within Australia, the new vehicle market has been essentially static in the 400,000 to 500,000 bracket for many years, and this is likely to grow only slowly to 520,000 (including CV derivatives) within the planning period unless sales tax is eliminated from passenger cars. Even if sales tax were abolished, the market would rise to about 558,000 vehicles.

2. Within this market, the proportion of commercial vehicle

derivatives is likely to grow to 18 percent, or about 90,000 to 100,000 units in 2005.

3. There is likely to be a very large developing market in countries within striking distance of Australia (viz. South East and Central Asia, Africa). However, there are two factors which make it unlikely that Australia will be able to export assembled cars to those countries in any quantity (Britten:1991):
   - o those countries are likely to want to assemble cars themselves under protective tariffs;
   - o established global manufacturers are facing shrinking home markets and have large surplus capacity. They may not welcome Australian subsidiaries' pressure to export assembled cars, particularly small cars;

4. It is not unlikely that, provided the global strategies of overseas owner manufacturers permit (or can be made to), there could be a large market in Australian made components. The Car Plan is of course pursuing this and other export possibilities.

5. To maintain a components industry, Australia will have to maintain an assembly function. This appears entirely feasible, especially for manufacturers who make 125,000 or more cars per year under lean production techniques (Womack et al:1990).

6. However, the pressure of the Car Plan, global rationalisation of manufacturers and lean production techniques among Australia's competitors may lead to a rationalisation of all types of automotive manufacturers in Australia.

7. For a range of reasons, it is not unlikely that cars manufactured in the developing countries will not be particularly fuel efficient, despite the economic imperatives that will apply in those countries. They will look for employment opportunity before environmental protection and may receive favoured treatment in the purchase of fuel.

8. A lead in fuel efficiency,if any, is likely to come from those global manufacturers who first get a foothold in those countries. For Australia, it is clear that a reputation for making fine cars and components needs to be maintained. This includes demonstrating that Australian cars are as fuel efficient as others overseas.

9. The current pressure for fuel economy in light passenger vehicles is driven by the greenhouse agenda. This may or may not be reinforced by concerns about fuel security. According to ABARE (1991), fuel security seems to be a 50/50 bet; but whatever that outcome it would be sensible for Australia to develop policies which minimise fuel use. This is seen as part of the future market environment.

10. Within the environment, it is not unlikely that fuel economy

in motor vehicles will move higher and higher in the national agenda; it would be sensible for governments to reinforce this.

11. Thus the market pressure for "smarter, larger, faster" cars is likely to be reversed; indeed there is evidence of this happening already.

12. If this scenario is accurate, the competitive position of Japanese based manufacturers in Australia will improve, unless some of the newer US based fuel efficient designs are introduced here.

WORKING PAPER NO. 4

POPULATION, PASSENGER CAR STOCKS AND FUEL CONSUMPTION PERFORMANCE

PREPARED FOR:

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

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CONTEXT

Within the context of developing a comprehensive policy response to the Government's planning target to reduce greenhouse gas emission, the Department of Transport and Communications acting in concert with a number of other government agencies commissioned Nelson English, Loxton and Andrews Pty. Ltd. (NELA) to assess the potential to reduce fuel consumption by new passenger cars sold in Australia.

Interim information is being presented to the Steering Committee by way of a series of seven Working Papers as follows:

Working Paper No.	Title
1	Available Options for Fuel Efficient Technology
2	Documentation of Technologies Available to Improve Vehicle Fuel Economy
3	Production and Marketing Factors Affecting the Introduction of Fuel Efficient Technology
4	**POPULATION, PASSENGER CAR STOCKS AND FUEL CONSUMPTION PERFORMANCE** Consumption Performance
5	Report on International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, Berlin, 25-28 March, 1991
6	Review of Policy Instruments Available to Governments
7	Definitions, Process and Procedures.

1. INTRODUCTION

1.1 BACKGROUND

The Brief requires, inter alia, that the major constraints to the introduction of fuel efficient technologies be identified, together with the options open to Governments to overcome these constraints.

These questions are addressed by this Working Paper and Working Paper No. 5 which reports the results of an International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, held in Berlin, 25-28 March, 1991.

1.2 OBJECTIVES

The objective of this Working Paper 4 is to update the inventory of transport task and fuel consumption by passenger cars within the Australian transport sector [1] to 1988, and consider consumption forecasts by ABARE and others, in order to provide the baseline against which fuel savings will be compared.

1.3 APPROACH

Ultimately, the projections of NAFC and FAFC produced by The Study rest on population trends, the national economy, car ownership and use, fuel prices and land use distribution, all of which are beyond the control of manufacturers.

Of the factors driving future fuel consumption, the Study attempted to predict only those which were within the control of automotive manufacturers, and received forecasts of other matters from Government sources, subject to approval by the Steering Committee.

These forecasts need to address population, households, car stocks and transport tasks in urban and rural areas and by passenger cars used privately and commercially (including Government). For vehicles used commercially, it is necessary to address those used by management and those used in fleets.

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1. Refer NELA (1988).

2. TRENDS IN POPULATION

2.1 POPULATION TRENDS

Table 2.1 summarises the trends and outlook for population throughout the Study period. The forecast figures are intermediate between the maximum and minimum estimated by the <u>Projections of the Populations of Australia: 1989-2031</u>, November 1990 release.

TABLE 2.1: AUSTRALIAN POPULATION AND HOUSEHOLD SIZE ACTUAL 1981 - 1990 AND FORECASTED 1991 -2005

Year	Population ('000)	Household Size
1981	14923	2.98
1982	15544	2.98
1983	15394	2.98
1984	15579	2.98
1985	15788	2.98
1986	16018	2.88
1987	16263	2.88
1988	16538	2.88
1989	16831	2.88
1990	17083	2.87
	Forecast	Household Size
1991	17736	2.87
1992	17588	2.87
1993	17839	2.87
1994	18089	2.87
1995	18322	2.87
1996	18569	2.87
1997	18798	2.87
1998	19019	2.87
1999	19232	2.87
2000	19343	2.87
2001	19651	2.71
2002	19856	2.71
2003	20058	2.71
2004	20258	2.71
2005	20454	2.71

2.2 TRENDS IN HOUSEHOLD FORMATION

Referring to Table 2.1, household size is estimated to fall from about 2.87 currently to 2.71 by 2005. This fall results from ageing of the population and the propensity for household formation with a single head of household.

3. TRENDS IN MOTOR VEHICLE STOCKS

3.1 NUMBER OF MOTOR VEHICLES ON REGISTER

At 30th September, 1988, ABS have two publications which quote passenger motor vehicle (PMV) numbers. From the SMVU there were 9,365,436 vehicles on register, of which 7,375,610 were passenger cars and station wagons (ABS Cat. 9208:SMVU, Table 2). The Census quotes 7,158,807 PMVs on register at the same time (ABS:9309.0). The ABS also publishes Catalogue 9303.0 which uses Catalogue 9309.0 as a base and adjusts according to new registrations and scrappages. Estimates for 1987/88 and 1988/89 in Table 3.1 were extracted from ABS Catalogue 9303.0.

Throughout this Study, "passenger cars" will be taken to include station wagons.

3.1.1 Trends in Passenger Car Registrations

Table 3.1 lists the number of passenger cars on register between 1970 and 1990.

3.1.2 Outlook for Passenger Car Registrations

Table 3.1 also includes forecasts to 2005 prepared by Donaldson et al (1990). For most purposes in the Study, these forecasts are used as a benchmark, although on occasions discrepancies on the high side up to 3 percent may be tolerated.

3.1.3 Trends in Car Ownership

The number of passenger cars on register has been growing steadily and the 1988 result indicates a passenger car ownership of 0.44 passenger cars per person, and 1.26 passenger cars per household.

Car ownership patterns are following a logistic curve, and the estimates provided by Donaldson et al (1990) suggest that car ownership will rise to about 0.50 by 2005.

The figure is likely to be higher than this in cities. Analysis of the Melbourne outlook by DJA (1989) suggests that vehicle **availability** in Melbourne in 1986 was already at 0.50 and would asymptote to 0.55, reaching about 0.54 in 2005. DJA indicate that similar outcomes are anticipated for Sydney.

These results were used to develop estimates of new car registrations as described in Section 3.4.4. The flow through to estimates of total car park prepared during those calculations show a discrepancy from estimates by Donaldson et al fluctuating in the range +0.71 to +2.65 percent depending on year.

Thus on the basis of car ownership expectations, the estimates shown in Table 3.2 may be conservatively low by up to 3 percent.

TABLE 3.1: TOTAL PASSENGER MOTOR VEHICLES ON REGISTER - 1970-2005

YEAR	TOTAL FLEET
70-71	3,990,938
71-72	4,141,300
72-73	4,361,600
73-74	4,604,000
74-75	4,858,500
75-76	5,072,800
76-77	5,243,000
77-78	5,462,200
78-79	5,657,200
79-80	5,799,300
80-81	6,021,000
81-82	6,293,800
82-83	6,462,700
83-84	6,636,200
84-85	6,842,700
85-86	6,985,400
86-87	7,072,800
87-88	7,243,600
88-89	7,442,200
89-90	7,672,300
	FORECAST
90-91	7,835,358
91-92	7,910,707
92-93	8,210,217
93-94	8,461,456
94-95	8,667,684
95-96	8,806,257
96-97	8,948,490
97-98	9,153,316
98-99	9,348,099
99-00	9,503,223
00-01	9,634,226
01-02	9,792,030
02-03	9,922,973
03-04	10,169,315
04-05	10,256,635

Sources: Donaldson et.al. (1990); ABS Cat No.9303.0

TABLE 3.2: ESTIMATED VICTORIAN PASSENGER MOTOR VEHICLES BY TYPE OF REGISTRATION AND ZONE OF USE; 1990. (1)

RISK ZONE (2)	PRIVATE					BUSINESS												
	Private	Pension. Concess.	T.P.I. (4)	PRIVATE TOTAL	Percent	Private Business (5)	Motor Veh. Carrying Goods for Hire	Taxi & Private Hire	Other Hire	Other	PRIVATE SECTOR SUB-TOTAL	Government: Govt. & Consular	Government: Council & Shire	GOVT. SUB-TOTAL	BUSINESS TOTAL	Percent	TOTAL	Percent
URBAN																		
High risk	1,040,482	109,786	2,727	1,152,995		169,100	53,350	3,325	198	122	226095	6,629	3,375	10004	236,099		1,389,094	
Medium risk	263,670	30,013	719	294,402		21,866	3,558	324	59	103	25910	311	1,129	1440	27,350		321,752	
Total Urban (3)	1,304,152	139,799	3,446	1,447,397	74.5	190,966	56,908	3,649	257	225	252005	6,940	4,504	11444	263,449	87.9	1,710,846	76.31
NON URBAN																		
Low risk	429,595	63,742	1,472	494,809	25.5	28,938	2,030	384	73	421	31846	2,000	2,321	4321	36,167	12.1	530,976	23.69
Total	1,733,747	203,541	4,918	1,942,206	100.0	219,904	58,938	4,033	330	646	283851	8,940	6,825	15765	299,616	100.0	2,241,822	
Percentage				86.6											13.4			100.0

SOURCE: ROADS CORPORATION (VICROADS).

NOTE:

(1) Passenger Motor Vehicles includes sedans, station wagons, coupes and roadsters.

(2) Risk categories are assigned by the TAC to each postcode district within Victoria.

(3) Contains Provincial centres that fall into the low risk category, but are deemed to be Urban centres. (i.e. Ballarat, Bendigo and Wodonga). This represents about 2 percent (45297 veh.) of the total PMV count.

(4) T.P.I. = Temporarily or Permanently Incapacitated.

(5) PMV used in connection with Business, Trade or Profession.

3.1.4 Ownership Patterns

An estimate was made of the breakdown of car ownership by private and business owners, the latter being divided into classes of household businesses[2] and companies. Within companies, cars are allocated to management and salespersons, with a small number of vehicles being retained in fleets and not taken home in the evening by company staff.

There is no information available which can provide the necessary breakdown directly, and the estimate was initially based on a range of data sources, including surveys undertaken by the ITS in Sydney in 1985, the SMVU (1988), taxation (FBT) statistics and information supplied by VICROADS for Victorian sedans, station wagons, coupes and roadsters by registration type and TAC rate code (1990). Finally, the results were discussed with collectors of industry statistics and a fleet management firm.

The VICROADS' data (Table 3.2) breaks the vehicles into risk zones which are assigned to each postcode by the TAC. The vehicles were segregated into Urban and Non-urban zones as defined by the ABS Survey of Motor Vehicle use. A comparison of the two zoning categories shows that all medium and high risk zones also fall into the Urban zone category. The remaining low risk zones fall into the Non-Urban category as defined by the ABS with the exception of the Cities of Ballarat, Bendigo and Wodonga. These cities are rated as low risk, but are considered to be Provincial Urban Centres by the ABS.

For the purpose of creating a table of Urban and Non-Urban registrations, the VICROADS's data was modified so that the cities of Ballarat, Bendigo and Wodonga are taken from the low risk, Non-Urban category and placed in the Urban category.

To determine the number of vehicles that need to be relocated from Non-Urban to Urban, the populations of these Provincial Urban centres were divided by the average number of people per urban household (Hensher) to give number of households, and then multiplied by average number of vehicles per urban household (Hensher) to give number of vehicles. The estimated number of PMV vehicles in Ballarat, Bendigo and Wodonga is 45297.

VICROADS officers indicated that the distributions indicated by its statistics were probably representative of NSW and Queensland as well as Victoria, and if so the distribution would be representative of perhaps 80 percent of Australian passenger cars.

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2. Businesses operated from households, typically tradespeople, sole agents, certain types of professionals, direct selling representatives, etc.

This body of information is collectively redundant and the estimate of the Australian distribution was obtained by resolving discrepancies where necessary and making judgements in those cases where the information was somewhat sketchy.

Table 3.3 estimates the number of vehicles registered privately and to businesses (includes Government) in urban and rural areas.

TABLE 3.3 ESTIMATED NUMBER OF CARS AND STATION WAGONS REGISTERED IN AUSTRALIA, BY TYPE OF REGISTRATION AND LOCALITY OF USE (1988)

	PRIVATE	BUSINESS				TOTAL
		HOUSEHOLD[1]	MANAGEMENT	FLEET	SUB-TOTAL	
URBAN	5,599,735	182,600	486,933	60,867	730,400	6,330,135
NON URBAN	1,007,033	NA	NA	NA	38,442	1,045,475
	6,606,768		499,516		768,842	7,375,610

SOURCE: ABS Catalogue No. 9208.0, (1988) (p8)
ITS Surveys.
Australian Taxation Office (FBT) Statistics
Note: Last three digits have no significance.
[1] For definition, see text.

It is certain that the majority of passenger cars are registered privately, the estimate in the Table being about 88 percent.

According to taxation statistics, nearly 500,000 cars were allocated to management by companies and would be subject to FBT. This represents some 65 percent of business registered cars. Most of these are thought to be based in cities, although doubtless there are many sales vehicles used on country trips.

Over 182,000 vehicles are operated by various types of home occupation, including professionals, tradespeople and single person businesses operating from home.

There is virtually no information about the ownership breakdown of business registered vehicles in non-urban areas, and no reason to believe that the proportions are similar to those in urban areas.

These results are consistent with estimates by Schou (1980), that just over 5 percent of all passenger cars are registered for business purposes.

All business vehicles classified herein as "management" vehicles are assumed to be subject to the Fringe Benefits Tax.

3.1.5 Locality of Ownership

Table 3.3 reports that 6.33m or just over 85 percent of all cars on register are located in urban areas.

Nearly all commercially registered cars are located in urban areas.

ITS surveys show 20 percent of passenger cars garaged in Sydney dwellings in 1985 were owned by business or Government.

3.2 AGE OF THE FLEET

It appears that the average age of passenger cars on register has been steadily increasing for a number of years.

Assuming that new vehicles are counted as being of zero age, it is estimated that the average age of passenger cars in the fleet was:

Year	**1976**	**1979**	**1982**	**1985**	**1988**
Average Age	6.17	6.3	7.3	7.7	8.6

Source: ABS Census Data

The BTCE (1991) have estimated that in 1971 some 29 percent of Australian cars were 3 years old or less: in 1988 only 13 percent. In 1971 around one quarter of Australian cars were ten years old; in 1988 almost half.

3.3 REGISTRATIONS OF NEW PASSENGER CARS

3.3.1 Annual Registrations

Table 3.4 summarises the trends in registration of passenger cars since 1965. Over the last 25 years the annual passenger car registrations has fluctuated grown from just over 330,000 in 1965 to nearly 510,000 in 1985. However, growth is not steady, with a fall to 364,000 in 1987 and subsequent regrowth to 410,473 in 1988 and nearly 450,000 in 1990.

Passenger cars represented nearly 79 percent of all registrations of 521,961 vehicles in 1988.

3.3.2 Annual Registrations by Type of Registration

Table 3.5 summarises the sales of motor vehicles in Australia by size of vehicle and type of purchaser.

The Table shows that 213,458 vehicles or about 52 percent of all vehicles were sold to Government and business in 1988.

Government and Business purchasers acquired 151,276 large and medium class vehicles which represents 70.8 percent of all purchases by this class of customer.

TABLE 3.4: NEW MOTOR VEHICLE REGISTRATIONS - AUSTRALIA

Year	Passenger Vehicle	Station Wagons	Total Passenger Vehicle	Light Commer'l	Trucks and Buses	Total Commer'l	Total Annual Regist'ns	Annual Change (Percent)
1965	258,057	73,694	331,751	47,412	27,866	75,278	407,029	
1966	245,175	61,513	306,688	46,854	25,206	72,060	378,748	-6.9
1967	275,594	59,947	335,541	50,601	26,931	77,532	413,073	9.1
1968	310,267	58,569	368,836	51,445	29,420	80,865	449,701	8.9
1969	343,275	57,604	400,879	54,131	33,148	87,279	488,158	8.6
1970	358,181	54,880	413,061	55,582	32,955	88,537	501,598	2.8
1971	362,669	54,555	417,224	56,730	30,557	87,287	504,511	0.6
1972	353,924	51,928	405,852	62,039	32,169	94,208	500,060	-0.9
1973	402,123	57,802	459,925	73,997	37,936	111,933	571,858	14.4
1974	413,674	61,924	475,598	76,191	36,729	112,920	588,518	2.9
1975	402,581	70,043	472,624	78,387	42,204	120,591	593,215	0.8
1976	386,847	81,856	468,703	87,597	50,105	137,702	606,405	2.2
1977	354,064	76,289	430,353	87,096	43,981	131,077	561,430	-7.4
1978			451,467			127,130	578,597	3.1
1979			462,205			113,001	575,206	-0.6
1980			453,378			121,487	574,865	-0.1
1981			462,657			143,414	606,071	5.4
1982			480,009			146,546	626,555	3.4
1983			433,515			132,089	565,604	-9.7
1984 (1)			442,355			196,390	638,745	12.9
1985			509,589			186,267	695,856	8.9
1986			398,739			131,512	530,251	-23.8
1987			363,964			87,865	451,829	-14.8
1988			410,473			111,488	521,961	15.5
1989			448,514			158,985	607,499	16.4

Source: ABS 9301.0 Registration of New Motor Vehicle 1965 - 1983.
: 1984 - 1990 PAXUS Australia Pty Ltd, Bulletin - New Motor Vehicle Registrations.

Notes: Commercials includes utilities, panel vans, rigid trucks, articulate trucks, other truck type vehicles and buses.

3.3.3 Annual Registrations by Vehicle Class

Table 3.5 also shows that 259,395 cars, or about 65 percent of all passenger cars sold are in the medium to large class, and that only 26.7 percent were small vehicles.

Table 3.6 shows that the distribution of new vehicle purchases by vehicle class has changed significantly since 1971.

The proportion of small vehicles has risen from 20.8 to 26.8 percent, and the proportion of luxury and upper luxury from 2.7 to 10.0 percent.

These shifts have been at the expense of medium and upper medium cars which tend to be the ones manufactured in Australia.

TABLE 3.5: SALES OF NEW PMV BY TYPE OF PURCHASER AND CLASS OF VEHICLE FOR 1988 (1)

	MINI/ SMALL	MEDIUM	LARGE	LUXURY	TOTAL	PERCENT BY PURCHASER CLASS
Commonwealth	1124	1795	1484	217	4620	13.2
State	4258	8511	9056	184	22009	63.0
Local	1141	1938	3403	141	6623	19.0
Hospital	676	507	487	11	1681	4.8
Total Government	7199	12751	4430	553	34933	8.5
	20.6	36.5	41.3	1.6	100.0	
Business	26358	43377	8390	22448	160573	89.9
Rental	4880	3464	8170	817	17331	9.7
Taxis	6	18	676	11	711	0.4
Total Business	31244	46859	7236	23276	178615	43.5
	17.5	26.2	43.2	13.0	100.0	
Private	71145	57924	50195	17661	196925	48.0
	36.1	29.4	25.5	9.0	100.0	
TOTALS	109588	117534	141861	41490	410473	
	26.7	28.6	34.6	10.1	100.0	
Government Share	6.6	10.8	10.2	1.3	8.5	
Business	28.5	39.9	54.4	56.1	43.5	
Private	64.9	49.3	35.4	42.6	48.0	
	100.0	100.0	100.0	100.0	100.0	
Government Total	7199	12751	14430	553	34933	8.5
Business Total	31244	46859	77236	23276	178615	43.5
Private Total	71145	57924	50195	17661	196925	48.0
TOTAL	109588	117534	141861	41490	410473	100.0

Source: AIA.
Note: Paxus classifications determine classes.

3.3.4 Outlook for New Registrations

There are no official estimates of the registration of new vehicles beyond 1995, and the estimates for 1990-1995 prepared by Donaldson et al (1990) appear to have been exceeded for 1990 by about 100,000 units.

Discussions with manufacturers failed to produce any estimates of new vehicle registrations which could be of assistance to the Study. The general comment was that the market was expected to stay relatively flat although one manufacturer mentioned a high scenario in the order of 525,000 in 2005.

TABLE 3.6: PERCENTAGE OF NEW VEHICLES SOLD IN AUSTRALIA BY VEHICLE CLASS AND YEAR - 1971-1988

YEAR	MINI + SMALL	MEDIUM	UPPER MEDIUM	LUXURY	UPPER LUXURY	TOTAL
1971	20.8	19.4	57.0	2.7		100.0
72	20.1	23.7	53.2	3.0		100.0
73	22.0	23.1	51.3	3.7		100.0
74	24.8	22.9	47.5	4.8		100.0
75	25.1	31.7	37.7	5.5		100.0
76	15.3	42.3	38.0	4.4		100.0
77	25.8	32.5	37.0	4.6		100.0
78	21.4	32.7	40.4	5.4	.1	100.0
79	20.5	34.1	33.0	9.9	2.6	100.0
80	23.8	40.0	28.6	5.1	2.5	100.0
81	26.2	37.3	27.5	6.4	2.6	100.0
82	27.9	33.9	27.9	7.7	2.5	100.0
83	27.2	39.0	23.7	7.7	2.4	100.0
84	24.2	37.2	27.6	8.2	2.7	100.0
85	23.3	38.0	27.9	7.7	3.2	100.0
86	28.9	28.9	30.8	7.5	3.8	100.0
87	26.2	27.6	36.3	6.4	3.6	100.0
88	26.8	28.9	34.4	5.8	4.2	100.0

Source: ITS 1991

It was therefore decided that the Study should prepare its own forecasts, and used the following as the basis:

- o population forecasts provided by the ABS (refer Section 2.1);
- o statistics of sales of new passenger motor vehicles and passenger car scrappage rates for the period 1988-1990 prepared by ABS 9303.0;
- o estimates of price elasticity of demand for new vehicles (-0.60) and for scrappage (-0.66) prepared by the ITS;
- o an assumption that the Australian dollar would fall by about 15 percent (i.e. to $US0.70) to 1995, and that this would translate directly to a corresponding increase in new car prices;
- o an assumption that the fall in the motor vehicle tariff announced in the March Industry Statement would translate directly into a fall in new car prices.

Table 3.7 estimates the actual number of new passenger cars added to the register for the period 1988-2005, together with the resultant car ownership after taking account of scrappage.

The Study considered that the most satisfactory control on the estimate was the flow through to overall car ownership, as based on the ABS population forecasts.

TABLE 3.7: ESTIMATED NEW PASSENGER VEHICLE REGISTRATIONS BY TYPE AND YEAR - 1988-2005

		<---------New Registrations Registered as--------->						
	Car		<-----Business----->			Subtot.	CV	Total
Year	Own'ship	Private	Fleet	Other	Subtot.	Cars	Deriv.	PMV
1988	0.44	194191	16763	192770	209532	403723	6750	410473
1989	0.44	211788	18577	213636	232213	444001	4513	448514
1990	0.45	251141	16909	194456	211365	462506	4987	467493
1991	0.45	252533	17210	197911	215121	467654	5340	472993
1992	0.46	248695	16948	194903	211851	460546	10638	471184
1993	0.46	244738	16678	191802	208481	453219	15887	469106
1994	0.47	240662	16401	188607	205008	445670	21076	466746
1995	0.47	236255	16100	185154	201254	437509	26172	463681
1996	0.47	237070	16156	185793	201949	439019	31896	470915
1997	0.48	237443	16181	186085	202266	439709	37728	477437
1998	0.48	237915	16213	186455	202668	440583	43740	484323
1999	0.48	238356	16244	186800	203044	441399	49918	491317
2000	0.49	237609	16193	186215	202408	440016	55994	496010
2001	0.49	236953	16148	185701	201849	438802	62215	501016
2002	0.49	232634	15854	182316	198170	430805	67504	498308
2003	0.49	229538	15643	179890	195532	425070	73110	498181
2004	0.49	226456	15433	177474	192907	419363	78719	498081
2005	0.49	220486	15026	172795	187821	408307	89628	497935

Note: Results for 1988-90 from ABS.9303.0

There are two points of comparison: firstly, overall car ownership estimated on the basis of forecasts by Donaldson et al (1990) vary from 0.45 in 1988-89 to 0.50 in 2004-5. The above figures start from a smaller base in 1988 and grow to an estimate of 0.51 in 2005.

This discrepancy is small and in any event tends towards the higher estimates of car ownership prepared by DJA (1989).

Note however, that the 1995 estimate of 487,900 new passenger cars compares with the estimate of 483,000 prepared by Donaldson et al.

It is requested that the Steering Committee consider the estimates of new passenger car registrations and if thought fit, approve them for further use in the Study.

Alternative forecasts are requested if these are not considered satisfactory.

3.4 SCRAPPAGE OF OLDER VEHICLES

Scrappage rates in 1990 were 3.52 percent, and this is estimated to grow to about 3.7 percent by 2005.

Low scrappage rates have been due to many factors, such as an increase in design life, increases in the real prices of new cars, and higher interest rates.

3.5 CONDITION OF THE ROAD SYSTEM

Table 3.8 shows that nearly two-thirds of Australian roads are unsealed, but that the large distances of unsealed roads occur in the larger States.

ACT roads are over ninety percent sealed, and Victorian over 50 percent. In South Australia, only about 25 percent of roads are sealed.

3.5.1 Travel on Unsealed Roads

While unsealed roads comprise 65 percent of the total length of Australian rural arterial roads, the more important statistic is the total amount of vehicle kms driven on unsealed roads.

This information is not readily available because of the way road inventory information is collected on local roads. However, NAASRA (1984) estimated that only 2 percent of total travel occurs on unsealed rural arterials.

On the basis that most urban roads are sealed, it was concluded that the Study could confidently assume that over 98 percent of vehicle kms of travel take place on sealed roads.

TABLE 3.8: LENGTH OF ALL ROADS OPEN FOR GENERAL TRAFFIC BY STATE AND CONDITION, JUNE 1988

(kilometres)

Surface of Roads	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	TOTAL
SEALED:									
Bitumen or concrete	77041	67918	56700	2347	41193	9236	5649	2445	283656
Percent of Total									35.03%
UNSEALED:									
Gravel, etc.	64979	47682	44397		40613	1320	5808	170	216852
Formed	34953	23786	51855	72505	40262	271	4507		228139
Cleared	19207	21012	16637		19889	176	4148		81069
Total Unsealed	119139	92480	112889	72505	100764	13650	14463	170	526060
TOTAL ROADS	196180	160398	169589	95979	141957	22886	20112	2615	809716

Source : Year Book Australia.

4. TRENDS IN USE OF FUELS BY PASSENGER CARS

The outlook for fuel supply and use provides a backdrop to the development of policies which seek to improve fuel economy among new motor vehicles sold in Australia. Clearly, if fuel is cheap and plentiful, the case for a policy of fuel economy would be hard to justify.

4.1 FORECAST OF CRUDE OIL AVAILABILITY

Figure 4.1 illustrates the predicted demand and supply scenario for oil until 2005.

The figure shows that the demand for liquid fuels in Australia is steadily rising by about 25 petajoules annually, to reach 1900 PJ in 2005.

The supply function is depicted by three scenarios as developed by the Bureau of Mineral Resources, Geology and Geophysics and published in ABARE (1991.p27). Probability indicators are attached to alternative future levels of production from undiscovered resources. For example, a production estimate at the 90 percent probability level means that there is a 90 percent chance of production being at least as high as the figure shown. The higher the probability level, the more conservative the assumption.

AIP (1990) predicts Australia's level of crude oil self sufficiency will be:

1990	88 Percent
1993/94	60 Percent
1997	80 Percent

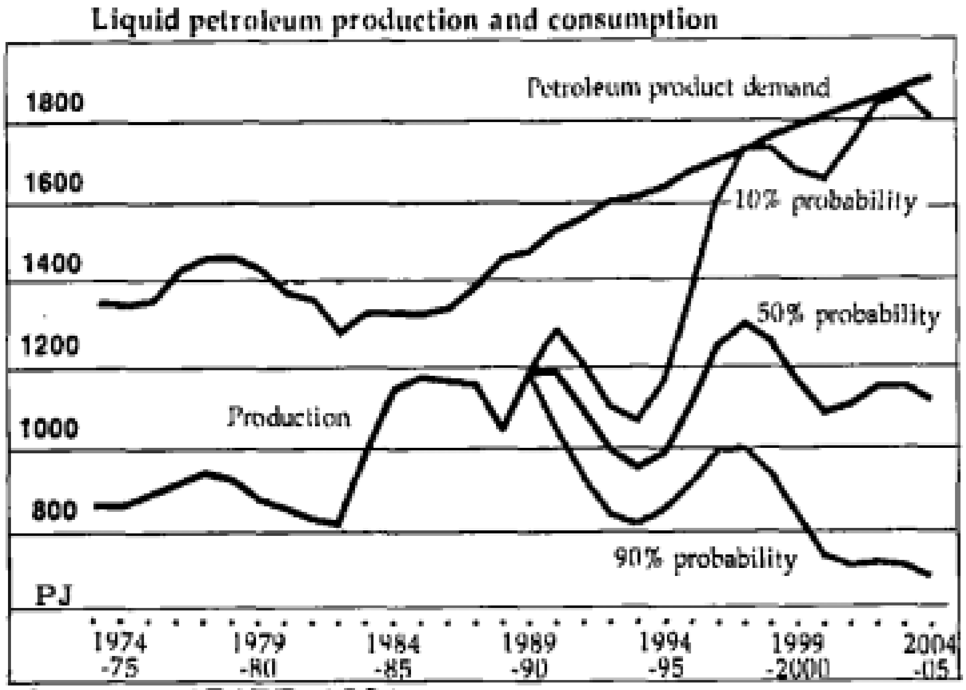
These predictions are comparable with ABARE's 50 percent probability scenario.

NELA's view is that these results provide no justification for Australia to feel comfortable with the outlook shown in the Figure. There is only a 10 percent probability that Australia will be self sufficient in oil production this decade, and a 50 percent chance that the current shortfall will increase. This includes a 10 percent chance that it will increase by about six times!

The National Population Council (1991,p.50) nominated a 'life' for Australian oil resources of only 11 years and, while this is a more simplistic view than that provided by Figure 4.1, it is a rational and understandable way of looking at what is in fact a major issue in the long term outlook for the Australian economy and lifestyles.

It is not good enough to take a simplistic view that Australia can simply import oil to replace run-down domestic stocks, because of the economic and security of supply implications.

FIGURE 4.1: PREDICTED DEMAND AND SUPPLY SCENARIO



Source: ABARE 1991

Australia is part of a world energy scene, and is a long way from the main suppliers. Apart from perhaps 0.2 percent losses in transporting crude oil from the Middle East to Australia, there is a prospect of increased competition for oil consumption from the newly industrialised countries at a time when low cost oil resources are tending to be concentrated into a decreasing number of countries.

Garriba (1991) points out that no country can afford to isolate itself from the interdependent and global matrix of energy problems. Without adequate and secure energy flows, Australia will need to enter the twenty first century with an edge in energy conservation and efficiency of use, at least comparable to its trading partners in the OECD countries.

This concern is in addition to those of atmospheric degradation and climate change which are the drivers for this Study.

Because transport is such a large consumer of energy, it is essential that it not only identify international best practice in new vehicle technology and in the transport system, but also that it develops those techniques which apply directly to those types of resources in which Australia has a comparative advantage.

This Study focuses on new motor vehicles driven by petrol and diesel powered engines. Diesel power represents a very small proportion of existing fleets, largely because Australian crude mostly comprises the lighter fractions.

AIP (1989) predicts increases in the demand for middle distillates (automotive diesel fuel, etc) through the 90's and by 1999 unleaded petrol is expected to account for 86 percent of sales of petrol (1990 is about 31 percent).

If Australia is placed in a position where oil imports dominate, diesel powered engines may become more attractive, and we may see penetration of the fleet up to 15 percent, as is the case in some European countries. Realistically, this is not a likely scenario before year 2000.

Also, during this period Australia will have an opportunity (if it chooses) to develop technology to adapt the large reserves of natural gas to transport use. A consideration of the energy chain analogous to that reported by Bang and Holden (1991) could indicate that natural gas from the North West Shelf applied to transport in Australia may be up to 10 percent more efficient than use of Middle East crude in petrol or diesel powered engines. Such efficiency gains are worthwhile in a climate of world competition for fossil fuels as foreshadowed by Garriba.

Appropriate Australian research is already proceeding in the arena of heavy transport vehicles, and the possibility of spinoffs for passenger car fuelling in the latter parts of or just beyond this planning period should not be ruled out too early.

4.2 FORECAST OF FUEL PRICE

4.2.1 Gasoline Prices

Petrol in Australia has been subject to Government price control in one form or another for more than 50 years. Maximum wholesale prices are determined by the interaction of two processes - the actions of the Prices Surveillance Authority (PSA), which is a Federal Government statutory authority, in determining the Capital City Base Intervention Price (CCIP) for all grades of petrol and automotive diesel fuel each business day, and the actions of each refiner/marketer company in notifying the PSA of its prices to the limits set by the CCIP.

The PSA calculates the CCIP as follows:

- o a seven day average of world parity prices of refined product (eg. petrol) converted to Australian dollars;
- o freight costs (provides a landed cost which includes cost of shipping, insurance and loss premiums and wharfage costs.);
- o At present 7.4 cents/litre which represents refiner/marketers' domestic costs of storage, marketing, distribution and return on funds employed; and
- o Federal Excise Duty of 25.77 cents/litre.

Oil Companies can notify the PSA of a price up to the CCIP. Since the Gulf War, the seven day average is calculated on the average of the Petrol and Crude Oil baskets. Historical data indicates that petrol price fluctuations follow a similar pattern to crude oil price fluctuations (assumes an insignificant manufacturing component).

The PSA then adds the respective State Government Franchise Fee to the CCIP to equate to wholesale price for each State.

PUMP PRICE

Service stations which are franchised, owner-operated, distributor supplied or independent brand stations (94 percent of all stations) set the pump price of petrol by adding that service station's margin to the price paid to the oil company.

Breakdown of the pump price of a litre of leaded super grade petrol for Melbourne on 18 February 1991, as published by the AIP is as follows:

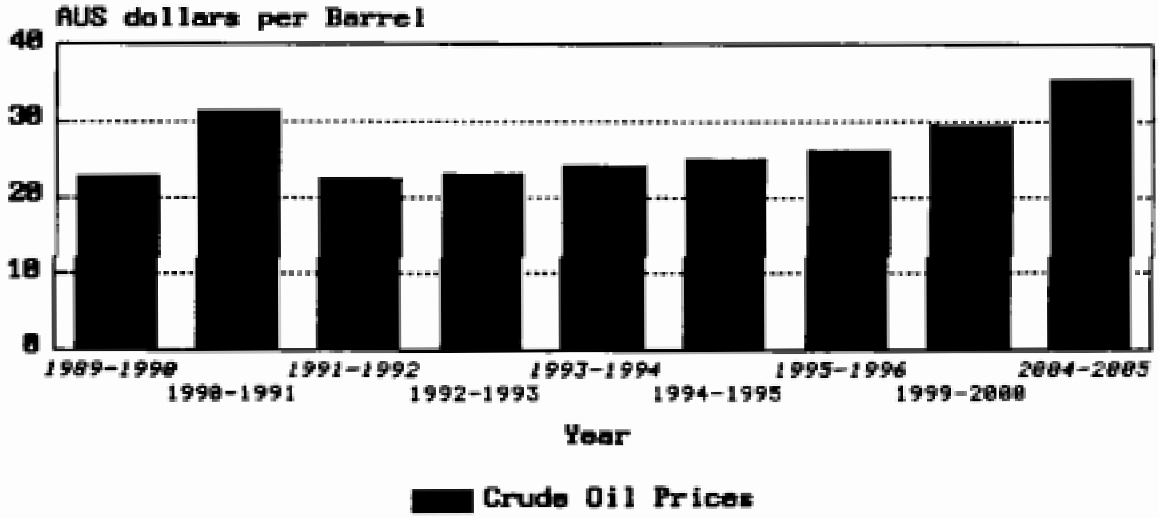
		Price (cents)
Government	Federal Product Excise	25.8
Government	State Franchise Fee	7.9
Government	Federal and State secondary taxes on crude oil	6.0
Oil Industry	Service Station	4.0
Oil Industry	Petrol Marketer	7.4
Oil Industry	Oil Refiner	7.7
Oil Industry	Oil Producer	12.9
Total		71.7

Source: AIP February 1991.

The world trade weighted forecasts for crude oil prices is illustrated in Figure 4.2. ABARE assumes that petrol prices will increase at the same rate as oil prices - which they assume to be about 2.6 per cent a year in real terms - from 1991-92 onwards.

To forecast retail petrol prices the starting point must consider changes in the world parity crude oil price. Using February 1991 petrol price components as detailed in this Section as an indicative guide, Table 4.3 provides forecast for petrol prices to 2005. The forecast methodology was discussed with the DPIE.

FIGURE 4.2: PROJECTED CRUDE OIL PRICES

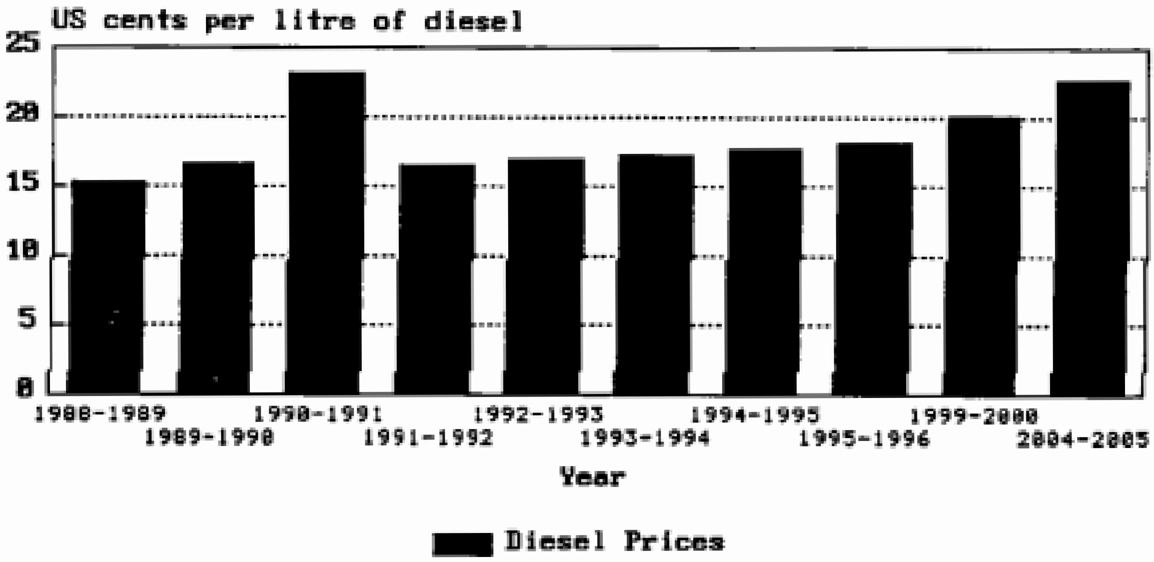


Source: Projections of Energy Demand and Supply. Australia 1988/89-2004/5. ABARE January 1991

4.2.2 Diesel Prices

On 13 March 1991 the PSA set the price of diesel at 1.22 cents below petrol. Over a year the world price of diesel varies dramatically according to the seasons in the northern hemisphere. These fluctuations are averaged by the PSA and the price of diesel is set accordingly. Forecasts for the price of diesel are calculated by, converting the crude oil projections from $US per barrel to US cents per litre and then applying a formula provided by ABARE. The price of diesel (Figure 4.3) has a linear relationship with the price of crude oil.

FIGURE 4.3: PROJECTED DIESEL PRICES



Source: Pers Comm. ABARE. 1991

TABLE 4.3: FORECASTS OF PETROL PRICES TO 2005 (2)

	Australian cents per litre					
	1988/89	1989/90	1990/91	1994/95	1999/00	2004/05
World Parity Crude Oil Price/Litre:						
Resource Cost/Lt Petrol	8.5	9.8	12.9	10.7	12.6	15.1
Estimated Crude Oil Levy	4.0	4.6	6.0	5.0	5.9	7.0
Total (1)	12.49	14.37	18.9	15.71	18.52	22.19
Refining Costs	7.7	7.7	7.7	7.7	7.7	7.7
Federal Product Excise Tax	25.8	25.8	25.8	25.8	25.8	25.8
State Gov't. Franchise Fee (4)	4.1	4.1	7.9	7.9	7.9	7.9
Estimated Wholesale Price	50.09	51.97	60.3	57.11	59.92	63.59
Petrol Marketer (12.27%) (3)	6.1	6.4	7.4	7.0	7.4	7.8
Service Station (6.63%) (3)	3.3	3.4	4.0	3.8	4.0	4.2
Aver. Price:Petrol/Litre (1990/91 Dollars)	59.6	61.8	71.7	67.9	71.2	75.6
Aver. Price:Petrol/Litre 1988 Dollars (5)	49.0	50.8	58.9	55.8	58.6	62.2

Source: ABARE 1991 and AIP 1991.

Notes:

(1) Forecasted world parity crude oil prices converted to Australian cents per litre. The 1990/91 figure was 19.66 which is an estimated average for the year. The number used for the spot price of 71.7 is as above.

(2) Calculations were based on 1990/91 breakdown of petrol prices, provided by AIP, which were applied to all other years.

(3) Percentage of Wholesale price.

(4) Victorian SGFF assumed to be representative of Australia.

(5) ABS provided a deflator to convert to 1988 dollars, 176.0/214.1.

4.3 CONSUMPTION BY PASSENGER CARS

Road transport is a major user of energy; estimates by ABARE (1991) indicate that it accounts for 30.3 percent of final energy consumption in Australia. Automotive gasoline is predominantly used by light vehicles (mostly cars) and is the most important component of road transport fuels, providing 72.9 percent of final energy consumed.

ABARE forecasts of growth in road transport energy (1.7 percent per year to 2005) assume, inter alia, substantially higher fuel prices and a marked increase in the rate of improvement in average fuel consumption per vehicle.

It is interesting to compare the 29 percent growth for 1990-2005 predicted by ABARE with expectations of others. Greene et al (1990) estimated that Australian transport sector fuel demand would increase by over 33 percent by 2005. NELA (1990) estimated that motor vehicles in Melbourne would increase their fuel consumption by 37 percent between 1986 and 2001.

Clearly the differences reflect different assumptions, and/or different sectors of the market. However given the continuing ageing of the fleet, the technological outlook for fuel consumption of new passenger cars, and the outlook for fuel prices identified by this Study (refer WPs 1 and 4), it may be that the ABARE forecast is if anything conservatively low.

Table 4.4 summarises the consumption of all types of fuel by cars and station wagons in 1988. Of the total volume of 13895.4 million litres consumed, 94.4 percent was gasoline, and 73 percent of all fuel was consumed in the capital and major provincial cities.

TABLE 4.4: TOTAL AMOUNT OF FUEL CONSUMED BY CARS AND STATIONS WAGONS, FUEL TYPE AND AREA OF OPERATION, AUSTRALIA (Twelve months ended 30 September 1988).

(Million Litres)

	Petrol			Distillate		Dual		Percent
	Leaded	Unleaded	Total	or Diesel	LPG	Fuel	TOTAL	of TOTAL
URBAN:								
Capital City	6222	1670	7892	86	159	202	8339	60
Provincial Urban	1354	376	1730	36	9	26	1801	13
Total	7576	2046	9622	122	168	228	10140	73
NON URBAN								
Other than Urban	2316	673	2989	88	7	53	3137	23
Interstate	438	134	572	34	0.4	12	618.4	4
Total	2754	807	3561	122	7.4	65	3755.4	27
TOTAL URBAN AND NON URBAN	10330	2853	13183	244	175.4	293	13895.4	100
Percentage of Total	74.4	20.5	94.9	1.7	1.3	2.1	100	

Source: ABS Catalogue No. 9208

Only 244 million litres, or 1.7 percent of total volume was diesel fuel. This is low by comparison with some other countries, e.g. in Europe, where diesel cars are very popular. Consumption of diesel in Germany and the Netherlands as a percentage of total fuel consumed is:

	1985	1988
West Germany	22.3%	13.6%
Netherlands		13.0%

Source : IEA:1990,p.61.

However, when considering diesel engines as an alternative in the search for fuel economy, it is necessary to recognise the extent of additional energy consumed in refining. This issue is addressed in WP7.

Additionally, diesel engines are heavy and noisy, and produce visible and odorous exhaust emissions. Due to its relatively unrefined state, diesel fuel contains high levels of sulphur and aromatics, much of which are emitted in a soot like particulate known to contribute to environmental problems such as photochemical smog and acid rain. The particulate is also the cause of health problems. The tiny carbon particles absorb sulphuric acids and carcinogenic atomatics, such as benzene, and can burrow deep into lungs. According to a US 1990 EPA study, health impacts from exposure to diesel exhaust range from temporary acute symptoms to cancer of the lungs and other organs.

On the basis of calculations undertaken by NELA (1990,Table 4.1), about 46 percent of fuel consumed by passenger cars in urban areas is consumed during the peak four hour period, when idling is a major contributor to fuel consumption.

NELA (1990) estimated that motor vehicles in Melbourne would increase their fuel consumption by 37 percent between 1986 and 2001.

5. THE AUSTRALIAN TRANSPORT TASK BY PASSENGER CARS

The purpose of this Section is to examine trends in the transport task performed by Australian passenger cars, including providing an outlook for 2005.

5.1 KILOMETRES TRAVELLED BY PASSENGER CARS

5.1.1 Kilometres Travelled by Locality

ABS statistics from Survey of Motor Vehicle Use 1988 indicate that 73 percent of all kilometres travelled by cars and station wagons occurs in urban areas.

TABLE 5.1: TOTAL KILOMETRES TRAVELLED BY CARS AND STATIONS WAGONS, AND AREA OF OPERATION, AUSTRALIA (Twelve months ended 30 September 1988.)

(Million Kilometres)

	Cars and Station Wagons	Percent by area of operation	Total for all Vehicles	Percent of cars to Total
URBAN:				
Capital City	69201	59	85837	45
Provincial Urban	15384	13	20379	10
Total	84585	73	106216	55
NON URBAN				
Other than Urban	26833	23	40343	17
Interstate	5222	4	7356	3
Total	32055	27	47699	21
TOTAL URBAN AND NON URBAN	116640	100	153915	76

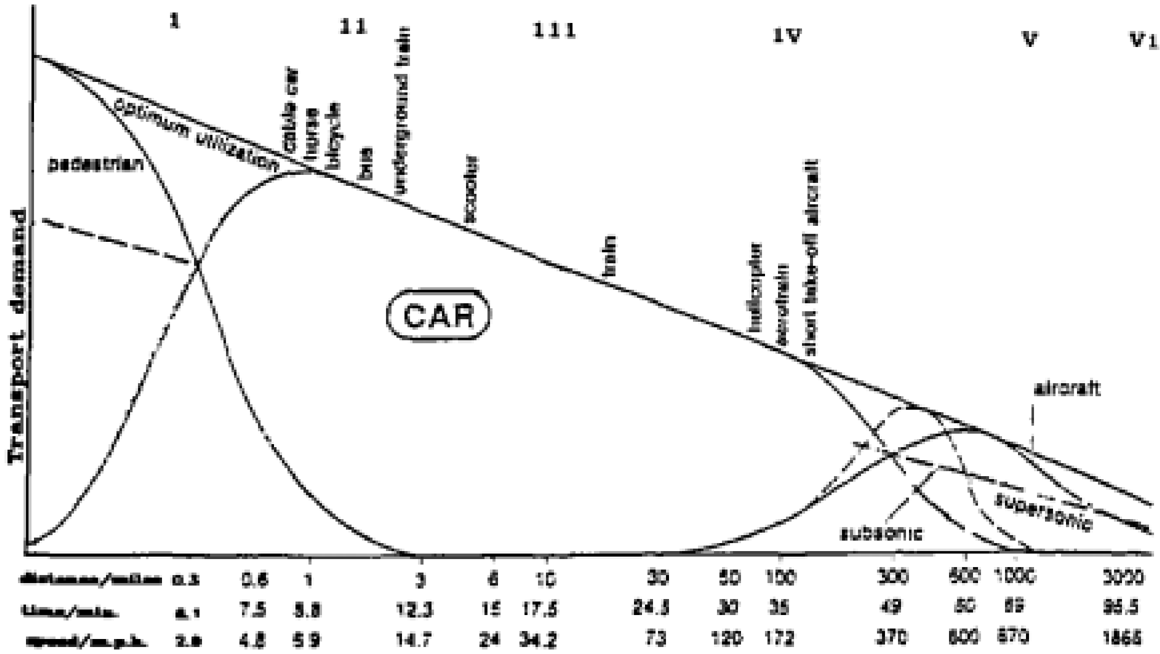
Source: ABS Catalogue No. 9208

5.1.2 Trip Length Distribution

In Australia, very little is known about the patterns of trip length or usage by passenger cars, and it is necessary to draw parallells from overseas studies.

Cousins (1991) found that in the UK, the car dominated travel modes, being the favoured mode for more than eighty percent of journeys between 0.5 and 200 miles in length. Refer Fig. 5.1.

FIGURE 5.1: PATTERN OF CAR USE BY 1990 CAR OWNERS IN THE UK



Source: Cousins 1991

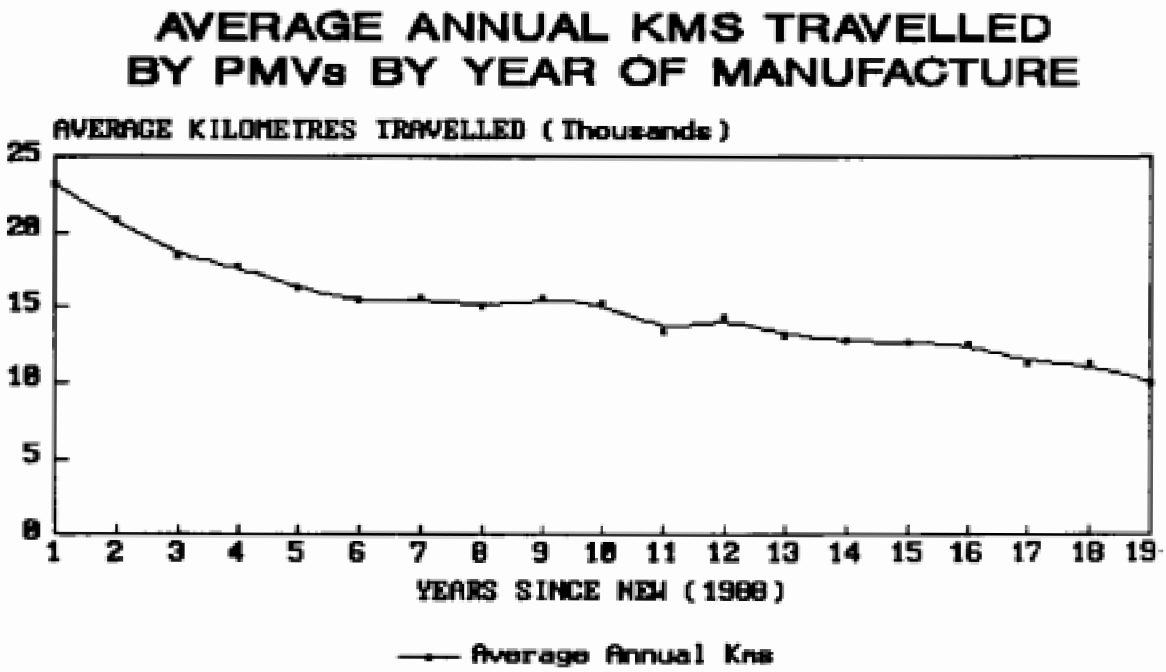
It is not unlikely that this result is representative for Australia.

5.1.3 Average Annual Distance Travelled

Figure 5.2 illustrates the annual distance travelled by all passenger vehicles in 1988 on register by age of vehicle.

The graph clearly shows that the newer vehicles in the fleet each travel, on average, more kilometres per year than the older vehicles in the fleet. For example, fifteen year old cars travelled on average 12640 kms, compared with one year old cars which, on average, travelled approximately 23,154 km.

FIGURE 5.2: ANNUAL DISTANCE TRAVELLED



The average distance travelled is 15,800 km. However, the Figure 5.2 shows that there is a large difference in the extent of use given to new versus old vehicles.

It is to be noted that the average annual distance travelled per vehicle is about equivalent to the U.S., about 7 percent more than in the U.K. and Germany, and about 50 percent more than in Japan or other European countries (IEA:1990c).

It is understandable that the newer cars, say up to 3 years old, have an greater annual kilometrage, because this group contains the bulk of PMVs registered to businesses which, on the basis of 1985 surveys, the ITS has estimated travel some 22,200km annually on average.

The average is brought down because new privately registered vehicles are thought to be purchased by the older age groups (say 45-65 years) which typically do not travel high annual mileages.

It is interesting that vehicles aged more than 10 years nearly all travel less than 15,000km.

5.1.4 Annual Kilometrage by Ownership

TABLE 5.1: TOTAL NUMBER OF VEHICLE KILOMETRES TRAVELLED BY PMVs BY AREA OF OPERATION AND PURPOSE OF TRAVEL IN AUSTRALIA, (1988)

(million kilometres)

	PRIVATE			BUSINESS				
	TOTAL TO AND FROM WORK	PRIVATE	SUB-TOTAL	HOUSEHOLD	MANAGEMENT	FLEET	SUB-TOTAL	TOTAL
URBAN (1)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	84,585
NON URBAN	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	32,055
TOTAL	29,743	62,135	91,878				24,762	116,640

SOURCE: ABS Catalogue No. 9208.0, (1988); NELA Estimates.

n.a. = not available

NOTE: (1) Urban includes Capital Cities and Provincial urban centres.

The question of the use of passenger cars on unsealed roads arises in a product design context.

The annual distance travelled by business and private vehicles is different, and each appear to travel different average annual distances depending on whether they are predominantly used in urban or rural areas.

Because the annual distance travelled is different for management and fleet vehicles, it is necessary to identify the locality of use between urban and rural.

5.2 PASSENGER KM CARRIED BY PASSENGER CARS

Information for passenger kilometres was extracted from NELA 1988. Cars and station wagons constituted 79 percent of the total passenger task of road vehicles in 1985, of which about 63 percent occurred in urban areas. Private travel represents 68 percent of all passenger kilometres for PMVs.

In urban areas, passenger movements should be considered in terms of peak hour and off peak periods, because travel characteristics in those periods differ markedly due to the predominance of commuter travel in peak periods.

Peak hour flows are dominated by the journey to work, which accounts for about 35 percent of private car travel. In this mode, the fleet average fuel efficiency is poor compared with other modes, due to relatively low vehicle occupancies for those kinds of trips (work trip occupancies range from 1.2 to 1.4 compared with about 2.2 to 2.4 for other trip purposes) and being forced to drive in congested conditions.

On the basis of a four hour peak period (7am-9am; 4pm-6pm approx), urban peak period trips made by private and commercial vehicles comprise 40-45 percent of total urban trips (Brisbane: 1960, Melbourne: 1978), with about 40 percent between 9.00am and 4.00pm. Only about 5+ percent of trips occur between 10.00pm and 7.00am.

NELA (1990) estimated on the basis of 1985 figures that the peak four hours account for about 34 percent of urban road passenger km. This suggests that trip lengths by car are shorter during peak periods, and reflects the attractiveness of rail travel for the longer commuting journeys. There are cases, e.g. from outlying centres to the CBD of capital cities, where the modal split to rail rises as high as 70 percent.

Estimates of the passenger task depend to some extent on the treatment of passengers carried by trucks. NELA (1990) estimated on the basis of 1984/85 figures that urban travel by road represents about 61 percent of total domestic road passenger kilometres. More recent BTCE estimates which neglect truck passengers in 1988 indicate that up to 64 percent of the passenger task may be in urban areas.

Whatever, the private car dominates urban travel, being responsible for almost 144 billion pass.km. or nearly 88 percent of total urban travel of about 164 billion passenger km in 1988. Rail carried about 7.2 billion and bus carried 4.0 billion passenger km. in urban areas (pers.comm. BTCE). These results represent very marginal changes from 1985 in favour of private car use.

6. TRENDS IN FUEL CONSUMPTION BY PASSENGER CARS

Fuel consumption needs to be considered at the level of the individual new vehicle, the weighted average new vehicles which enter the fleet each year (NAFC) and the average consumption across all vehicles in the fleet (FAFC).

WP7 explains the definitions relevant to the National Average (NAFC) and the Fleet Average (FAFC).

6.1 GUIDE TO FUEL CONSUMPTION OF INDIVIDUAL PASSENGER CARS

An estimate of the fuel consumption relevant to individual makes and models of passenger cars sold in Australia is published annually in the Australian Fuel Consumption Guide for New Car Buyers (e.g. DPIE:1990).

The Guide provides a sales weighted average of test fuel consumption results as provided by manufacturers through the FCAI. This is a voluntary arrangement which is sponsored and encouraged by Government, but there is no regulation which requires manufacturers to furnish fuel consumption data. Vehicles sold by firms which are not members of the FCAI are not included.

It is understood that those manufacturers which provide data do so in accordance with the FCAI *Uniform Code of Practice on Furnishing Fuel Consumption Data*. Clause 3.5 of that Code states that the Department is entitled to information from each manufacturer about the test procedures and data used. However, enquiry with responsible Departments indicated that data had not been examined for many years. The test procedures used are described in WP7, where a comment is made about their suitability for international comparison.

According to the Guide, the most economical cars on the market in Australia during 1990 were the Suzuki Swift manual (5.4 l/100 km) and the Diahatsu Charade (5.5 l/100 km) [3]. Several other models approach these figures. These are mini class cars and represented only about 6 percent of the total PMV market in 1990.

Presumably, this small share indicates that most new car buyers require/desire larger vehicles. Refer WP3. Some smaller and even more economical cars are on the market overseas.

6.2 NATIONAL AVERAGE FUEL CONSUMPTION (NAFC)

Figure 6.1 shows the national average fuel consumption (NAFC) of new cars and station wagons sold in Australia from 1978 to 1989. The figure shows that following a sharp drop between 1978 and 1980 (coinciding with the introduction of voluntary standards), the NAFC has delivered more or less linearly, achieving 9.2 l/100km in 1989.

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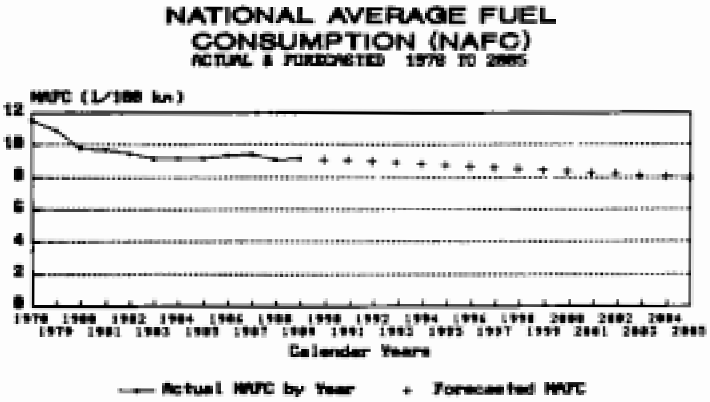
3. Using the 55/45 weighting as applied to the NAFC calculations.

FIGURE 6.1: AUSTRALIAN NAFC, 1978 - 2005



Source: FCAI September 1990

These represent a decrease in NAFC by 23 percent since 1978. It could have resulted from an improvement in fuel economy of individual vehicles, from a tendency of the market to acquire a higher proportion of smaller vehicles in the purchase mix, or both.

6.3 AUTOMOTIVE INDUSTRY EXPECTATIONS FOR NAFC

Figure 6.1 also shows the FCAI projections (under a business-as-usual scenario), for NAFC to 2005.

These forecasts essentially extrapolate the trends of the period 1981-1986, and predict an improvement to 8.0 l/100km by 2005 (Wylie:1990). According to Wylie, larger decreases might be achieved if there is a move in consumer preference towards smaller cars. This happened in 1990.

6.4 FLEET AVERAGE FUEL CONSUMPTION (FAFC)

Table 6.1 shows trends in FAFC from 1976 to 1988. The Table suggests that the FAFC in Australia has fallen steadily from 12.6 l/100km in 1976 to 11.8 l/100 km in 1988. In that period, total distance travelled by cars and station wagons increased by 49 percent, total fuel use by 41 percent and gasoline use by 34 percent.

On road fuel consumption for individual vehicles tends to be higher than for new vehicles for several reasons:

- o fuel consumption tends to increase as the effects of age take their toll of engine tuning or friction resistance, transmissions, tyres, etc increase;
- o non-optional driver performance, such as rapid acceleration, aggressive driving style and tendency to high speed driving;
- o as vehicle ownership and use increases, there is a propensity towards increased congestion, short journeys,

cold starts etc, which results in actual drive cycles differing from test drive cycles.

TABLE 6.1 TRENDS IN VEHICLE USE, AUSTRALIA 1976-1988 CARS AND WAGONS

Year Ending 30 Sept	Total Distance Travelled Million Km	Total Fuel Used ML	Total Gasoline Used ML	Fleet Consumption L/100km
1976	78 531	9 873[1]	9 873	12.6
1979	84 872	10 727	10 696	12.7
1982	96 109	12 046	11 843	12.5
1985	106 574	12 917	12 462	12.0
1988	116 640	13 894	13 183	11.8

[1] Type of fuel not collected. Assumed to be mostly gasoline.

Source: ABS Survey of Motor Vehicle Use, No. 9208.0, Various issues.

Limited data suggests that on road operation consumes at least 20% more fuel than might be expected on the basis of fuel consumption tests of new vehicles.

This improvement in the fleet average is a result of a number of factors, including the declining NAFC and some substitution for gasoline by LPG, but may have been retarded by the ageing of the car fleet discussed in Section3.2.

Not only has the ageing of the fleet slowed down the introduction of more fuel efficient new cars, but the fuel consumption of any given car tends to increase with age.

However, substitution for gasoline has been particularly important in vehicles other than cars and station wagons and as a result the share of total gasoline consumed by cars and station wagons increased from 76.6 percent in 1976 to 81.2 percent in 1988.

The significant difference between NAFC and FAFC is thought to be largely due to the existence of older, higher fuel consumption vehicles in the fleet. Reductions in FAFC are very difficult because the average age of cars in the Australian fleet is thought to be increasing.

Table 6.2 lists some examples of comparisons between actual fuel use by fleet vehicles and data in the Guide, which indicates the magnitude of the discrepancy between test results for individual cars and the on road results.

TABLE 6.2: COMPARISON OF DATA FROM 1988 FUEL CONSUMPTION GUIDE AND FLEET VEHICLE INFORMATION

Model	Fleet data	Guide data City	Guide data Country
Toyota Camry sed	10.0	9.5	6.8
Nissan Pintara	11.2	10.5	8
Toyota Corolla 1.6	9.6	8.5	6.8
Ford Laser 1.6	10.7	9	7.2
Mitsubishi Magna	12.1	10.5	7.2

Source: Choice, June 1985, p.45.

The extent to which such differences undermine the credibility of publicly available fuel consumption information such as that shown in the Guide must be carefully assessed and, if necessary, additional information may be required to maintain credibility.

The question of credibility on publicly available information is important to this Study, as the public must be able to undertake their own measurements if they are to participate in any public policy which pursues fuel economy.

Given that FAFC is the ultimate indicator of fuel economy at the national level, another important issue for this Study is the extent to which it is affected by new vehicles entering the fleet. It is perhaps too easy to think that by introducing policies which operate on new vehicles only (such as mandatory fuel consumption standards), the national fuel economy will quickly fall into line.

For example, it is interesting to note that the FAFC for the (much newer) US fleet was 11.5 L/100 km in 1989, only slightly better than the older and less fuel efficient Australian fleet which delivered 11.8 L/100 km in 1988.

Policy instruments which operate on new vehicles but which might be shown to impact most directly on FAFC are those which cause the market for new vehicles to expand, thus increasing the rate of replacement of older vehicles by new, more fuel efficient vehicles; and thereby cause the use of older vehicles to decrease.

6.5 NEW CAR FUEL CONSUMPTION OVERSEAS

Throughout the Study there was anecdotal evidence and professional literature put before the Consultant that the fuel consumption of Australian passenger vehicles compares unfavourably with those in other countries, notably Europe, the

United States and Japan.

Table 6.3, which summarises class specific averages from the Guide and compares them with averages derived from US EPA test results, is illustrative of that information.

TABLE 6.3: AVERAGE FUEL CONSUMPTION (L/100km) FOR AUSTRALIAN AND EQUIVALENT US PASSENGER CARS BY VEHICLE CLASS:1990

	Australia	U.S. (equivalent)
Mini	6.5	5.25
Small	7.7	6.90
Medium[1]	8.8	7.87
Large[1]	10.7	8.95
Luxury	10.0	8.6
Upper Luxury	10.9	10.7

Note: Australian medium and large class is taken to be equivalent to US compact and intermediate/large respectively.

Comparisons can be made at various levels, bearing in mind the purpose for which the comparison is made. This Section addresses comparisons made on the basis of:

(a) standard tests of equivalent make/models available for sale (or possibly comparable vehicle classes). This may be relevant to consideration of whether new vehicles available for sale in Australia deliver equivalent or similar fuel consumption to mechanically equivalent vehicles sold elsewhere. If not, it provides a baseline (comparable with the NAFC calculated by the FCAI) against which one might assess the benefits of transporting available technology overseas into Australian production;

(b) NAFC or comparable statistic as published by the authorities in various countries. This may be relevant to a consideration about whether the overall fuel consumption of new vehicles is suitable to the overall transport task faced by the vehicle fleet. There are two possible variants of this test:
   - o a sales weighted test fuel consumption which counts the sales mix of vehicles entering the market but retains the city/highway weighting provided under the US test procedures and AS 2877-1986;
   - o a sales weighted test fuel consumption which counts the sales mix of vehicles entering the market, but with the city/country weighting adjusted from 55/45 to 70/30, which is the transport task applicable to Australia;

(c) FAFC or comparable statistic as obtained from dividing aggregate fuel consumption by aggregate transport task.

NAFC is the comparison usually used by informed technologists, while FAFC could be more useful to lay observers. A sales weighted national average for new vehicles weighted 70/30 for transport task is never used, although is more objective for

Australia than NAFC.

6.5.1 Comparison for Individual Vehicles

Individual vehicles are purportedly tested for fuel consumption under strictly controlled and objective conditions; e.g. AS 2877-1986 is (at least nominally) identical to the US FTP_{76} and HWET test as discussed in WP7.

For this reason, plus the fact that the US EPA has a large testing programme associated with the CAFE regulations there, it was most convenient to use cars sold in the US as the benchmark for close comparison between individual vehicles.

Table 6.4 summarises the direct comparison for a range of mechanically similar vehicles sold in Australia and the US. The information sources were the Australian 1990 Guide and the U.S. 1990 EPA Test car list. In selecting U.S. information, the Study always selected models with air conditioning, and the lower inertia weight for those models tested at several weights.

The Table shows vehicle types where the exact U.S. counterpart in terms of engine, fuel system and transmission could be matched. In most cases, the axle ratios were also matched although in some cases the axle ratio in Australia is slightly higher.

Note that these comparisons may not be exact as the detailed test specification of dynamometer horsepower absorption and inertia weight settings for Australian tests were not available.

In considering these results, it must be remembered that it was not the intention to make a value judgement about the relative merits of cars in terms of their suitability for their respective markets. Doubtless they are all fine cars, and suitable to market, otherwise they would not survive.

Rather, "equivalent" cars were chosen on the basis that they were mechanically identical; or the attributes which are addressed by test procedures are identical; or they have attributes which are addressed by test procedures and which can be modified at nominal cost to make them identical.

The Table shows minor differences between vehicles which are otherwise identical. For example, there are a number of cases where there is a difference in axle ratio, which would affect fuel consumption.

In such cases, minor discrepancies between equivalents can be allowed for with sufficient accuracy by applying the laws of physics and engine management theory.

In this context, the hypothesis was that calibration differences alone between Australia and the US cause a 10 percent (or more) change for many, but not all, models.

TABLE 6.4: COMPARISON OF FUEL ECONOMY: U.S. VS AUSTRALIAN CARS

Class	Model	U.S.	Australian Comb. MPG	% Difference Comb. MPG in Fuel Economy	Engine Size	Fuel System	Trans-mission	Axle Ratio U.S.	Axle Ratio Aus.
Mini	Daihatsu Charade	43.4	36.8	17.9	79	FI	M5-2	4.64	4.64
	Daihatsu Charade	38.2	33.7	13.2	79	FI	A3-1	3.61	3.87
	Suzuki Swift/Sprint	54.3	43.8	24.0	61	C	M5-2	4.10	4.10
	Suzuki Swift/Sprint	45.6	38.2	19.2	61	C	A3-1	3.86	3.95
	Suzuki Swift GT	37.1	36.2	2.5*	79	FI	M5-2	4.10	4.1
	Hyundai Excel	36.1	36.3	-0.1*	90	FI	M4-2	4.02	4.02
	Hyundai Excel	37.1	37.2	0.0*	90	FI	M5-2	4.02	4.02
	Hyundai Excel	35.5	34.6	2.5*	90	FI	L4-5	4.06	4.06
Small	Mazda 323	36.3	31.5	15.2	112	FI	M5-2	3.62	3.61
	Mazda 323	31.8	29.0	9.5	112	FI	L4-2	3.48	3.47
	Mitsubishi Mirage/ Lancer	37.7	38.8	-2.9*	90	FI	M5-2	4.02	4.02
	Toyota Corolla	37.3	31.1	19.8	97	C	M5-2	3.72	4.06
	Toyota Corolla	34.1	30.4	12.1	97	C	L3-1	3.33	3.33
	Toyota Corolla	34.9	30.8	13.4	97	C	L4-3	2.82	2.96
	Honda Accord	31.8	25.1	26.7	132	FI	M5-2	4.06	4.06
	Honda Accord	28.4	23.8	19.2	132	FI	L4-2	4.29	4.29
	Mazda 626	31.2	27.2	14.7	133	FI	M5-2	4.11	4.11
	Mazda 626	28	24.8	12.7	133	FI	L4-2	3.7	3.7
	Mitsubishi Galant	30.4	31.1	-2.4*	122	FI	M5-2	4.02	4.02
	Mitsubishi Galant	27.7	26.6	4.0*	122	FI	L4-5	4.01	4.35
	Toyota Camry	33.7	29.4	14.8	122	FI	M5-2	3.74	3.94
	Toyota Camry	31.3	28.4	10.2	122	FI	L4-3	3.53	3.94
Sports	Ford Capri	30.6	30.1	1.7*	97	FI	M-52	3.85	3.85
	Toyota Celica	31.3	30.8	1.8*	132	FI	M-52	3.74	3.74
	Toyota Celica	30.6	29.4	4.2*	132	FI	L4-3	3.03	30.03
	Mazda MX-5	31.9	31.9	0*	98	FI	M5-2	4.30	4.30
	Honda Integra	29.6	29.6	0.0*	112	FI	M5-2	4.40	4.40
Luxury	Toyota Cressida	24.0	23.7	1.2*	180	FI	L4-5	3.91	3.91
	BMW 318	28.2	29.0	-2.8*	110	FI	M5-2	4.10	4.10
	Mazda 929	24.1	21.6	11.4	180	FI	L4-2	3.91	3.91

* Difference less than ±5% suggest no change in fuel economy.

Source: U.S. MPG from 1990 Test car list except for Suzuki Swift which uses 1988 Values. Australian MPG from 1990 Fuel Consumption Guide for New Car Buyers.

The Table shows significant differences in fuel economy for 16 out of 30 cars examined, with the Australian models having higher fuel consumption in each significant case. Most of the high sales volume cars, with the notable exception of the Mitsubishi Lancer and Hyundai Excel, appear to have fuel economy ratings ranging from 10 to 24 percent lower in Australia. (Differences of ? 4.0 percent may be due test variation or rounding error and should be considered non-significant.) Among low volume direct imports, fuel economy differences are essentially zero, except in isolated cases such as the Mazda 929.

While these comparisons for "matched pairs" are useful, there are no simple comparisons possible for the Holden Commodore, Ford Falcon/Fairmont, Nissan Pulsar and Pintara as equivalent cars are not sold in the U.S. However, comparisons with near equivalents among these models based on engine displacement, transmission and weight are shown in Table 6.5.

Again, differences in the order of 10 to 15 percent are observed in 3 of the 4 comparisons with only the Pintara (manual transmission) displaying essentially zero difference. The Commodore vs. Le Sabre comparison is not a good one as the Le Sabre is a considerably larger, heavier car but still attains much higher levels of fuel economy then that attained by the Commodore with the same engine.

The discrepancies described above were referred to manufacturers, the SAE LVCC and the Client. CAFC calculations under the FCAI Code were requested from manufacturers, in the hope of obtaining information which would explain the discrepancies, but these were not forthcoming.

In discussions, manufacturers' representatives suggested that undertaking actual tests or examining and comparing the actual test procedures in different countries is the only way this issue can be examined objectively. There was no possibility of this Study undertaking such expense, and in any event it was not considered to be necessary if test results were made available for the comparison.

It is surprising that fuel consumption testing and reporting in Australia is done on such a confidential basis and there is no public awareness of the test results as occurs, for example, with electrical appliance labelling. Although the FCAI Code allows inspection of data by the DPIE, we understand that this has not been done since COP procedures were introduced into ADR compliance arrangements supervised by DOTC.

The discussions with Plan Producers indicated that the issue is extremely sensitive and in particular, the US based manufacturers strongly resisted the proposition that such comparisons could be validly made: in part, this concern reflected their perception that their models are specifically for the Australian market and customer requirements; in part, it questioned the validity of adjusting for mechanical discrepancies between models by additively applying small increments.

TABLE 6.5: FUEL ECONOMY COMPARISONS FOR AUSTRALIAN CARS AND NEAR US EQUIVALENTS

Model	Engine	Transmission	Axle Ratio	Fuel Economy (MPG)
Nissan				
Pulsar (A)	1.6 L-FI	M-5	4.17	30.8
Sentra (U.S.)	1.6 L-FI	M-5	4.17	34.4 (11.7%)
Pulsar (A)	1.6 L-FI	A-3	3.60	29.0
Sentra (U.S.)	1.6 L-FI	A-3	3.60	33.2 (14.5%)
Pintara (A)	2.4 L-FI	M-5	3.89	27.8
Stanza (U.S.)	2.4 L-FI	M-5	3.90	28.4 (2.1%)
Pintara (A)	2.4 L-FI	A-4	3.88	25.3
Stanza (U.S.)	2.4 L-FI	A-4	3.88	26.8 (5.9%)
Holden/GM				
Commodore* (A)	3.8 L-FI	A-4	3.08	21.9
Le Sabre (U.S.)	3.8 L-FI	A-4	2.84	25.6 (16.9%)
Ford				
Falcon CFI (A)	3.9 L-CFI	A-4	3.08	23.2
Taurus (U.S.)	3.8 L-FI	A-4	3.19	25.9 (11.5%)

* Berlina at 3085 lb vs. Le Sabre at 3295 lb.

This latter issue was addressed by EEA (1991, P.2-4) which reports that the approximation used by the study has been found to yield results accurate to ± 0.05l/100 km (± 0.2MPS in U.S. parlance).

The Japanese based manufacturers were more accepting of the principles of comparison, although they also pointed out that cars need to be designed to meet market requirements.

Extensive discussion and consideration of the results, including consultations as abovementioned, provided a range of possible reasons for the discrepancy, but none could be confirmed because of manufacturers' reluctance to release test data and calculations and conflicting opinions received.

The Consultants identified or were advised about the following possible sources of discrepancy:

- o differences in calibration of engines and transmission systems;
- o differences between test facilities;
- o differences in test procedures;
- o differences in the general rigour of fuel consumption test practices by testing personnel (as compared to practices for emissions);
- o differences in preparation of vehicles for testing; e.g. some vehicles tested may not be the base vehicle; or some not fully run in;
- o differences in vehicle fitout, e.g. type or size (mean radius) of tyres, oils used, fitout of safety and emissions devices, etc.) or fuel type may differ between countries;
- o the rounding rules included in the FCAI *Uniform Code of Practice for Furnishing Fuel Consumption Data;*

Leaving engine and transmission calibration aside for the moment, the remaining issues are discussed in turn below.

Differences in Test Facilities and Procedures

Nominally, there is no scope for differences in test procedures or differences between test facilities. The tests are purportedly objective and to a consistent specification (AS 2877-1986), and a correlation testing programme is in place.

One would hope that there would be no need to confirm compliance to test procedures. However procedures do allow the use of formula and there is a possibility that a particular model may have different weights within the same inertia weight class.

It was argued by some Plan Producers that Australian manufacturers use the "formula" method for determining dynamometer power absorption setting, whereas U.S. manufacturers coast-down times. However, many manufacturers in Australia claimed that they utilised actual coast down times.

Also, Australian manufacturers base the fuel economy rating on the heaviest model configuration, whereas every sub-configuration is tested in the U.S. The Study was unable to confirm this, but it should be noted that U.S. buyers usually purchase higher levels of options such as air conditioning, power windows, etc., so that this is unlikely to be a valid reason for the discrepancy.

It would have been helpful to the Study if dynamometer settings for the Australian tests had been supplied by manufacturers.

Discussions with manufacturers indicates that a system of correlation testing is in place involving a test vehicle. This test vehicle visited each test facility in late 1989 but it is understood that results are not yet to hand. Thus the Study cannot comment about whether there was significant discrepancies between test facilities used for the 1990 Guide.

Some manufacturers argued that US fuel differs from Australian. However, the octane rating for regular unleaded petrol is 87 R?M/2 in the US, identical to the octane rating in Australia. In both countries, emissions/fuel economy tests are understood to be conducted with a controlled specification fuel required for the US Test Procedure that has an octane rating of 93 R?M/2. Most cars except some luxury or high performance cars accept unleaded regular.

Incidentally, the US unleaded fuel has an 87 R?M/2 octane number, similar to Australia. However, all certification types tests are performed with Indolene, a controlled specification fuel.

Differences in General Rigour of Testing

There is limited evidence that vehicles may not in some cases be prepared for testing in conformity with AS 2877-1986. The SPCC (1989) reports the results of tests of "new" and "in-service" passenger cars undertaken at the Motor Vehicle Testing Laboratory at Lidcombe during the years 1987-1989. The procedures described in the report claim that the testing was done in accordance with AS 2877-1986.

However, examination of the test results shows that the new vehicles tested mostly have an odometer reading less than 100km, which does not strictly follow Clause 2.1 of AS 2877-1986, which requires a test vehicle to have an odometer reading of 6400km or other lesser figure if the manufacturer specifies (the running in clause). It was noted that a similar situation exists in respect of testing done by the EPA in Victoria (pers.comm., Greenhouse Unit).

Enquiry at the SPCC indicates that the main purpose was to test for emissions from showroom and operating vehicles and the fuel consumption results are in the nature of a byproduct. There was no attempt to strictly adhere to Clause 2.1.

The SPCC results report a fuel consumption for new vehicles in the order of 10-15 percent higher than the Guide. Typically, there are two factors that would account for the difference noted by the SPCC:

- the "green engine" effect could be as much as 5-6 percent for an engine with only 100km use;
- test car to production slippage. The US EPA have found this to be 3 to 4 percent, and a figure of 5-8 percent is possible although considered high.

If anything, the SPCC results tend to support those set down in the Australian Guide, though it would be better if the tests conformed precisely to AS 2877-1986.

Differences in Preparation and Fitout of Vehicles

Discussions on this issue mostly revolved around tyres and oils used.

Australian tyres may have a higher rolling resistance than some used in the US. However, some manufacturers suggested that U.S. tires built for a softer ride offer higher rolling resistance;

Australian oils are 20W-40 versus more fuel efficient oils in the U.S. This may be so, but the maximum effect of such oils on fuel economy is 0.5 to 1.0 percent.

Differences arising from Rounding Rules

The FCAI Code requires test results to be rounded off by as much as 0.3 l/100km, depending on the magnitude of the fuel consumption measurement. This rounding carries through to the Guide. However, the maximum effect of roundoff error is of the order of 3 to 5 percent and should occur in both directions, i.e., it will round-down some fuel consumption test results.

Conclusion on Individual Vehicle Comparison

A significant effort was made to compare individual vehicles sold in Australia with mechanically identical vehicles sold in other countries. Because of uniform testing procedures adopted, and the availability of objective evidence from the US EPA, vehicles sold in the US were used as the benchmark.

A discrepancy of 10 to 15 percent was found in more than half the vehicles compared.

Many models (although they are low sales volume models) do not display any difference in fuel economy, suggesting that there is nothing unique about Australian conditions that should cause such a large difference in fuel economy. This element of the analysis may be controversial, but the fuel economy of Australia and U.S. models should be nearly identical if all technological factors are controlled in the comparison.

Extensive consultation with Plan Producers and the SAE LVCC indicated that this matter was very sensitive, and several factors suggested by the industry were explored in an attempt to find an explanation. However, the results were inconclusive on this potentially significant issue and the Study was forced to rely on judgements based on the evidence available.

On balance, the Study concluded that it would be unlikely for the discrepancies arising from individual factors explored to all be additive and even if they were, they probably do not add up to as much as 10-15 percent.

It seems apparent that if they so desired, several manufacturers of high volume models could reduce their fuel consumption test results simply by recalibration of the test facilities, by preparation of vehicles appropriately, by recalibration of to engine's and/or transmission systems or some combination of these possibilities.

It was therefore further concluded that calibration/calculation adjustment should be included in the Maximum Technology Scenario.

For forecasting future fuel consumption under the Maximum Technology Scenario at each target year by vehicle class, the Study utilised an upfront "calibration benefit" of 10 percent applied to all classes except sports and luxury. This benefit was taken at the first target year (1995) and is believed to be conservative (low).

The analysis, when viewed in the context of the review of market requirements included in WP3, suggests that under the present regime of market culture and government regulation, there is little incentive for manufacturers to tune engines or programme engine management to maximise fuel economy - indeed emissions control is a more significant imperative. In comparison, the US CAFE legislation carries a severe financial penalties ($US50 per mpg per vehicle sold) if fuel economy targets are not achieved. It and incentives to improve beyond targets. Refer WP6.

It is not improbable that US manufacturers prepare test vehicles very strictly, because of the financial penalties involved in failing to meet the standard.

If Australia is to introduce a policy which applies pressure to manufacturers and importers of vehicles sold in Australia, it is important that this policy includes measures to ensure accurate measurement and reporting of the fuel consumption of those vehicles. The present system appears inadequate and in any event, the results should be available for public scrutiny.

There is every reason for Australian manufacturers to report the lowest levels of fuel consumption, particularly those manufacturers who may be attempting to export vehicles. In the international marketplace, the technology incorporated into Australian made vehicles should be equivalent to the most fuel efficient available internationally.

This suggests that a policy intervention may be required if improved fuel economy is required in Australia.

The evidence presented in this Section should not be construed to mean that Australia should introduce CAFE standards, which are very controversial even in the U.S. Their net worth to the US community in terms of social losses is by no means established.

It may be unwise for Australia to impose mandatory fuel economy standards simply to achieve a tightly controlled test procedure.

6.5.2 Comparison of New Car Fuel Consumption

Tables 6.6 and 6.7 summarise the trends and the outlook for new car fuel consumption in a selection of overseas countries.
The values derived from the various fuel economy test procedures are not strictly comparable among countries due to differences in test procedures; vehicle selection and pre-conditioning; differences in size mix; the more fuel efficient vehicles available overseas; and differences between countries in respect of safety and emissions regulation, etc.

For example, fuel consumption estimates for Australia and the United States are the composite values derived from the 1975 Federal Test Procedure and Highway Fuel Economy Test procedures for city and highway driving. The fuel consumption values for the European countries are measured using the ECE cycle test procedures for city driving and highway travel at 90 km/h and 120 km/h speeds. Hence, the fuel consumption values shown in the table cannot be compared directly.

Despite the difficulties in comparison, the Table suggests that new cars sold in Australia:

- o can claim an overall improvement in measured average fuel efficiency for new passenger cars. However, the improvement is much less than in Canada and the United States were passenger cars in 1973 were about 50% less efficient than in 1988;
- o parallells the two relatively distinct phases in the improvement in fuel efficiency of passenger cars over the period considered shown in other country statistics. The early strong improvements in fuel efficiency can be related to a period of high fuel prices, and the introduction of efficiency standards overseas and pressure by the Fraser

Government in 1979. As the price stimulus decreased after 1983, the rate of improvement can be seen to slow and even, in the case of Japan and West Germany, to reverse, as the composition of the fleet of new cars shifts towards a higher proportion of heavier, more powerful vehicles. WP6 shows that the US CAFE standards also increased from 1986.

TABLE 6.6: ACTUAL NEW VEHICLE FUEL CONSUMPTION (L/100KM)

	1973	1978	1979	1980	1983	1984	1985	1986	1987	1988
Australia	-	11.80	10.90	10.20	9.20	9.45	9.50	9.30	9.40	9.10
Canada	16.50	13.10	11.40	10.30	8.48	8.51	8.49	8.38	8.28	8.10
Denmark	9.00	-	-	7.50	7.30	7.00	7.10	-	6.80	
West Germany	10.30	9.80	9.60	9.00	8.10	7.80	7.60	7.50	7.70	7.90
Italy	8.40	8.30	8.30	7.70	7.30	7.00	7.00	6.80	6.80	6.80
Japan	10.40	8.80	8.60	8.30	7.80	7.80	8.00	8.30	8.60	8.60
Netherlands	-	-	-	-	7.54	-	7.15	-	7.19	-
New Zealand	-	-	10.50	-	9.70	9.40	9.20	9.00	9.00	9.00
Spain	-	-		8.70	-	-	7.40	-	-	7.40
Sweden	-	9.30	9.20	9.00	8.60	8.60	8.50	8.40	8.30	8.20
Switzerland	-	-	-	9.70	-	-	9.10	8.90	8.80	8.70
United Kingdom	11.00	10.00	9.90	9.60	7.90	7.60	7.50	7.50	7.40	7.40
United States	16.50	13.10	11.59	10.00	8.91	8.74	8.52	8.37	8.28	8.20

Note: 1. The levels of efficiency (litres per 100 km) cannot be directly compared due to differences in the test procedures, primarily between cars from different regions. Efficiency changes over time are unaffected by such disparities.

Source: McInnes (1991); BTCE.

Differences in product mix are important, and the better fuel consumption in the US is disturbing. Not only are fuel prices lower there, but also USA-made cars tend to be larger than Australian cars. This is illustrated by the proportion of 4,6 and 8 cylinder cars sold in each country. In the USA in 1987, V8's made up 20% of the market for USA-made cars, V6's made up 30% and 4's made up 50%. In Australia, comparable figures were 1%, 40% and 59% respectively.

One contribution to better US fuel economy concerns weight reductions, especially those due to introduction of front wheel drive. This is estimated to provide a 10% fuel economy benefit compared with rear wheel drive and in 1987 in the USA, where front wheel drive accounted for 74% of all new USA-made cars sold. The market share of front wheel drive cars sold in Australia is around 60%. Much of the difference appears to be accounted for by the fact that the USA equivalents of the Australian Ford and Holden 6 cylinder cars are V6's with front wheel drive.

TABLE 6.7: PROJECTED NEW CAR FUEL CONSUMPTION (Selected Countries)

	Projected L/100km				
	1990	1995	2000	2005	2010
Aust.	10.0	9.7	9.4	8.0	NA
Canada	8.1	7.9	7.7	NA	7.6
Germany*	7.9	7.7	7.4	NA	6.8
Italy	6.8	7.1	7.1	MA	NA

* Relates to FRG data only
Source: IEA 1990, ABARE 1991 (GGE in AT Feb); BTCE:1991

Table 6.7 suggests that the outlook for fuel consumption through to 2005 is likely to be similar to the past; the FCAI estimate that NAFC will fall to 8.01/100 km by 2005, while other countries achieve up to 1.51/100km lower.

An important issue is that the most fuel efficient cars in the US are imported, and the same occurs in Australia. The changes in the NAFC of cars manufactured in and imported to the USA are summarised in Table 6.8.

TABLE 6.8: USA NATIONAL AVERAGE FUEL CONSUMPTION (L/100km) BY PLACE OF MANUFACTURE: 1987 - 1990

YEAR	DOMESTIC	IMPORTS
1987	8.3	7.5
1988	8.2	7.5
1989	8.3	7.7

Source: U.S. Dept. of Transportation Annual Report, 1990.

It seems clear that if Australia puts policies in place which favour the sale of more fuel efficient new vehicles, then those policies will favour imports rather that locally manufactured cars. This has occurred in the US.

6.5.3 Comparison of Fleet Average Fuel Consumption

Table 6.9 indicates that in all countries, FAFC has not improved as rapidly as the figures for new cars would suggest.

TABLE 6.9: AVERAGE FLEET FUEL CONSUMPTION (Litres/100km)

	1973	1979	1980	1983	1984	1985	1986	1987	1988
Australia[1]	-	12.70	-	12.40	-	12.00	-	-	11.80
Denmark	9.02	-	8.60	-	-	8.80	-	-	8.50
Canada	-	15.70	13.80	13.10	-	12.43	11.84	-	-
West Germany	-	10.80	10.80	10.90	10.90	10.90	10.90	10.80	10.70
Italy	-	-	8.50	-	-	8.00	-	-	7.60
Japan	-	11.80	-	11.00	11.00	12.00	10.70	-	-
New Zealand	-	11.70	11.50	-	8.20	7.80	7.80	-	7.90
Spain	-	9.50	-	8.40	8.20	8.70	8.50	8.50	8.50
Sweden	-	10.90	10.90	10.80	10.80	10.70	10.50	10.30	10.30
Switzerland	-	-	10.70	10.32	-	9.30	9.20	9.10	9.00
United States	18.10	16.30	15.50	13.70	13.20	12.90	12.90	11.76	10.80

[1] Interpolated for Table 6.8
Source: McInnes (1991); BTCE.

The BTCE (1991,p.17) has pointed out that Australian car fleet economy has improved only marginally since 1979 compared with other countries of the world.

Comparing the results in the Table, Australian fuel consumption fell between 1979 and 1988 by about 7 percent, compared with much higher gains (s (up to 30 percent in the US and New Zealand) in the same period.

6.5.4 International Comparisons - A Trap for Young Players

The above Sections illustrate the difficulties which arise when lay observers and even the scientific literature attempt to compare the fuel consumption statistics from different countries.

In regard to the fuel efficiency of the new vehicle fleet, it is common to use NAFC as the basis. This test is scientific in nature and bears only an indirect relationship to the fuel consumption delivered by the subject vehicles in an on road situation.

Interpretation of the results by lay observers is fraught with difficulties and misunderstandings arising from:

- o the volumetric measures used;
- o the weighting process used to average fuel consumption of an individual car on the basis of the Transport Task;
- o the weighting process used to average fuel consumption across all new cars as compared with what happens in all cars registered.

Except for the international comparisons discussed above, this Study expresses fuel consumption uniformly in litres/100km. This eliminates confusion arising from U.S. Gallons vs. Imperial Gallons, and the US practice of measuring fuel economy in terms of a harmonic mean.

With respect to weighting of urban/country drive cycles, WP4 showed that the Australian urban/non-urban ratio was 73/27, not

55/45 as applicable to the US and referred to in the US test procedures and AS 2877-1986. An approximate figure of 70/30 is near enough on both a transport task and fuel consumption basis. If this ratio were applied, it would tend to increase NAFC for the same mix of new vehicles sold in any given year.

Using the example of the Suzuki Swift manual, this correction would cause the standard fuel consumption figure to rise from 5.4 to 5.6 l/100km, or 4 percent.

This issue is relevant in the context of the fourth objective in the Brief, which requires that the Study:

> "...assess the economic implications....of meeting the following...[NAFC]...targets for new vehicles by the year 2005:
> 8.0l/100km;
> 7.0l/100km;
> 6.0l/100km; and
> 5.0l/100km."

Because Australia has more city driving, vehicles in use here will have to introduce more technical options to achieve any one of these targets, than would be the case if they were set, for example, in the US.

In other words, an international comparison based on NAFC will give lay observers an impression that the fuel economy being achieved by new vehicles introduced to the fleet in Australia is worse than is actually the case, given an equivalent sales mix.

This situation provides an opening for those who may oppose the introduction of policy measures to enhance fuel economy by replacing the existing fleet with newer vehicles (i.e. increasing the scrappage and sales rates).

The Consultant brought the issue to the attention of the Committee and was instructed to use the US 55/45 ratio, on the grounds that this would provide the most valid comparison across countries.

While this may be the case in strict scientific comparison, it would seem to risk placing a more onerous requirement on manufacturers and Australia generally if decisionmaking in respect to fuel economy becomes based on keeping up with international best practice, as appears likely to be the case.

Politically, it may be wiser to avoid using NAFC as a basis for international comparison, and to devise a measure which is more understandable to lay people.

This raises the question of the relative usefulness of NAFC and FAFC for this purpose. It is recognised that FAFC is difficult to control through policies over new vehicle manufacture, because of individual driving techniques. However, the FAFC result is detectable from Survey of Motor Vehicle Usage results, and is readily understandable by the public.

WORKING PAPERS NO. 5

REPORT ON INTERNATIONAL CONFERENCE ON TOMORROW'S CLEAN AND FUEL-EFFICIENT AUTOMOBILE, BERLIN, 25-28 MARCH, 1991

PREPARED FOR:

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MAY 1991

T A B L E   O F   C O N T E N T S

CONTEXT

Within the context of developing a comprehensive policy response to the Government's planning target to reduce greenhouse gas emission, the Department of Transport and Communications acting in concert with a number of other government agencies commissioned Nelson English, Loxton and Andrews Pty. Ltd. (NELA) to assess the potential to reduce fuel consumption by new passenger cars sold in Australia.

Interim information is being presented to the Steering Committee by way of a series of seven Working Papers as follows:

Working Paper No.	Title
1	Available Options for Fuel Efficient Technology
2	Technical Feasibility of Introducing Fuel Efficient Technology
3	Economic Feasibility of Introducing Fuel Efficient Technology
4(a)	Outlook for Fuel Consumption
4(b)	Implications of Likely Directions in Other Motor Vehicle Design and Operation Regulations
5	**Report on International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, Berlin, 25-28 March, 1991**
6	Review of Policy Instruments Available to Governments
7	Impact Analysis - Process and Procedures

1. INTRODUCTION

1.1 BACKGROUND

A Conference was held in Berlin on March 25-28, 1991 on Tomorrow's Clean and Fuel Efficient Automobile. The Conference was sponsored jointly by the OECD, IEA, Commission of European Communities and the European Conference of Ministers of Transport.

The Conference was designed to be an informal Forum for open dialogue and contact between government officials, industry executives and senior experts from research and development institutions, environment agencies and industry.

The objectives of the Conference were to:

- o analyse the present trends of automobile development worldwide and assess the desirable evolutions in view of critical environmental issues, sustainable development and energy security;
- o evaluate near-term and long-term technology developments, prospects for market penetration and favourable approaches to technology transfer, in particular between Eastern and Western countries;
- o suggest appropriate policies to promote, worldwide, the large-scale development of more energy efficient and less polluting vehicles, and identify critical barriers to this development;
- o assess the socio-economic, trade, and political implications of such policies.

The Conference discussed both new technical options and the economic, trade and social implications of fuel efficiency strategies and the possible economic, regulatory and educational measures available to Governments which wish to pursue fuel efficiency goals.

1.2 OBJECTIVES

The objective of this Working Paper 5 is to summarise Mr. Duleep's impressions of the results of the Conference and provide a compendium of papers issued at presentations.

The Bibliography lists all papers which were obtained from the Conference. A copy of these was forwarded to the FORS.

2. TRIP REPORT

A plenary session on March 25th provided an overview of concerns with the automobile. Michael Walsh presented a paper showing that automotive registration and VMT growth had outpaced population growth considerably. He concluded by stressing the need for newly emerging nations in the East to quickly move to the most modern emission control technology possible and look to new technology to solve the greenhouse problem.

In a similar review, von Welsacker suggested that technology alone can never solve the problem and fundamental social changes were required. He also pointed to the fact that the problem was in the West, not in newly emerging nations, as the West provided a poor model for development.

J. Gawell from the Association of Swedish Car Manufacturers stressed the progress in reducing emissions and fuel consumption that had been made, and stated that manufacturers would continue to make progress. He suggested that more emphasis needs to be placed on transport infrastructure.

G.M. Portal from the European Petroleum Industry Association stated that crude oil would continue to play a central role as a transportation fuel for the foreseeable future, and efforts into reformulating gasoline and diesel would improve emissions to the point where alternative fuels may be unnecessary.

Jean Delsey of the Transport Research Institute (France) stated that prototypes as well as research had shown 25 to 35 percent reduction in fuel consumption was possible, but vehicle manufactures and consumer preference had resulted in larger more powerful vehicles erasing the technology gains.

Finally, Mr J.G. Al of the Air Directorate of Netherlands described a "sustainable mobility system" as one where the goal of mobility is met by harmonisation and co-ordination of various bodies that govern vehicle technology, road design, public transit and land use planning.

On Tuesday, two parallel sessions were held, one on market factors and the other on vehicle technology. Mr. Duleep attended the technology session for the most part, but attended two presentations in the other session. The two included a detailed analysis by Lee Schipper of LBL (California) who showed that none of the OECD countries with the exception of the U.S. managed to improve energy intensity (the energy used per unit of travel) between 1970 and 1987 inspite of large increases in fuel prices. The second paper was by C. Luckner from the German Ministry of Environment on their plans to reduce CO_2 emission by setting Fuel Consumption goals based on vehicle weight. Germany is looking to set stringent goals for fuel economy improvement.

The technology sessions, where Mr. Duleep I presented a paper, provided the usual dichotomy of views. Researchers from France and Germany presented papers showing that a 35 to 45 percent improvement in fuel consumption was possible in the post-2000 time frame. These figures agreed closely with my presentation that showed a fuel economy increase of 50 to 80 percent was possible by 2010. Papers from France and Germany were presented by Jean Delsey of INRETS (France) and by H. Flenker of IABG, Germany. A paper from Hungary showed the potential for reducing NO_x from diesel engines by running with a low compression ratio of 14:1 versus the more normal 17:1.

In contrast, manufacturers were reluctant to admit any improvement was possible with technology, and they contested the earlier papers' results by stating that they were impractical. VW reviewed some of their advanced prototypes fo stop/start diesels fitted with catalysts as well as the diesel/electric hybrid vehicle. Renault presented data on some advanced technology prototypes, but declared that these were impractical for production. Nissan and Mitsubishi described their broad focus strategy for meeting the greenhouse problem but provided no data on individual cars or prototypes, and did not discuss the actual attainable values of fuel economy in the future. During panel discussion, German manufacturers suggested only a 10 to 15 percent fuel consumption reduction was possible by 2005, but presented no supporting data.

In other technology sessions, papers were presented on alternative automotive engines, electric vehicles and alternative fuels. These papers generally concentrated on long-term research that had less application for the next 10 to 15 years. A new type of hybrid bus (electric to diesel) was described, suggesting the potential for substantial fuel savings with current diesel buses.

A final session on the problems of Eastern Europe focused on the current vehicle and emissions technology in Eastern Europe and plans for upgrading their performance. I raised the potential for lessons from Asia, but East European nations believed that Asian conditions were too dissimilar for comparison.

3. CONCLUSION

In conclusion, the following major points emerged:

- Most nations in the OECD have experienced a similar trend in increased vehicle size and performance that detract from fuel economy.

- Fuel price increases are not a sufficient mechanism to counteract these trends.

- Most countries are looking to a combination of "command and control" approaches <u>and</u> market approaches to control fuel consumption.

- There is little disagreement among researchers on the technologically feasible level of fuel economy possible by 2005/2010.

- Automobile manufacturers are reluctant to disclose data on what is possible, and oppose efforts to increase fuel economy by regulatory mandates.

SUMMARY OF PAPERS PRESENTED AT THE OECD INTERNATIONAL CONFERENCE ON "TOMORROW'S CLEAN AND FUEL-EFFICIENT AUTOMOBILE: OPPORTUNITIES FOR EAST-WEST CO-OPERATION", BERLIN 25TH-27TH MARCH, 1991

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WORKING PAPER NO. 6

REVIEW OF POLICY INSTRUMENTS AVAILABLE TO GOVERNMENTS

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DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

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NELA

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CONTEXT

Within the context of developing a comprehensive policy response to the Government's planning target to reduce greenhouse gas emission, the Department of Transport and Communications acting in concert with a number of other government agencies commissioned Nelson English, Loxton and Andrews Pty. Ltd. (NELA) to assess the potential to reduce fuel consumption by new passenger cars sold in Australia.

Interim information is being presented to the Steering Committee by way of a series of seven Working Papers as follows:

Working Paper No.	Title
1	Available Options for Fuel Efficient Technology
2	Technical Feasibility of Introducing Fuel Efficient Technology
3	Economic Feasibility of Introducing Fuel Efficient Technology
4	Population, Passenger Car Stocks and Fuel Consumption Outlook
5	Report on International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, Berlin, 25-28 March, 1991
6	**REVIEW OF POLICY INSTRUMENTS AVAILABLE TO GOVERNMENTS**
7	Definitions, Process and Procedures

NELA

1. INTRODUCTION

1.1 BACKGROUND

There is a very high correlation between fuel economy and minimisation of greenhouse emissions and, although the Brief focuses on the former, the interrelationship cannot be ignored in a policy context. Carbon dioxide emissions can be reduced by decreasing fuel use in vehicles.

However, there is one fundamental difference between policies that reduce fuel consumption and those that reduce emissions. The technical reality is that there is no after-treatment device which can be attached to a car such that fuel consumption can be reduced to zero or close to zero, as can emissions in the case of the catalyst on gasoline engines (Berg:1991,p.6;Berger:1991,p.3).

The only options for reducing greenhouse emissions are reduced fuel consumption or use of alternative fuels. From the perspective of this Study, it is sufficient to accept the high correlation between greenhouse gases (nominally carbon dioxide emissions) and fuel consumption.

Bleviss (1988) suggests that the most direct way that governments can affect the fuel economies of the cars sold in their countries is by setting efficiency standards or targets.

To date, Australian motor vehicle manufacturers and importers have participated in voluntary fuel economy programmes including publication of fuel consumption information relating to new light passenger vehicles.

In recent years, action by overseas governments on fuel consumption or emissions regulation has affected manufacturers' global strategies, and there is every indication that this trend will continue into the future. Increasingly, manufacturers which serve the larger markets (Europe, the United States and Japan) have been required to balance the traditional market pressures for larger or more powerful vehicles against the signals being issued by those concerned about global warming and management of crude oil supplies.

There are limitations on what Plan Producers can do to achieve fuel economy of new vehicles sold in Australia, because all (or nearly all) motor vehicle designs (vehicles or components) are prepared by overseas owners. With few exceptions, the Australian design effort consists essentially of adapting overseas designs to accommodate the ADRs and Australian road and market conditions. Refer WP3.

To a large extent, those original designs are driven by Government regulation and market perceptions in Europe, the United States and Japan. As they flow through to the design of new vehicles sold in Australia, they are reflected in reductions to the NAFC. Refer WP4. For Australia, many of the 'soft' options on fuel economy are already incorporated into new car models. Refer WP1.

Meanwhile, the Commonwealth Government adopted, on October 11, 1990, an Interim Planning Target of stabilising emissions of those greenhouse gases not controlled by the Montreal Protocol on Ozone Depleting Substances by the year 2000 (based on the 1988 level), and reducing those emissions by 20 percent by the year 2005.

While recognising the need to restrict emissions and to aim for a 20 percent reduction, the Government will not proceed with the adoption of response measures which have net adverse economic impacts nationally or on Australia's trade competitiveness in the absence of similar action by major greenhouse gas producing countries.

In addition, a Referral was given to the Industry Commission on greenhouse gases and the issue was been placed on the agenda for a Special Premier's Conference in 1991 (Kelly and Kerin:1990).

It has been suggested that to achieve the Government's interim target using fuel efficiency of vehicles alone, the NAFC will have to be reduced to below 5 l/100 km by 2005. This compares with a 1988 figure of 9.16 l/100 km., or over 45 percent reduction.

As shown by WP1, available and applicable technologies will not deliver this outcome, even if manufacturers can be encouraged or coerced to utilise the technology. A target of 5 litres/100km by 2005 will require draconian measures to eliminate all except the smallest vehicles; alternatively, it might be achieved by introducing further policy measures to reduce the overall consumption of gasoline. Beyond 2005, there may be some prospect of a technological fix.

Nonetheless, it is to be expected that the Australian automotive industry will need to change its approach if it is to deliver fuel consumption targets below the figure of 8 l/100km suggested by the FCAI for 2005.

In order to explore the options for such changes beyond technical innovation, the Brief required that the Study assess, inter alia, the effectiveness of certain alternative policy instruments available to Governments. The principal drivers of this requirement were:

(a) the Government commitment to reduce emissions of greenhouse gases by road vehicles;
(b) Government departments' perceptions of unsatisfactory progress in improving the fuel economy of new passenger vehicles sold in Australia, and the propensity of purchasers of new passenger cars to choose those models which are fuel efficient.

1.2 OBJECTIVES

This Working Paper 6 provides an initial definition and description of the main policy instruments required by the Brief.

It is not intended to provide a comprehensive analytical framework for policy analysis; that is addressed in the main report. It does however, include material which contributes to that end.

Where the Brief requires an assessment of Australian or overseas experience of certain policies (e.g. as in the case of mandatory fuel economy goals and labelling), these descriptions are included, but do not necessarily contain all the material included in the main report.

1.3 TYPES OF POLICY INSTRUMENT

There are a wide range of policy instruments proposed from time to time which seek to deliver particular goals in the transportation sector.

Section 2 addresses some of the major areas of existing Government intervention in Australia. There is considerable intervention in all areas of the transportation market, including manufacturing/importing, distribution, ownership and use.

A "long list" of possible policy instruments is included in Chapter 5 of the main report, categorised in these terms. Based on the results of WPs 1 through 5, the Study ranked alternative policy options as follows:

- public education and information programmes, plus ancillary actions;
- market based instruments;
- direct regulation or "command and control" instruments.

Information programmes are discussed in detail in Section 3 of this WP. Section 4 discusses economic instruments which might be suitable for improving fuel economy, while Section 5 addresses command and control options including a brief review of fuel consumption regulations used overseas.

1.4 CANDIDATE POLICIES LISTED BY THE BRIEF

The Brief lists six policy instruments which must be examined:

1. the introduction of mandatory fuel economy standards (similar to those operating in the United States), including consideration of the date of introduction, and penalties for non-compliance;

2. a variable (sales) tax regime which applies taxes on the acquisition of new vehicles according to some formula which might address, for example, the weight, power, size, or other vehicle characteristic which is influential in its fuel consumption;

3. the treatment of cars in the context of:
   - varying the deductibility of cars for business income tax purposes, according to fuel consumption;
   - setting depreciation allowances at a level not exceeding that applicable to small fuel efficient cars;
   - varying the fringe benefits tax applicable to cars included in salary packages, according to fuel efficiency criteria;

4. collecting registration charges:
   - according to a scale which is a function of the power and weight of a vehicle (used to be done in Queensland);
   - through a direct levy on fuel;
5. varying the imposts on fuel;
6. influencing the vehicle purchase decision by:
   - delivery of public information and education programmes on fuel economy for new passenger vehicles;
   - introducing fuel economy labelling of motor vehicles, either on a voluntary basis or as part of a mandatory system.

However as shown in Chapters 3 and 4 of the main report, and in later Sections of this WP, the Study did not limit itself to these policy instruments. This extension is consistent with the requirements of the Brief.

1.5 CONSTITUTIONAL MATTERS

In additional to political concerns which arise from time to time around various types of government policy, the Constitutional arrangements prevailing in Australia make it essential to consider the capability of various levels of Government to implement different types of policies.

Australia is a federation of sovereign States, with an Australian Constitution. The Constitution assigns many powers to the Commonwealth, the relevant ones from the point of view of this Study being the ones over taxation, corporations and overseas trade (customs and excise). In addition, the States have from time to time ceded certain limited powers to the Commonwealth.

Subject to the provisions of the Constitution, and any other authority ceded by the (sovereign) States to the Commonwealth, the powers of the States are virtually unlimited.

In order to resolve 'grey' areas between the powers of the Commonwealth and the States, a large number of consultative mechanisms have been established. One of the most important for this Study is the ATAC.

Turning to the specifics, it is clear that information programmes including labelling can be implemented by both levels of government. The voluntary publication of fuel consumption information is administered by the Commonwealth.

The main form of economic regulation of automotive manufacturers is the Car Plan, which is administered by the Commonwealth under the corporations and overseas trade powers. There is no fuel economy agenda in this legislation.

Sales taxes, personal and company income taxes can be implemented by the Commonwealth only.

Fuel taxation can be levied by both Commonwealth and the States, the latter form being the Business Franchise Fee. The Inter-State Commission (1990) has questioned the legality of the Business

Franchise legislation, but this has not been tested in the appropriate legal jurisdiction.

It would, in NELA's opinion, be a pity if the Business Franchise legislation in the States was found to be invalid. Fuel taxation is a useful way to manage the demand for passenger transport, and this is most important in capital and, to a lesser extent, major provincial cities. The Business Franchise Fee allows each State to sensitively levy different levels of fuel tax on different localities (as they do now with motor vehicle registration and third party insurance charges), thus having the potential to achieve a much higher level of transport efficiency than would be possible from a Commonwealth perspective.

Annual charges, notably registration charges and third party insurance, are imposed by the States under transport legislation. In 1989, the Inter-State Commission recommended referral of these powers to the Commonwealth, but this has not happened to date.

Command and control mechanisms can most easily be implemented by the States, although the provisions of the Motor Vehicle Standards Act of 1989 provide the basis for compliance testing of new motor vehicles. The ADRs are administered under this legislation. This legislation provides a basis for a wide range of information about the design and construction of new motor vehicles to be provided to the Commonwealth, but at present there is no fuel consumption agenda in the ADRs.

Before the promulgation on the Motor Vehicle Standards Act, mechanisms relating to the inspection and testing (mechanical, safety, emissions and fuel consumption) of new or operational passenger cars were entirely the responsibility of the States and were administered under transport or environmental protection legislation. The Commonwealth has little or no access to this type of regulation except through the Motor Vehicle Standards Act.

2. EXISTING MARKET INTERVENTION

There is already substantial Government intervention in the transport industry, much of which operates on the manufacture, sale, ownership and use of passenger cars. Most of the instruments are economic, but some command and control ones are used.

2.1 INFORMATION AND MONITORING PROGRAMMES

Of non taxation instruments, only information, research and training programmes can be said to have minimal adverse impacts on the industry. The Commonwealth has a number of such programmes in place:

- The DPIE, in conjunction with the FCAI, produces the Australian Fuel Consumption Guide for New Car Buyers. This is a fundamental document to this Study and is further discussed under Section 2.1.1;
- The NSW Department of Minerals and Energy, in conjunction with the National Roads and Motorists Association, has produced a booklet on vehicle fuel economy;
- An accredited course in motor vehicle fleet management is being developed by the Commonwealth. The course will be directed at persons whose responsibilities include vehicle fleet management. Objectives include reducing consumption of traditional fuels, increasing efficiency of fuel use and increasing fleet manager's awareness of their responsibility to the environment.
- the Commonwealth is also about to undertake a major energy audit of its motor vehicle fleet with the aim of identifying the amount of patterns of liquid fuel use and identifying, evaluating and recommending options to reduce fuel use. The results of this initiative are expected to not only save fuel in the Commonwealth's vehicle fleet, but also to lead to savings in other fleets as operators follow the Commonwealth's example.

2.1.1 Effectiveness of The Fuel Consumption Guide

The Guide is a booklet which has been published annually by the Commonwealth Department of Primary Industries and Energy since 1979. It lists fuel consumption information for new cars sold in Australia by manufacturers who are members of the FCAI. The booklet also includes fuel saving hints and conversion charts.

The list includes a technical description of each make and model and includes an FCAI estimate of fuel consumption for city and highway driving on the basis of test results provided voluntarily by manufacturers according to AS 2877-1986 and the FCAI Code for Provision of Fuel Consumption Data.

The Department also co-ordinates distribution nationally. This is consistent with the national basis for administration of the car industry and the Commonwealth's key role in determination of oil policy. It contrasts with the state by state focus of other programmes of energy conservation information such as appliance energy labelling, which results from State control of electricity and gas supply.

Several market research studies have investigated the impact of the Guide, the most recent being carried out in 1988 (CCEM, 1988). Since that study, increased efforts have been made by the Commonwealth Government and some sectors of the car industry to promote the Guide and distribute it through a wider range of outlets, so data from it may not be current. Nevertheless, some important lessons can be learned from experience with the Guide.

There has been consistent public support (over 80% of survey respondents) for information on vehicle fuel consumption. Public awareness of the Guide rose from 15% in 1984 to 26% in 1988, and the number of private purchasers using the guide rose from 3% in 1984 to 6% in 1988. However, this is still a low level of impact. It is not clear to what extent consulting the Guide actually led to changes in purchasing decisions.

A wide range of methods have been used to disseminate the Guide, and to promote it. These have involved motoring organisations, car dealers, service stations, Government agencies and media advertising.

This experience seems to confirm the conclusion of the Artcraft Report (CCEM, 1988, p.10) that information by itself, at least in this form, is insufficient to significantly change car purchasing behaviour.

In a later Section, the issues surrounding a possible fuel economy policy are considered in order to enhance the impact of the Guide and possibly to modify the approaches to provision of fuel consumption information.

2.2 ECONOMIC INSTRUMENTS

2.2.1 Taxes and Charges

As shown by Table 2.2, there a number of types of taxes and charges levied by the Commonwealth and the States, over and above the usual plethora of income, payroll land and other taxes and charges which are imposed on business and individuals generally, making automobile manufacture, distribution, ownership and use one of if not the most regulated sectors in the country.

These taxes and charges have a major influence on the price system faced by manufacturers, distributors, owners and users of motor cars (these groups need to be considered independently). In 1988, around $12 billion dollars was raised from all sources.

It is accepted that the Commonwealth Treasury and other departments may not regard all these revenues as taxes or charges, and they may not all find their way into the Consolidated Revenues of the Commonwealth or the States. Items classified as a charge are used to offset costs incurred by Government in supplying services to industry.

TABLE 2.2: COMPONENTS OF TAXATION IN THE MOTOR VEHICLE INDUSTRY 1984 - 1988/9

($million)

	1984-85	1985-86	1986-87	1987-88	1988-89
Commonwealth Taxes					
Employers' payroll taxes:					
- Fringe Benefits Tax Payable			256.9	427.4	485.7
Taxes on provision of goods and services:					
- Sales Tax (1)	1,744.6	1,922.5	1,659.2	1,954.8	2,320.8
- Excises on crude oil and LPG (2)	4,241.8	4,065.8	2,105.5	2,079.4	1,197.0
- Royalties on Production		169.0	103.0	117.0	61.0
- Refined Product Excise					
- Petrol	1446.1	1903.8	3177.8	3353.3	3676.8
- Diesel	561.8	773.2	1229.1	1323.0	1458.7
Tariffs	n.a.	n.a.	n.a.	334.3	440.2
Taxes on use of goods and performance of activities					
- ACT Motor Vehicle Taxes	19.3	21.2	23.7	30.3	38.3
Sub Total Commonwealth Taxes	8,014	8,856	8,555	9,620	9,678
State and Local Government Taxes and Fees					
Taxes on use of goods and performance of activities					
Motor Vehicle Taxes;					
- Vehicle registration fees and taxes	925.2	986.8	1,062.4	1,163.5	1,242.1
- Stamp duty on vehicle registration	382.9	428.9	456.5	516.2	650.7
- Drivers' licences	131.9	137.9	149.2	157.3	170.2
- Road transport and maintenance taxes	28.5	33.5	35.0	42.5	44.6
Royalties on Production		314.3	214.4	220.0	149.0
Petroleum products franchise taxes	508.3	553.0	621.5	674.3	680.0
Sub Total State and Local Gov.	1,977	2,454	2,539	2,774	2,937
Total	9,990	11,310	11,094	12,393	12,615

Source: ABS Catalogue No. 5506.0; BTCE, Annual Numerical Series: Road User Payments, 1991 Taxation Statistics, Supplement to the Annual Report: Commissioner of Taxation; and AIP, Oil and Australia 1991 Statistical Review.

Notes: (1) Sales tax figures include more than PMVs.

Business Type No.	Sales Value of taxable goods					
1	Motor Cars, commercial vehicles, including motor bodies, semi trailers etc.	5,521	5,936	4,659	5,585	7,240
2	Tyres, tubes, retread and recap rubber, wet cell batteries, oils and greases	1,131	1,187	1,109	1,156	1,312
11	Motor Vehicle parts and accessories	1,857	2,254	2,224	2,719	2,737
33	Composite businesses including motor vehicles and parts	214	236	304	315	314
Total		8723.2	9612.7	8295.8	9774.2	11603.8
Assume PMVs attract 20 Percent Sales Tax		1,745	1,923	1,659	1,955	2,321

(2) This a now Resource Rent Tax and includes petrol, diesel, kerosene, aviation fuels, etc.

It is not the purpose here to argue the merits or otherwise of any of these taxes and charges, but rather to point out that they do exist, that they virtually control the price signals delivered to the players, that the collection mechanisms impose significant overheads on the players, and that it is within Government's power to change these instruments or the amount of each impost.

Thus Government could significantly change the behaviour of manufacturers, distributors and consumers by changing the structure of these taxes and charges without significantly changing the amounts collected.

Fringe Benefits Tax

This is a tax payable by companies if they allow use of company cars for private purposes. There are two methods of calculation involved, a log book method and a standard formula method.

The log book method is very time consuming and costly, and most companies opt for the formula, even in cases where this would involve more tax to be paid.

FBT is paid on nearly 500.000 cars in Australia, possibly because it is possible for a person allocated a company car as part of a salary package to save money on income tax.

Sales Taxes

Sales taxes are levied at a rate of 20 percent on all cars priced below a certain figure which changes with CPI. The rate is 30 percent above that figure which, from the point of view of the Study, was taken to be upper luxury class cars. As shown by Table 2.2, sales taxes are levied on a wide range of parts, accessories as well as cars and commercial vehicles.

There is no disaggregation of sales tax by vehicle type, and a figure of 20 percent of goods value was used as the estimate of revenue raised.

Excises on Crude Oil and LPG

From the price paid by refiners for locally produced crude, the Australian producer pays both a royalty and, since 1989, a Resource Rent Tax (RRT). The excises on crude oil and LPG shown in the Table were collected on that basis before the RRT came into being. After 1989, the components would be split, and for 1989-90, RRT was $42m and other excises $1232m.

The BTCE have argued that the Resource Rent Tax (formerly the Crude Oil Levy) is irrelevant to the discussion of policies which affect the automotive industry. The basis of this position is that if there were no tax, producers would sell crude at world parity prices. In principle, there is no objection raised to this viewpoint if Government wishes to see things that way.

However, an alternative view was taken in the US during the early 1970s. There, it was argued that domestic oil resources are owned by the community, and should be sold domestically at the cost of production. In those years, the US imposed price controls to ensure this occurred, and those policies provide the background to the development and use of mandatory fuel consumption standards in the US. It is only comparatively recently that the US has allowed the price of domestic oil to rise to world parity, and the US still has the lowest fuel prices in OECD countries.

From the point of view of this Study, these alternative treatments illustrate the dichotomy between the use of market based instruments (in Australia) and command-and-control instruments (in the US). The only real difference is that in Australia the rents are distributed across all Australians via the Consolidated Revenue, whereas in the US the benefits were taken by the people who used the fuel (perhaps a "user gains" rather than a "user pays" policy).

Consideration of this dichotomy was a recurring theme during the Study, because the Brief required an analysis of both market based and command-and-control instruments.

The total collected from excises on crude oil and LPG ($1,197 Million for 1988-89) cannot be disaggregated to identify taxation on motor fuel only and it includes all outputs from crude oil.

Royalties on Production

Royalties apply to fields which are not subject to RRT, and revenues are shared between the Commonwealth and State Governments. The rate of royalty is set as a percentage of the wellhead value of the petroleum produced.

Refined Product Excise

Referring again to Table 2.2, the refined product excise represents another market based instrument imposed by the Commonwealth on petroleum product, including petrol, automotive dieselene, fuel oil, heating oil and kerosene. This is automatically adjusted in accordance with CPI and currently raises the largest single contribution to the revenue, of all market based instruments.

Tariffs

Tariffs (import duties) received by the Federal Government (Table 2.3) for completely built up (CBU) PMVs over the last three years have been:

TABLE 2.3: CUSTOMS EXCISE DUTY PAID IN THE MOTOR VEHICLE INDUSTRY

Year	Customs Excise Duty
1988	$334,267,796
1989	$440,190,044
1990	$407,703,902

Source: Personal Communications with Automotive Industry Association, March 1991.

ACT Motor Vehicle Taxes and State Registration Charges

ACT motor vehicle taxes are levied on vehicles registered in the ACT. They correspond to State registration charges.

The registration charge is levied by the States on car ownership, and at $1242m in 1988-89 is the fourth highest revenue raiser.

Its purpose varies from jurisdiction to jurisdiction. In some cases it is a fee for service, for recording the vehicle on the State or Territory motor vehicle register; in other cases it may also include a charge for road use. Other registration related charges, on the other hand, may include a charge for road use in addition to service charges for motor vehicle inspection.

The total registration amounts presented in Table 2.4 are comparable, however, since they include all of the fees and charges mentioned.

Enquiry in NSW indicates that "Other registration related charges" consists of three components:

1. Road Tax, which has four categories determined by size and weight;
2. Third Party Insurance; and
3. Third Party Insurance Levy.

TABLE 2.4: GOVERNMENT REGISTRATION CHARGES - CARS AND STATION WAGONS

30TH JUNE 1989

	N.S.W.	VIC.	QLD	W.A.	S.A	TAS.	N.T.	A.C.T.
Registration Fee ($ per vehicle)	31	102	134	64	49	28	53	185
Other Registration related charges ($ per vehicle)	224	0	0	11	0	43	15	17
Total ($ per vehicle)	255	102	134	75	49	71	68	202

Source: Inter-State Commission 1990. Road User Charges and Vehicle Registrations: A National Scheme. Volume 2 Appendices. March.

Note however, that this perspective is not uniform among States or even among observers. For example, the ISC (1990,p.243) regards Third Party Insurance payments made at the time of registration separately from the total registration charge.

Stamp Duty on Vehicle Registration

This is a charge levied by the States on the occasion of transfer of ownership of second hand cars.

Drivers Licence Fees

Each State levies an annual fee on drivers' licences. Sometimes this fee is levied to cover more than one year, e.g. in Victoria the fee is levied on renewal every 6 years.

Road Transport and Maintenance Charges

These charges are levied on the transport of goods. Although it is thought to be mostly on trucks, cars are not excluded.

Petroleum Products Franchise Fees

These amounts are levied by all States except Queensland. The rationale relevant to a particular impost can and does become confused, e.g. the Business Franchise Fees in Victoria are applied in part to transport management and maintenance, and in part to Government underwriting of losses incurred by members of a failed financial institution.

2.2.2 The PMV Plan

For many years, the automotive industry has been excluded from the Commercial Tariff Concession System and this is expected to continue at least up to year 2000.

The 1984 PMV Plan originally operated on a combination of quotas and tariff protection, the former being abolished from 13th April, 1988. Quotas are ignored for the purposes of this Study.

Aims of the PMV Plan

The Government's stated objective is the development of an Australian automotive industry that is viable and internationally competitive, providing higher quality vehicles at lower real prices to consumers.

In 1991, the Government considered the recommendations of the Industry Commission Report on The Automotive Industry (IC:1991), and subsequently announced arrangements for the passenger motor vehicle industry to the year 2000 which have as their major objective the creation of a viable internationally competitive Australian industry.

This was to be achieved by changes to passenger motor vehicle assistance arrangements which encourage further restructuring and rationalisation in the industry, and a concentration on those areas in which it is most competitive.

Tariff Protection

Nominal tariff protection on passenger motor cars and commercial vehicle derivatives (PMVs) and original equipment (OE) PMV components for the period through to year 2000 are as shown in Table 2.5. There are no stated tariff arrangements beyond year 2000.

TABLE 2.5: TARIFF RATES (PERCENT) FOR PMV AND OE COMPONENTS

1st January	Percent
1989	42.5
1990	40.0
1991	37.5
1992	35.0
1993	32.5
1994	30.0
1995	27.5
1996	25.0
1997	22.5
1998	20.0
1999	17.5
2000	15.0

Automatic Duty Free Entitlement

Subject to the penalties applying under certain minimum requirements described below, there is an automatic by-law entitlement for duty free import of up to 15 percent of the value of production which will be retained for vehicle producers to 31 December 2000. It is available for the importation of either completely built-up (CBU) vehicles or original equipment components.

From 1 January 1991 until 31 December 1996, minimum volume requirements will be retained such that:

- o for Plan Producers to receive the full 15 percent by-law entitlement, production will have to reach 30,000 units per year per model; and
- o below 30,000 units per year, the by-law entitlement will be progressively reduced to 0 at 20,000 units per year per model.

Export Facilitation Under the PMV Plan

A modified export facilitation scheme will come into effect from 1 January 1991 and operate to 31 December 2000. The arrangements are too detailed to be addressed by this Study, and the following are assumed:

- o there are no "hurdles" for vehicle and component producers, or for importers;
- o credits are calculated on the basis of one dollar for every dollar of Australian automotive value-added in the local content of eligible exports. This ignores certain phasing out allowances on earning of export credits without value-added testing.
- o In the calculation of export credits, PMVs and relatively complex assemblies such as engines or transmissions will be considered as 100 percent value-added;

- credits will provide Plan participants with the right to reduce duty paid on imported automotive products. One dollar of credits will earn a duty reduction equal to one dollar multiplied by the tariff rate for PMV's and OE components in the year of use;
- there are no ceilings on the level of export credits that Plan participants can earn, and there are no restrictions on the direct use or sale of export credits;
- the arrangements are extended to allow for the inclusion of automotive machine tooling, automotive tooling and services relating to automotive design and production as eligible exports;
- the export facilitation scheme will not apply on exports to New Zealand;
- there are no offset obligations.

Commentary

As discussed in WP4, the Study assumed that total sales of PMVs would continue at their current rate of 410,473 units, subject to changes in price caused by changes to the exchange rate, changes in tariff and changes to population, as well as by policy options to be considered by the Study.

For the purposes of this Study, it was assumed that the year 2000 tariff rate and other applicable arrangements will continue to 2005. Other assumptions relating to the projection of vehicle sales are discussed in WP4.

No particular allowance was made for the automatic duty free entitlements, as it was assumed that rationalisation among Plan Producers would result in each one producing more than 30,000 units per model.

It is widely accepted by Government and industry sectors that the new arrangements under the PMV Plan will lead to a major fall in volume of Australian production, although there is considerable debate about the extent of that fall.

Statements by the Minister for Industry, Technology and Resources have foreshadowed some rationalisation among Plan Producers during this decade (Dabowski:1991).

One estimate by the Industry Commission (1991) is that local production volume will fall from the 1988 level of 323,924 (sales of 330,416) units to a figure in the range 230,000 to 330,000 units.

DITAC (1991) has expressed reservations about this forecast, and suggested that the higher figure is the most likely outcome and possibly higher if there is a prolonged upturn in the economic cycle. It pointed out that, between 1984 and 1989, average production volumes per plant increased from 46,000 to 52,000. However, in this period Australian production fell from about 370,000 units to about 323,000 units (AIA:1988,p.18).

Now forecasts by the Industry Commission (1990,Appdx F) are based on estimates prepared by the ORANI model and by NEIRS, with the latter resulting in the lower figure.

The Study does not have such tools available, but recognises that ORANI is calibrated on 1982-83 data and is designed to estimate marginal changes to inputs and outputs given the technological situation at that time.

The Study has some reservations about these assumptions. Firstly, the industry invested consistently over the period since 1982-83 and the technology of motor vehicle production in Australia may well have changed due to progressive introduction of different production techniques over that period. This would tend to invalidate the technical coefficients incorporated in ORANI. Secondly, the changes predicted are not marginal.

It is noted that the automotive industry is characterised by high fixed costs; the minimum volume below which a plant cannot recover its fixed costs is widely assumed to be about 250,000 units, and this is one of the factors affecting Plan Producers' tendency to adopt long model runs (up to eight years).

It seems that the Australian manufacturers have done well in being able to survive in the face of a low volume market. Some observers believe that this has been due to the high tariff protection in those years, while manufacturers suggest that their survival is largely due to their being able to find a niche in the global strategy of overseas owners.

This niche is predominantly in medium and large classes, which in 1988 were about 60 percent (includes about 241,300 PMV and PMV derivatives) of total registrations. Local production supplied nearly 82 percent of the medium and large classes sold in 1988.

The DPIE (1991) argue that the system of export credits will encourage the industry to look to export markets for increased volumes, and hence economies of scale.

However, this is likely to apply to medium and large vehicles only, and possibly some components manufacturers. Australian manufacturers have low scope or capability in automotive design (except for "Australian-isation" of overseas models), and cannot readily interfere with the strategies or operations of their overseas owners.

It was concluded that any pressure on Australian manufacturers to change production to small vehicles (if that is required to enhance Australia's fuel economy) will favour importers, because of the inertia of existing plants. Not only has this conclusion been reached on the basis of plant inspections and discussion with Australian manufacturers, there is also comparative evidence from the US where, despite the strong local manufacturing industry, the tendency to increase sales of small vehicles as a result of CAFE standards has been shown to have favoured importers, as discussed in a later Section and in the main report.

Such an imperative imposed on Australian manufacturers would require them to invest in a production capability for vehicles which are in direct competition with plants operated by their owners overseas.

It is doubtful if overseas owners will tolerate direct competition from Australian subsidiaries, unless some other benefit to their global strategy is available.

Even if they did however, substantial investment in new plant and equipment would have to be eventually funded from profits made in Australia. Such Annual Reports which are available from Plan Producers indicate low profitability, and the current climate is characterised by considerable price cutting, shedding of labour and low volume production.

On balance, it was concluded that any significant pressure flowing from a fuel economy policy which causes a shift in market share from medium/large cars to small cars carries with it considerable risk of an abandonment of manufacturing of the traditional Australian medium and large car and a fall in the number of Plan Producers and plants. This could exceed falls which have already been foreshadowed by the Minister for Industry, Technology and Commerce.

2.3 COMMAND AND CONTROL INSTRUMENTS

Command and control instruments applied in Australia mostly operate on manufacturing and use of motor vehicles. There are such controls over sale or ownership of motor vehicles.

From the perspective of this Study, the most significant instrument of this type is the system of Australian Design Rules which require all vehicles sold in Australia to comply to certain mechanical, emissions and safety standards.

Controls over use of vehicles are predominantly in the nature of limits over driving behaviour, although most States have a system of motor vehicle inspections which is triggered on change in ownership.

2.3.1 Australian Design Rules (ADRs)

The Australian Design Rules (ADRs) set down a number of technical attributes which must be incorporated into new vehicles, as a prerequisite to import, registration and use on Australian roads.

The ADRs take force nationally under the Federal Motor Vehicle Standards Act and are administered by the Federal Office of Road Safety. The Act applies to vehicles prior to first supply to the Australian Market. Control of vehicles which are already in service is the responsibility of the States and Territories.

The Vehicle Standards Advisory Committee (VASC) and the Advisory Committee on Vehicle Emissions and Noise (ACVEN) have responsibility for safety and environmental Design Rules, respectively. After endorsement by all State, Territory and Federal ministers for transport in the Australian Transport Advisory Council, the ADRs are tabled in the Federal Parliament and subsequently administered as National Standards under the

Motor Vehicle Standards Act.

Scope of ADRs

The arrangements to provide assurance that vehicles sold in Australia comply with the ADRs are broken up into the following areas:

- Development of standards;
- Certification of vehicles to the standards;
- Audit of vehicle manufacturing and testing facilities;
- Investigation of safety defects and recall.

The ADRs cover a wide variety of safety requirements such as seat strength, seat belts, crashworthiness, glazing, brakes, tyres and other features to improve occupant protection. They also set out requirements for vehicle exhaust emissions and noise.

There are currently 66 ADRs relating to the various vehicle categories of passenger vehicles, motorcycles, commercial vehicles, omnibuses and trailers.

It is the government's policy to harmonise, wherever possible, with international standards unless there are significant safety grounds to do otherwise. At present, over 60% of the ADRs are aligned with international standards, predominantly the European ECE regulations, although gaseous emission standards are modelled on the US Federal environmental regulations.

Day to Day Administration

The Motor Vehicle Standards Act appoints the Assistant Secretary, Motor Vehicle Branch in the Federal Office of Road Safety as Administrator of the Act, with responsibility for determining the compliance of motor vehicle models with the ADRs and issuing approvals.

The approval process has two main parts:

- Manufacturers submit to the Administrator documented evidence that each vehicle model has been tested and complies with the performance standards specified in all the ADRs applicable to that vehicle; and
- An example of each vehicle model is inspected to check that all regulated features capable of being visually assessed are actually present.

After successfully meeting requirements, an approval to fit compliance plates to that model type is issued, allowing normal bulk registration to commence.

Manufacturing plants and the laboratories used for ADR testing are regularly audited by the Administrator's staff or by specially trained overseas agents to maintain confidence in the validity of test results and in the continuing compliance of production vehicles.

Internationally agreed quality system and auditing standards are used for this work, and overseas agents are themselves routinely monitored to ensure consistency of approach.

2.4 CONCLUSION

The passenger transport market is already subject to a large measure of Government intervention, and as a result theories of market failure can be applied only with difficulty.

The principal type of intervention is economic, with taxes and charges of many types being imposed. The ADRs constitute a significant control over vehicle manufacture. Information programmes are very limited.

It is noted that there are a number of measures which have been used both in democracies and centrally planned economies which are not now in use in Australia. These apply across the complete automotive environment: manufacturing, sale, ownership and use. These are addressed in the main report.

Four of these, mandatory fuel consumption standards, variable sales tax regimes, annual registration charges and labelling are contemplated by this Study. These are discussed in the following Sections.

3. VEHICLE FUEL EFFICIENCY LABELLING AND OTHER INFORMATION STRATEGIES

The Brief required that the Study examine matters concerning vehicle labelling and public education programmes. As discussed in the main report, it was concluded that the importance of such programmes, properly backed up with an appropriate testing regime, cannot be overstated.

This Section explores a number of issues relating to such programmes, including the necessary approach and issues relevant to the design of successful programmes.

3.1 INTRODUCTION

The review of the market environment discussed in WP3 led to a conclusion that fuel economy is relevant to, but not high on the agenda of the decision criteria of purchasers of passenger cars, and that this relative lack of concern flows through to manufacturers' design practices and marketing strategies.

This is not to say that such a programme is not needed. Quite the reverse. Table 3.1 shows the Artcraft (CCEM:1988) survey results on the need for vehicle efficiency labelling and inclusion of fuel consumption information in advertising. Artcraft considered these options in some detail, including evaluation of possible label designs.

TABLE 3.1: SUPPORT FOR INFORMATION ON FUEL CONSUMPTION OF NEW VEHICLES (CCEM, 1988,20)

ATTITUDE TOWARDS PROVIDING FUEL CONSUMPTION INFORMATION:

	PRIVATE NEW VEHICLE PURCHASERS 1984 %	PRIVATE NEW VEHICLE PURCHASERS 1987/88 %	FLEET OWNERS 1987/88 %
ON NEW VEHICLES IN CAR SHOWROOMS			
Should	84	83	81
Should not	13	12	15
Unsure	3	5	4
IN ADVERTISEMENTS FOR NEW VEHICLES:			
Should	79	77	75
Should not	17	16	22
Unsure	4	7	3

Clearly, there is strong support in principle for provision of information by both methods. However, support in principle, while a useful indicator of public sentiment, falls far short of support for a specific approach. Further, it does not indicate whether the respondents will utilise the information.

After a brief review of the types of information programmes which have been used around the world, this Section considers the role and application of information programmes in a fuel economy policy. This includes information which may assist with the design of a comprehensive public information programme and where vehicle labelling may be useful.

At this point, we reiterate that NELA believes a comprehensive information programme to be necessary if other policy instruments are to be successful and accepted by the public.

3.1.1 Information Programmes Used in Other Countries

Vehicle efficiency information programmes were established in the 1970s by many nations, and were still in place in the mid-1980s (Bleviss:1988). These programmes seek to promote fuel economy by heightening consumers' awareness of the efficiency of the vehicles they are buying.

Table 3.2 lists known fuel economy programs by country. The most popular form of information dissemination used is fuel efficiency guides similar to The Australian Fuel Consumption Guide for New Vehicles issued by the DPIE in Australia (DPIE:1990).

Responsibility for developing and distributing these guides varies with country, and may include the national government, the automobile industry and/or automobile associations. With the exception of West Germany, a non governmental responsibility generally means that no comprehensive guide is published.

Many countries also either require or recommend that labels containing fuel consumption information be affixed to a visible portion of a new car when it is offered for sale. Issues relating to labelling are discussed in a later Section.

3.2 THE ROLE OF AN INFORMATION PROGRAMME

Information is widely recognised as a fundamental issue in development of policies which operate on consumer choice. It is this recognition which underpins all advertising programmes and, given the low priority allocated to fuel economy in the marketplace, it should not be surprising if manufacturers' advertising programmes do not emphasise fuel economy.

Policy instruments which seek to manipulate the market rely on consumers having "perfect information", so that rational choice can occur. Lack of information is also acknowledged as a substantial barrier to technological and social change and innovation.

TABLE 3.2: FUEL ECONOMY INFORMATION PROGRAMS

COUNTRY	Takes lead or major responsibility for Publishing Fuel Efficiency Information	Publishes Annual Fuel Efficiency Guide	Publishes Annual Fuel Efficiency Lists	Specifies Vehicle Labelling Procedures	Provides Information on Fuel Efficient Driving	Specifies Advertising Guidelines	Requires Fuel Efficient Driving Training for Licence	Government uses Media to Advertise Availability of fuel Efficiency Information	Vehicle Fuel Efficiency Inspection	Developing Fuel Efficiency Information Program	Evaluation Completed of Program Effectiveness
Australia	G	YES	NO	*	YES	YES	NO	YES	NO	YES	* *
Austria	G,I,C	NO	NO	NO	YES	YES	YES	NO	YES	NO	NO
Belgium	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO
Canada	G	YES	NO	YES	NO	YES	NO	YES	NO	NO	NO
Denmark	G	YES	NO	NO	YES	NO	NO	YES	NO	NO	NO
Greece	G	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO
Ireland	G	NO	NO	NO	YES	NO	YES	NO	NO	YES	NO
Italy	I,C	NO	YES	NO	YES	NO	YES	NO	NO	NO	NO
Japan	G	YES	NO	NO	YES	NO	YES	YES	NO	NO	NO
Luxembourg	G	NO	NO	NO	YES	NO	YES	NO	YES	NO	NO
Netherlands	G	YES	YES	NO	NO	NO	NO	YES	YES	NO	NO
New Zealand	G,C	YES	NO	YES	YES	YES	NO	YES	NO	NO	NO
Norway	C	YES	NO	NO	YES	YES	NO	NO	NO	NO	NO
Portugal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Spain	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sweden	G	YES	NO	YES	YES	NO	NO	YES	NO	NO	NO
Switzerland	*	NO	NO	NO	NO	NO	YES	NO	NO	YES	NO
Turkey	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO
United Kingdom	G	YES	NO	YES	YES	NO	NO	NO	NO	NO	NO
United States	G	YES	NO	YES	NO	YES	NO	NO	NO	NO	YES
West Germany	G,I	YES	NO	NO	YES	YES	YES	YES	NO	NO	NO

SOURCE: International Energy Agency, Fuel Efficiency of passenger Cars, 1984

NOTE: G = government; C = consumer associations.

* Under consideration

** A feedback sheet is incorporated into the Fuel Consumption Guide.

In practice, it is usually assumed that consumers suffer from a shortfall in information. However, this requires some confirmation. Henderson (1980,p.47), in referring to CAFE supporters who argue consumers do not give appropriate attention to fuel economy when buying cars, points to evidence to the contrary. Compare the US/Canada (low petrol prices and the predominance of fuel-inefficient cars) with Europe/Japan (high petrol prices and the predominance of fuel-efficient cars).

There is a shortage of data describing the level of information actually obtained by consumers in Australia, and this Study has expressed reservations about the adequacy of information available. On the other hand, a similar comparison to the one by Henderson suggests that similar buying decisions are made to those abovementioned.

With regard to energy conservation programs, studies by Crossley (1981), the Victorian Department of Industry, technology and Resources (1988) and many others have discussed the effects of lack of information. The International Energy Agency (IEA), in its report Energy Conservation in IEA Countries (1987, 34) states:

> "information programmes should be the cornerstone of every conservation strategy: they can motivate and create awareness, explain conservation opportunities, improve technical skills, and publicise other government programmes"

However, this enthusiasm for information programs leaves two major questions:

- o is information sufficient without other programs?
- o what kinds of information programs are appropriate and effective in each situation?

In the context of vehicle fuel efficiency, the answer to the first question seems to be "no".

The IEA (1987,p.35), for example, correctly perceives regulation as a supplementary device to correct failure in the market mechanism:

> "regulations and standards can be valuable in some instances to maintain long-term momentum and to overcome market limitations, particularly in special market segments".

This would include markets heavily influenced by style and advertising. For example, the motor vehicle industry spends several hundred million dollars annually on advertising style, image and high performance, and any review of the advertising product appearing in the media leads to the conclusion that, with some exceptions, information disseminated among potential new car buyers does not emphasise the benefits of fuel conservation.

It would therefore be unrealistic to expect information alone (such as is provided in the Guide) to establish fuel efficiency as a major purchase criterion.

This conclusion is not new. Artcraft (CCEM:1988,p.10) concludes that:

> "...the communication of fuel consumption information concerning new vehicles will not work effectively in isolation. Providers and recipients alike view it at best as but part of a broader picture.

Thus, information programs which are limited to a range of relatively unconnected devices such as the Guide, vehicle labelling, and the occasional outdoor or print media advertising can be seen as necessary but not sufficient for the achievement of fuel efficiency objectives in the transport sector.

It is understood that the Commonwealth has reached this conclusion separately, and is considering a more comprehensive programme than has hitherto been seen in Australia.

The following Sections provide some guidance about the nature and type of information programme which might provide a public framework for a fuel economy policy.

Before considering the approach to an information programme which includes vehicle efficiency labelling as required by the Brief, it may be useful for the reader to the examples of electrical appliance labelling discussed in Appendix A.

3.3 DEVELOPMENT OF AN INFORMATION PROGRAMME

3.3.1 Need to Establish Credibility

For the programme to achieve the objective of influencing the purchase decision (for passenger cars), three criteria must be satisfied:

(a) the content must be appropriate;
(b) the information must be communicated effectively;
(c) the information about the benefits of fuel efficiency must satisfy a need that has significance to the consumer.

To some extent, these criteria are deceptively self evident. However, they are not straightforward and are examined in more detail in later Sections.

Especially in regard to (c), the suasion applied by the programme must be credible to the person being addressed. For example, a person driving a company car who pays nothing for fuel, at a time when the public perceives fuel as plentiful and cheap, will be hard to convince that the company should buy a fuel efficient vehicle and that he should use it as little as possible.

3.3.2 Mode of Operation

Once credibility is established, an information programme can be made to work in three ways:

1. by ensuring that potential purchases of cars have necessary and sufficient information to enable them to incorporate fuel efficiency into their decision process;
2. by changing the weighting placed by the individual on the factors considered in the decision. Thus, a successful fuel efficiency program should motivate car buyers to change their preferences towards more fuel efficient alternatives

so that they select different models and brands of vehicle. This skews the market profile in the desired direction;

3. by influencing product design, manufacture and marketing strategies. This further shifts the average of the products sold in the desired direction, as manufacturers improve the efficiency of their products to try to maintain market share. This does not refer to command and control instruments, which are considered separately. Rather, it involves convincing manufacturers that the information program will actually change consumers' decisions and hence impact on market shares. Manufacturers actions to deliver fuel economy then feed back into the range of products available to the consumer, and promote a social norm in favour of fuel efficient cars.

A program can be successful according to one or all of these ways, so that individual behaviour is reinforced by manufacturer response and vice versa.

3.4 SUGGESTED ELEMENTS OF AN INFORMATION PROGRAMME

At the outset, it is important to recognise that a major purchase decision such as the purchase of a car is rarely made on a completely rational basis by the individual buyer. It is too difficult for most people to compare quite dissimilar factors such as aesthetics or price discounts against longer term costs such as fuel and maintenance. Many relevant factors are weighed up in a fairly subjective way, then, after the decision has been taken, supportive arguments are collected to justify the decision. Thus, the effectiveness with which the content is communicated is also a crucial factor.

The suggested elements of a programme are built around these issues:

- it must be pitched at a target group(s), which is relevant to purchasing power in the marketplace and to creating opinion leaders;
- it must be technically credible. That is, it must be believable;
- It must be targeted to key points in the decision process and provide a path for positive, constructive and practical action in response to the message. It must be practical;
- the communication strategy must be developed with an eye to access of the target group(s) (it must be heard) and an appropriate level of complexity for each group (i.e it must be understandable);
- It must relate to an issue that is significant to the target group or, alternatively, convince the target group of its significance for them. It must be relevant;
- It must also provide a simple rationale for the action, so that the purchaser can justify his or her purchase decision to others in their peer groups. That is, it must be defensible.

These matters are discussed in turn below and the role of labelling is emphasised.

3.4.1 The Target Group(s)

Information programs must be carefully targeted from the point of view of:

- o the right target audience - the people who will make a decision on purchasing a car, either in the near future, or in the longer term;
- o the appropriate time - when they are formulating their criteria and developing shortlists. It is much easier to help shape a decision than to change an existing one.

As discussed in WP4, new vehicle buyers can be broadly categorised into private and business purchasers, with the latter acquiring 52 percent of new vehicle sales in 1988. The proportions vary year by year but typically, business purchases range form 40 percent to 60 percent of total.

The results of WP4 suggest that about 10 percent to 15 percent of these are bought for fleets (i.e. car pools), with the rest used by business executives at various levels, or by business people working from home.

Although CCEM (1988) rated fuel consumption third, behind size and "a good deal", for company cars, it is considered that those results were distorted by amalgamating in the same sample cars bought for executives with cars bought for pools. The Study believes that only the fleet component is biassed towards the more fuel efficient vehicles, whereas the bulk of company purchases are bought with an executive's preferences in mind (or are status purchases), and the CCEM findings for private buyers are more relevant than those attributed to fleets.

Only about 9 percent of luxury car buyers in 1988 were private buyers. The Study has little or no information regarding the socioeconomic status of these purchasers.

For private buyers, fuel consumption rated fifth, behind size, "a good deal", looks and reputation (CCEM:1988).

Thus only two factors (size and "deal") dominate all other criteria for many buyers. In particular, "size" may be interpreted as "big enough" by business buyers, while it may be interpreted as "appropriate for my needs (which may be for a small or large vehicle)" by private buyers. Also, in the early life of a vehicle, fuel costs comprise a small proportion of total operating costs. This, combined with concerns about the durability and practicability of smaller cars, and the prestige factor, may explain why the bulk of business purchases are less fuel efficient vehicles.

Within the private and business categories exist several groups, each with different perspectives on fuel efficiency.

Purchasers of business vehicles intended for field use are interested in overall ownership costs, and computerised fleet management systems are beginning to provide them with quite detailed information on the performance of large samples of vehicles. In contrast, business prestige vehicle buyers are less interested in fuel economy than the image of the vehicle. Small businesses often buy vehicles with a view to a mix of business and personal requirements.

Thus prima facie, any programme should be targeted towards encouraging executives and people working from home to buy more fuel efficient cars.

Private buyers also vary widely in their concern for vehicle fuel efficiency, with buyers of expensive prestige vehicles least interested.

Private buyer interest in four wheel drives and light vans seems to have doubled between 1988 and 1990, and about half of these vehicles are now purchased by private buyers. This seems to reflect increasing interest in recreational motoring, concerns about the safety of lighter, smaller vehicles, and the desire of many families to carry more than the five passengers that can be carried legally in even the largest sedans. Many four wheel drive vehicles and some light vans have high fuel consumption compared with conventional passenger vehicles.

3.4.2 Technical Content

Fuel consumption information should be based on data collected using the AS 2877-1986 test or some other credible basis. A clear case must be made to show that comparisons made on this basis are reasonably valid.

The Study developed several concerns about testing procedures used in Australia:

- the voluntary process of submission of test data is not conducive to verification by independent audit;
- the processes of calculation are masked by a rounding process and secrecy of test and CAFC data prepared by manufacturers and submitted to the FCAI;
- any attempt by the lay public to compare fuel consumption of particular vehicles with apparently similar vehicles offshore (i.e. the "world car") is frustrated by (a) and (b) as well as by minor technical discrepancies between specifications;
- even if overcome, such attempts give rise to significant discrepancies which do nothing to give confidence in the testing system or the fuel efficiency of cars sold in Australia;
- the test specification (i.e. AS 2877-1986) used in Australia is consistent with that use in the US by not with those used in Europe and Japan;
- even official testing facilities in Australia do not strictly adhere to the test procedures although they purport to do so;
- the city/country weighting (55/45) used in Australia to average fuel consumption bears no relationship to the actual city/country vehicle km of travel observed on Australian roads (70/30);
- there is no way a lay motorist can test his own car himself and come up with a result which is relatable to the figure published in the Guide.

In this situation, it is not surprising that only about 6 percent of new car buyers rely on the Guide for advice.

However, Government should not be daunted by the limitations of the existing processes underpinning the Guide. Not only is there an wide and demonstrated acceptance among the public of the need for such a document, but if the Government were to introduce a fuel economy policy, it would have little option but to develop robust testing procedures for any mandatory regulation. Such procedures are in place in other countries.

Many buyers will wish to make comparisons between vehicles, and a respected benchmark must be found, against which Australian new car buyers can compare the fuel consumption of their own vehicle and their own driving behaviour. The format of the Guide may be suitable for purposes of comparison, but the available data is far from perfect for the purpose.

3.4.3 Targeting to the Decision Process

It is important to make the fuel efficiency message visible at key points in the decision process. This is unlikely to be within the showroom, although some decisions are clearly taken there.

Artcraft (CCEM:1988p.76) suggest that the actual purchase of a vehicle usually happens within two months of the conscious decision to buy. Thus, pre-existing attitudes play an important role. Mellor (1984) suggests that most people fairly quickly form a short list of about three cars. He suggests that 60 percent of buyers will eventually purchase their original first choice, 25 percent one of the others on their list, and only 15 percent will buy a vehicle not on their original list.

Most people begin to visit car dealers after they have made a short list and after seeking information from newspapers, magazines and friends. Mellor (1984) suggests this is to avoid falling unprepared into the grip of a salesman. Artcraft found that 62 percent of buyers had made up their minds before visiting a showroom, and that about 40 percent visited four or more showrooms.

This highlights the importance of targeting information about fuel economy early in the decisionmaking process, or even before the buyer is conscious of being in the market for a replacement vehicle.

This is not to say, however, that scope does not exist to influence decisions in the showroom. Vehicle labelling programmes can assist in that regard. It may also be possible to actively increase the significance of point of sale information by appropriate promotional strategies.

3.4.4 The Communication Strategy

The communication strategy must present strong and consistent arguments that establish and reinforce the importance of fuel efficiency, and demonstrate that simple choices made in the purchase process do make a difference.

Effective communication is a challenging task, made more difficult by the fact that many external factors can impact on the process.

The form of presentation must be carefully considered, so that confusion is minimised and the information can be understood by the maximum number of people. For example, there still seems to be widespread discomfort with the use of litres per 100 kilometres as a measure of fuel consumption.

The cost of achieving visibility in the market place depends on the media background, the media channel used, and the design of the display and message.

If the background is, for example, a war in the Middle East, a relatively low budget fuel efficiency information program is likely to be enthusiastically amplified via many free media channels, and by the manufacturers of fuel efficient cars. It may also fall on a very receptive public who are keen to act. This seems to have been the case around 1980, after the Iranian Revolution.

However, it is much more difficult to communicate the fuel efficiency message at a time when oil supply is reasonably assured and prices are declining, as at present. This problem is exacerbated if many people are reacting against hasty responses to previous campaigns as was the case in the mid 1980s. Then, many people had responded to the 1979 crisis by buying cars which they perceived to be adequate, but which in practice proved to be too small for their needs.

To overcome this social dynamic would probably have required high expenditure on promotion, a carefully developed message that emphasised long term supply and environmental issues, and emphasis on Governments "practising what they were preaching" to maintain credibility. None of these criteria were satisfied by the Australian Government, which was in a position to lead opinion in this regard. This problem is reflected in anecdotes about Commonwealth cars being "...petrol guzzling Z-cars..." (CCEM, 1988, 28)

In addition, there is a very large volume of advertising for cars, as the car industry spends several hundred million dollars each year on advertising. This advertising not only presents the alternatives to prospective car buyers and promotes special deals, but it also serves long term aims of maintaining the visibility and image of each brand in the marketplace.

To the extent that such advertising targets vehicle attributes other than fuel economy, it adds to the background noise which information programmes about fuel economy have to overcome.

Thus the inclusion of fuel consumption information in advertising has two advantages: not only is it associated with a large volume of advertising which reaches the purchaser early in the decisionmaking process, but also it then ranks alongside other attributes in the overall image of desirability of ownership which is promoted by the message.

However, the information that can be communicated is very basic, and cannot take account of the effect on fuel consumption of accessories and options. Contact with the fuel consumption information is also remote from the showroom, where the final commitment is made.

These limitations bring pressure back on the process of determining technical content of the message in a way which is truthful and unambiguous.

The use of the existing standardised fuel consumption information in advertising has had a propensity for the message to be selective or misleading. There have been cases in Australia where advertisements have stated the highway cycle fuel consumption only (sometimes in miles per gallon). This implies a much lower level of fuel consumption than would a weighted city/country figure, and even lower in respect to on road fuel consumption.

It is also important that the strategy face up to widely held opinions about whether fuel efficiency is worthwhile for individuals, firms and Government. A search for fuel efficiency can result in higher maintenance costs, early retirement of older or gas guzzler vehicles, and so on. It must be shown that such actions are cost effective.

Because there are no predictors of success of such programmes, the expenditure is inevitably risky for Governments. Half hearted efforts at implementation of a communication program can also dramatically and adversely affect success. Innovative and imaginative approaches to advertising and promotion can achieve unexpected success or dismal failure for reasons that are often only clear with the benefit of hindsight.

3.4.5 Vehicle Labelling

Vehicle labelling is only one channel within an overall information programme, and is separately addressed here solely because it is referenced in the Brief. In a fully resourced study, all media channels would be similarly addressed.

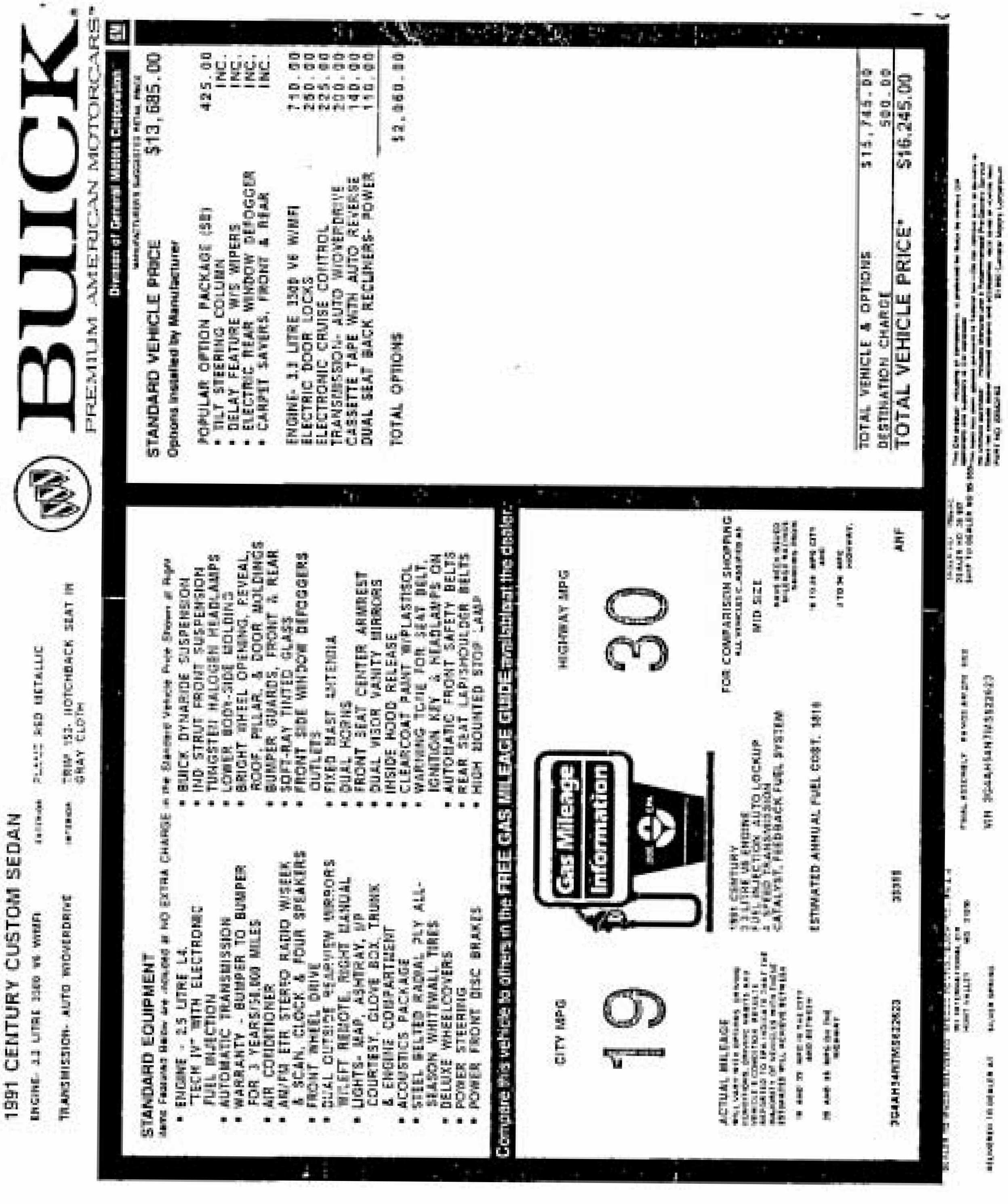
Figure 3.1 provides an illustration of an actual vehicle label design which is in use in the United States.

The content of the label is not consistent with the results of discussions held by Artcraft (1988,p.19) within focus groups, which suggested that the main intent of any label should be to direct new car buyers to the Fuel Consumption Guide, where they can gain access to comprehensive and comparative information.

This position was taken because of perceived major problems in trying to develop a simple and accurate method of presenting meaningful fuel consumption information on a label. This however, reflects the problems listed under Section 3.4.2, and go well beyond the labelling issue to the question of testing itself.

As shown by the Figure, a vehicle label provides a great deal of information about the vehicle specification, as well as a visual cue at the point of sale to encourage car buyers to consider fuel efficiency.

FIGURE 3.1: ILLUSTRATION OF A VEHICLE LABEL DESIGN



Because Australian new car buyers do not value fuel economy highly, and because most purchasers have made up their minds before entering the showroom, it is difficult not to conclude that a labelling programme brought in under the current attitudinal regime of would of itself have little or no effect on business purchasers or the majority of private car buyers. Today, labels might potentially impact on, at most, a quarter of car purchases.

However, vehicle labelling would have an important role as part of a broader strategy, as it would provide a moral and probably a legal reassurance to buyers that the car being purchased actually could deliver the intended fuel economy, as planned during the preliminary investigations.

3.4.6 Significance of the Message

The significance of the message can vary widely, and relate to several of the criteria of choice relevant to the consumer. For example, a message which demonstrates a net financial benefit to the consumer may be of significance to those consumers who choose rationally.

Rational behaviour is often assumed for Government information programs, but it should be noted that irrational behaviour in the marketplace is not uncommon. However, there are many other ways in which a message can be significant.

A high priority among all buyers is vehicle size, which is closely linked to the buyer's assessment of the tasks for which the vehicle will be used, and the deal offered by the dealer. This latter factor is a powerful emotional and financial factor in the purchase process. A one thousand dollar discount is often greater than several years' savings resulting from purchase of a more fuel efficient vehicle in the same size category.

It will be a challenge to make fuel efficiency a higher priority than vehicle size and price by using information programs alone.

At times when oil supply is under threat, many people seem prepared to take action that has a perceived long term strategic benefit: they are prepared to pay the equivalent of an insurance premium to protect themselves against possible future circumstances. Schou (1981) demonstrated that the threat of fuel rationing was the most effective incentive for fuel efficiency of the alternatives she studied. These included pricing, taxation measures and tax deductions.

Vehicle fuel efficiency may be unconsciously associated with other purchase factors, both positive and negative, which may influence the significance of the message. For example, some fleet managers seem concerned that more fuel efficient cars may have higher maintenance costs and shorter lives, which would offset fuel savings. Some buyers believe that they have adequately considered fuel efficiency if they purchase a four cylinder car, no matter how heavy or large. Some believe that more fuel efficient cars are necessarily more vulnerable in accidents, slower and smaller, and therefore may not satisfy requirements for space, towing or carrying capacity.

The attitudes of peer groups, and the behaviour of Governments and industry will also influence the individual's assessment of the significance of an issue. Where Governments are encouraging people to buy fuel efficient vehicles, it is important that they are seen to act in a consistent manner. This is particularly important when the message runs against popular sentiment, for example when oil prices are declining.

From the manufacturer's point of view, the message is significant if it changes the preference of some car buyers from one model to another or, more importantly, to a brand other than their own. If a message is considered damaging to market share and to the success of a manufacturer's long term sales strategy, an incentive is created to try to reduce the significance of the message as an influence on buyer behaviour. This may involve heavy promotion of other features such as size or power, criticism of the basis of the message, price discounting, and so on. Alternatively, if a manufacturer sees potential market gains, it may try to build on the fuel efficiency message.

3.4.7 Rationale for Action

Ultimately, the message must publicise and clarify the actions necessary for a buyer to choose a fuel efficient vehicle, including how that action relates to others being taken by governments and business to reduce fuel consumption.

It seems unlikely that any single media channel such as a vehicle labelling programme could achieve this.

Thus it would be necessary to articulate a public education programme with a range of instruments, including Government announcements, testing programmes, the Guide, brochures and like material, advertising and vehicle labelling.

Within such a framework, other necessary policy instruments such as identified by the Brief (i.e. sliding scales of taxes, mandatory fuel economy standards, etc.) would make up a sensible framework likely to be acceptable to the public. However, the justification for the use of such instruments would be based on the evidence that buyers discount the value of future fuel savings, and that they are influenced by non-economic factors such as prestige.

3.5 POSSIBLE MANUFACTURER REACTION

The concept of vehicle labelling and other information programmes outlined above was discussed with manufacturers. In general, the attitude was that the information within and presentation of the Guide was all that was necessary to inform potential buyers of the comparative position about fuel economy, and specifically that a vehicle labelling programme was unnecessary and undesirable.

However, the reactions of vehicle manufacturers to proposals for enhanced fuel efficiency information programs are probably not fixed at this time, and actual reactions will depend on several key factors:

- o the extent of intervention. Manufacturers generally resist Government intervention of any kind unless it is a form of assistance;
- o the likely interaction of the program with other Government strategies, particularly those aimed at restructuring the industry;
- o the likely effectiveness of the proposed program (assessed by their own market research), and hence the likely extent of its impact on competitive position;
- o the likely impact on each manufacturer's own model mix and market share;
- o the investment and R&D implications of attempts to respond to market changes generated by the programme;
- o the kinds of Government intervention that are likely to be imposed if proposals for an information programme involving labelling is rejected. This in turn is dependent on public opinion and Government strategy;
- o the extent to which manufacturers believe it will be possible to soften the extent of intervention.

Industry is likely to focus attention on its responsible efforts to support the Guide, and is likely to integrate the agenda for information programmes with the agenda for improved fuel economy.

In this latter context, manufacturers are likely to argue that their production programmes are tailored to the demands of the market, and that they are powerless to affect the behaviour of individual users (leadfoots) which lead to a failure to achieve fuel consumption targets. The dislocation that might be caused by a shift of market share to smaller vehicles, including loss of jobs in some plants, will be emphasised, as will the cost and difficulty of changing the production lines.

However, the car industry will also aim to show the community that it is responsible and concerned about energy efficiency as an environmental issue. It will therefore wish to be seen to be participating (within practical constraints) in efforts to improve fuel efficiency. Individual car manufacturers will also adopt their own strategies, depending on their assessments of the significance of the issue and their ability to take advantage of the trends in the marketplace.

3.6 CONCLUSION

Information programs alone, and particularly vehicle labelling programmes implemented in isolation are unlikely to achieve major improvements in vehicle fuel efficiency. However, they may be quite effective if used in conjunction with other market based policies.

The existing Fuel Consumption Guide provides comprehensive fuel consumption information, but there are a number of concerns about its adequacy to provide a basis for measuring progress under a fuel economy policy, or to act as a benchmark against which fuel consumption targets or standards can be measured. It is doubtful whether the lay public understands the meaning of the figures provided, although it may be useful for some to make comparisons between competing products.

Information programmes are seen as a necessary but insufficient component of any policy which aims to improve the fuel economy of passenger cars sold in Australia. Within such a programme, vehicle fuel consumption labelling could help increase use of fuel consumption information, and allow buyers to confirm the fuel consumption of their chosen model just at the point of sale.

Incorporation of fuel consumption information in vehicle advertising would improve access to the information, and make it available very widely and at an early stage of the decision process. This strategy could also be used to enhance the effectiveness of the existing Fuel Consumption Guide and any proposed vehicle labelling scheme.

Further work is needed to improve the credibility of fuel consumption information, and to address consumer concerns about safety, durability and size of fuel efficient vehicles.

4. ECONOMIC INSTRUMENTS

Economic instruments can be regarded as:

- o market based instruments, which seek to redress market failure by manipulating key market attributes, particularly prices; and
- o incentive based instruments, which create market like arrangements that mimic real markets in the way they generate incentives.

Both of these seek to arrange for the delivery of price signals from the market to both producers and consumers. These seek to induce outcomes which maximise welfare even though the players are taking rational decisions in terms of the information base available to them.

In this discussion, it is considered convenient to separate the discussion of the instrument and its characteristics from the discussion of the magnitude of the impost.

The discussion is not seen as being comprehensive. That would be beyond the terms of reference and in any event, should not be considered complete without inputs from other studies being undertaken by DASSET and possibly other agencies.

Rather, this discussion aims to consider matters which are relevant to the economic instruments nominated by the Brief, together with brief reference to other instruments which the Consultant believes may be useful in achieving fuel economy in new vehicles sold in Australia.

4.1 MARKET BASED INSTRUMENTS

Typically, these instruments include taxes, fees and subsidies. Within this Study, it was considered convenient to regard taxes as those imposts which are calculated with the objective of raising general revenue, and charges as those which seek to recover a contribution towards outlays incurred by government in the delivery of certain goods or services. Also, charges may seek to recover real resource costs expended by Government, or to create an impost to compensate for externalities (noise, air pollution, etc) incurred by a producer.

Of the many types of instrument available, the Brief requires that the Study consider variable sales taxes, fringe benefits tax, annual charges and fuel taxes.

4.1.1 Variable Sales Taxes

Sales taxes are an impost by the Commonwealth on the cost of manufacture of a vehicle or component, and hence are a cost to vehicle distribution. The impost amounts to 20 percent of the wholesale price, but upper luxury vehicles carry a loading (vehicles of value over $45,000).

Before 1991, there was a special luxury car tax of 50 percent imposed on luxury cars (over $45,000) but this was for a short time only and reduced to 30 percent in 1991.

In discussions, manufacturers reported that their experience of the luxury tax was that it had a sharp impact on sales of large cars which must have contributed to the downsizing which occurred between 1988 and 1990. Thus, if policies were required which would effectively downsize to reach some given NAFC target, the experience of the luxury car tax would seem to demonstrate the effectiveness of sales tax as a policy instrument for fuel economy.

Probably, a simple way to induce downsizing is to reintroduce a variant of the luxury car tax across more vehicle classes and use another instrument such as fuel taxes to top up the revenue loss if desired.

For all explorations of various policy instruments, the Study assumed that a loading of 10 percent over the standard rate applied to all policy options considered.

Thus the sales tax is seen here as a generic instrument which acts on vehicle purchase price in order to achieve fuel economy.

The Brief requires that a variable sales tax be considered. This is taken to mean that the concept of the luxury tax be extended to apply to other classes of passenger vehicle, and in principle this would lead to downsizing of the fleet.

Changes to sales tax operate directly on vehicle purchase price, and hence affect both new vehicle sales and scrappage rates. This concept was used, inter alia, to predict new vehicle sales in WP4.

A variant of sales taxes is the concept of "fee-bates", where a rebate fee schedule is established for new car buyers. There are two arms to this variant:

(a) it is mandatory for a supplier to list in the Guide (or similar regulatory document), the certified fuel consumption for each vehicle;

(b) the regulation prescribes a Fuel Consumption Target for each vehicle class. Each vehicle manufactured is compared with the prescribed fuel consumption for the class and a penalty imposed by varying the standard sales tax rate (i.e. 20 percent) upward or downward according to the quantum of variation from the class target.

A nominal variation of (b) is illustrated by the Californian "Drive-+" programme, where buyers receive a rebate or pay an additional fee depending on whether their vehicle of choice has a lower or higher emission certification than the standard (Ledbetter:1991).

This variant arises because in the United States, each State can set its own retail sales tax. There are Constitutional barriers to State sales taxes in Australia, although it would be Constitutional for the Commonwealth to adopt this variant.

A further variation would allow the Commonwealth to encourage manufacturers to deliver a class average fuel consumption equal to the Fuel Consumption Target for that class. This would apply where a manufacturer sells options to a standard model (such as automatic transmission, cabriolet, etc) which affect fuel consumption but do not take the model out of its class.

For this case, the variance of each car sold from the class Fuel Consumption Target would be used to obtain a class specific average for that manufacturer. Variations to sales tax (or other economic penalties or credits - see below) would be calculated on the basis of the class specific average. To some extent, this schema for calculating deviation from target is reminiscent of the processes used for calculating fines under the CAFE system in the US.

4.1.2 Company Taxation

Company taxation takes two forms, company income tax and the Fringe Benefits Tax (FBT). Both of these affect the annual cost of operation of a company owned vehicle, albeit the calculation of the amount of the tax varies as discussed below.

Thus company taxation deductions are seen as a generic device to operate on the number and mix of new vehicles purchased by companies. Tax deductions on company cars, depreciation schedules and Fringe Benefits Tax all operate on the annual costs borne by companies for their car fleet.

Where necessary, other instruments such as the fuel tax may be used to assure revenue neutrality.

Company Income Tax

Company income tax is levied at a flat rate of 39 percent on all taxable income, and the cost of ownership and operation of cars is nominally a Section 51 deduction.

Fringe Benefits Tax

FBT is not tax deductible in the hands of a company, and hence its tax effect is 100/61 times the tax effect of other car expenses.

It is understood that the FBT was introduced to restore equity and the revenue following certain decisions by the High Court (pers. comm. BTCE). It was seen by the business community as a disincentive to the practice of allowing employees private use of company cars. In practice however, the differential in company and private income tax rates and the sliding scale used for calculating FBT has proved to be a tax incentive rather than a deterrent.

Some observers would argue that FBT is a tax on the individual rather than the company. This is not the case, as few employees are required to pay the tax, the costs being 'buried' in the cost of employment along with other labour related charges such as superannuation, payroll taxes, workers compensation insurance, and so on.

Thus it must be accepted that as long as the cost of FBT is cheaper than paying individual tax, it must be regarded as a tax on companies.

Policy Impacts

In assessing the impacts of company taxation (income tax or FBT), the assumptions about purchasing patterns for company cars discussed in WP4 should be taken into account. This includes assumptions about the number of vehicles bought into the management fleet and the determinants of choice of those vehicles discussed in WP3.

WP3 and WP4 found that private purchases, purchases by firms for management and purchase by home occupations (and hence all except about 5 percent of new vehicle sales) are driven by determinants of vehicle choice which are similar to those for private purchases.

The policy objective for all company tax options is to reduce the propensity for companies to buy such large cars.

Company taxation operates on about 770,000 vehicles in Australia or just over 10 percent of the car parc. Companies bought 52 percent of new cars in 1988 and, on the basis of the results shown in WP4, the Study concluded that about three quarters of these were bought on criteria similar to those used for privately owned car purchases.

Market assessments by Cullen Egan Dell, and available statistics about the proportion of company cars bought annually between 1986 and 1990, indicate that apart from a transient three year response, the introduction of FBT has had no long term effect on the number of vehicles sold in Australia or the proportion of sales to companies.

The Study also concluded that companies take little interest in the cost of management cars, and view them as a cost of employment. Thus operating on the cost of management vehicles and household occupation vehicles was considered to have an effect similar to the payroll tax; i.e. it is viewed as a cost of employment rather than a cost of plant.

The Study concluded that FBT has had little long term effect on the size or structure of the fleet.

Thus apart from the different tax effect, estimations of the impact of FBT are a matter of adjustments to the revenue rather than being a useful tool for pursuing fuel economy.

However, companies do attempt to minimise life cycle costs for about 65,000 fleet vehicles and to this extent the company income tax issue is relevant.

Although there is no data which allows estimation of the effects of annual costs on company buyer behaviour, it was considered adequate to estimate the NPV of ownership over a four year period, and then use the ITS price elasticity of -0.6 to operate on the class mix.

4.1.3 Annual Charges

Annual charges are seen as a generic device to operate on the annual cost of ownership of those vehicles with higher fuel consumption. They include registration fees and third party insurance as discussed in Section 2.2.1.

Now NSW and some other States have a system of registration charges which are calculated on the basis of weight and engine size. Nominally, this suggests that a policy instrument might be formulated which operates on weight and engine size, the latter being a surrogate for acceleration performance. As shown by WP1, the weight and performance attributes are determinants of fuel economy.

The policy approach would be to apply a sliding system of charges on those attributes, to encourage individuals and companies to buy fuel efficient cars.

Unfortunately, econometric modelling by ITS reported in the Appendix to WP7 indicates that such instruments would have a low or negligible response.

It was concluded that for such an instrument to be effective, the size of the impost would have to be an order of magnitude larger than the size of current annual charges, i.e. several thousand dollars per vehicle per year.

It was considered that imposts of this magnitude would be politically unacceptable and in any event, they would be well beyond the range of validity of current econometric modelling.

Thus policy instruments which seek to operate on annual registration and/or insurance charges would require a completely new approach which is beyond the scope of the Brief.

4.1.4 Fuel Taxation

Fuel taxation is seen as a charge on vehicle use and device to increase the perceived cost of motoring and as a top-up for revenue losses/gains resulting from manipulation of other policy instruments. To the extent that fuel prices feed into the vehicle purchase decision, fuel taxation can be used as an instrument to affect the new vehicle mix and hence impose pressures for downsizing of the fleet. Refer WP7, Appendix 1.

The device is likely to be effective as it impacts directly on driver perceptions cost. However, this effect may be discounted for perceptions of management cars used for private purposes.

It is to be noted that Australian fuel prices are low by world standards, and hence there would appear to be ample scope for increasing the fuel tax. For example, a fuel tax increment to bring Australian fuel prices to the median of OECD countries would represent an increase in pump price of 75 percent, i.e. to $1.25 per litre (McInnes:1991).

An alternative possibility is to eliminate annual registration and insurance charges altogether and collect all imposts on ownership and use through a use instrument such as the fuel tax. This would have several advantages:

- o insurance costs are proportional to driving done;
- o uninsured motorists would be brought into the scheme;
- o the apparent cost at the pump would rise substantially, thus reducing the amount of car travel and shifting the demand for public transport;
- o there may be a net decrease in driving cost because of savings on insurance brokerage;
- o the system would not be regressive as is the case with other fuel taxes.

Assessment of the effectiveness of fuel taxation on fuel economy amounts to testing different fuel prices in the econometric models and obtaining a range of market shares which lead in turn to some desired value of NAFC.

4.2 INCENTIVE BASED INSTRUMENTS

Incentive based instruments includes the assignment of marketable credits and tradable emissions permits or licenses. In particular, they provide an instrument suitable for use within a variable tax regime which operates on vehicle distribution; i.e. they could be used instead of a variable sales tax.

Treasury (1989) suggests that incentives are preferable to command and control processes, and should be used to create a broad framework for producers and consumers to make decisions that take account of the effects of their actions on climate change.

Incentives have first order and second order effects. For example, a manufacturer who finds it costly to reduce fuel consumption may find it cheaper to reduce production and sell unneeded rights to another manufacturer or importer.

This creates a market for rights, and an incentive for both manufacturers and researchers to devise new technologies which further reduce consumption and produce more excess rights which can then be onsold in the market.

In order for this market-creating mechanism to be effective, it is important in the first instance to direct policy squarely at technologies which reduce consumption in motor vehicles, rather than at the distribution or usage activities which follow on.

Rights could be either granted or auctioned without affecting the efficiency of the measure.

A difficulty with these types of instruments is that new legislation would have to be sought in order to implement these devices, although they probably could be implemented by the Commonwealth under the corporations power.

There are no incentive based instruments contemplated by the

Brief, although some mention was made of possible options during discussion with the Steering Committee.

4.2.1 Marketable Credits

Sperling (1990) outlined a system of marketable credits, which he claims are a more effective economic instrument for achieving large reductions than fuel or vehicle taxes, or rebates. The following outlines the Sperling procedure, subject to exchanging emissions criteria to fuel consumption and vehicle class criteria more relevant to this Study.

Fuel consumption as measured by the approved test procedure are at the heart of the initiative, measured in l/100km. Standards are set for each manufacturer in terms of a fleet average and any variations from standard provide the basis for establishing a market.

Manufacturers average emissions across their vehicle fleet to establish their performance, similar to the CAFC calculation currently submitted to the FCAI for preparation of the Guide. When this calculation is compared with the set standard, manufacturers become entitled to "bank" emission credits when they beat the standard, and to sell or fuel consumption credits to other manufacturers who do not meet their standard(s).

The ability to trade standards is important to mitigate possible adverse economic inefficiencies arising from variations in marginal cost between one manufacturer and another, especially smaller manufacturers/importers that produce specialist vehicles in small quantities.

Alternatively, manufacturers might be given additional export credits under the Car Plan, but is to be noted that as the tariff declines to 2000, such credits will become less and less valuable to a manufacturer.

The following constraints apply to the averaging:

- o vehicles must be certified as falling into some fuel consumption class; this can be conceived as being equivalent to the vehicle classes described elsewhere in this report (where each class has its own fuel consumption target);
- o fuel consumption credits depreciate in value over time after being banked; this is because standards are continually tightened as indicated, for example, under the Maximum Technology Scenario;
- o a class of zero vehicle emissions would be nominated to provide a basis for influencing the pursuit of electric powered vehicles into the future. Manufacturers might be required to introduce a nominal but growing percentage of such vehicles after 2000;
- o averaging would not be allowed for light commercial derivatives or special purpose vehicles such as taxi packs. These would have to meet a categorical standard, but trading would be allowed.

Banking is especially critical to the scheme, not only because banking allows trades to occur, but also because it provides an incentive to introduce new technical options and products sooner in anticipation of a continuing tightening of fuel consumption standards.

Marketable credits are thought to be very effective: California aims to reduce vehicle emissions in new cars by 80 percent by 2003 using this device, which is more ambitious than is possible with other instruments.

There is only one known study of the economic impact of marketable credits; by McElroy et al (1984). That study indicated that the costs of emission control to automakers under a system of marketable credits without banking would be 25 percent less than under a regime of uniform emission standards.

Overall, the system appears to have potential for combining the best features of economic instruments with the best features of command and control. It is being seriously considered in California and may be worth consideration in an Australian fuel economy context.

4.2.2 Tradable Emission Rights

Rights would have to operate on CO_2 emissions to be effective in a fuel economy context. Even then, they would not be particularly practicable, because the rights would be assigned to the user rather than the manufacturer.

For large numbers of vehicles, the system would prove clumsy and should not be considered further.

4.3 A FINAL COMMENT

There are two difficulties with economic instruments:

(a) the very large transfers of money which is associated with them. This is illustrated by the very large balances shown in Table 2.1, and arises because of low price elasticities of demand; e.g. 0.6 for new motor vehicles;

o the difficulty of designing economic instruments which compensate for externalities.

At least in the first instance, the analyst may be looking for revenue neutrality to be balanced through adjustment to the fuel tax. However, one would have to have some limits in mind because fuel prices are politically sensitive.

Further, fuel price elasticities are likely to remain low because fuel represents only a small part of the total cost of owning and operating a car, technical improvements are making vehicles more energy efficient anyway, and we can expect income to tend to grow again after the recession is over but within the planning period.

A similar concern may arise if proposals to introduce high registration charges are introduced. The experience of truck taxation illustrates the political difficulty of introducing such charges. For many, private motor vehicles are seen as a necessity rather than a luxury, and some States have moved to set private registration charges to zero. High registration charges would be a reversal of this trend.

For the design of instruments which give manufacturers an incentive to implement policy goals, it is necessary to:

- force firms to factor the environmental cost of fuel consumption into their production or importation decisions;
- concentrate on those manufacturers or importers where fuel economy can be achieved at least cost. This might mean those who make cars above medium class;
- design market based measures which harness entrepreneurial skills.

Finally, there is always the issue of compliance. Taxation instruments induce a producer to reduce consumption to a level where the cost of reducing further exceeds the tax burden avoided by doing so.

This contrasts with the use of mandatory controls where considerable effort can go into evading them, e.g. parking restrictions are a good example of such perversities.

5. FUEL ECONOMY STANDARDS

5.1 INTRODUCTION

Fuel economy standards can take two forms, voluntary agreements between Government and the automotive industry, and mandatory fuel economy standards. The Brief specifically requires both to be addressed.

This Chapter initially reviews a number of voluntary agreements which have been identified in Australia and overseas. The US provides the only example of mandatory fuel consumption standards, although the arrangements in Canada and Japan did involve legislation.

Some comments on the prospects of such policies in Australia are made, as a lead in to the findings of the main report.

5.1.1 Test Procedures

At the outset, it must be stated that embarking of a policy of fuel economy standards implies a tightening of the test procedures used to determine compliance with the standards, over those which currently apply to new cars sold in Australia. Refer Section 3 and WP4.

It is also necessary to consider how the standards will be structured as a derivative of the testing of new vehicles. For example, Canada and Sweden use the US method of setting goals on a sales-weighted basis applicable to each automobile manufacturer. The situation in Japan is similar except that goals are set on the basis of the sales weighted average fuel economy of each manufacturer's fleet of automobiles within a given weight category. Programs in Spain , Italy, Germany and the United Kingdom are based on collective agreements with participating manufacturers to reduce the NAFC by a defined percentage. Australia had such a programme in the 1980s, but it has been discontinued.

5.2 VOLUNTARY FUEL ECONOMY STANDARDS

A number of countries have voluntary fuel economy goals, although their programs differed in several important ways. These programs are summarised in Table 5.1.

Most countries established 1985 as the target date for their guidelines; Australia set its target years as 1983 and 1987. Results have been mixed. Australia slightly missed its 1983 standard, and others such as Sweden may have been adversely affected during the mid-1980s because of a downswing in new car fuel economy.

In Australia, the voluntary agreement may have engendered the sharp fall after the 1979 announcement to 10.1 l/100km in 1981. After a steady decline to 1983, the NAFC tended to level off, whereas some may have expected that the steady fall would continue. If it had, WP4 Figure 5.1 indicates that Australia's NAFC may have been just over 8.1/100km by 1990.

TABLE 5.1: FUEL ECONOMY TARGETS/STANDARDS FOR PARTICIPATING IN INDUSTRIALISED COUNTRIES - TABLE 1 OF 1

COUNTRY	BASIS OF SUMMARY TARGET	MANDATORY VOLUNTARY	TIME PERIOD	SCOPE	TARGET/ STANDARD	COMMENTS
Australia	Statement on Energy Policy, June 1979, by Prime Minister.	V	1978 to 1987	All new passenger cars	National average fuel consumption in 1978 set to be 19.9mpg; in 1983 26.1	Average of 25 mpg reached in 1983, 1.1 mpg below the target.
Canada	Voluntary agreement backed by threat of mandatory standards	V	Model Year (MY) 1980 to 1986	All domestic and imported cars	Fleet average fuel economy set to be 19.9mpg in 1980; 27.5 mpg in 1986	Manufacturers allowed 2% credit for producing lead tolerant vehicles.
West Germany	Agreement between government and manufacturers in 1979.	V	1978 to 1985	All domestic and imported cars	Agreement by German domestic producers to reduce consumption by 12-15% between applicable years.	Data for 1982 shows 90% of fuel savings projected for 1985 has already been realised.
Italy	Agreement between government and manufacturers.	V	1978 to 1985	All cars and diesel-powered industrial trucks.	10% reduction in national average fuel consumption for cars, 5% for diesel trucks between applicable years.	-
Japan	Targets established pursuant to the "Nationalisation of Energy Consumption Act", 1979.	V	Fiscal Year (FY) 1980 to 1985 for domestic; FY 1980 to 1988 for imported.	All gasoline-powered passenger cars.	Targets set for specific weight categories ranging from 46.1 mpg for vehicles up to 1270lbs. to 19.9 mpg for vehicles over 2786 lbs; all must be reached by end of target period.	Fiscal year ends on March 31st. Overall goal of targets is to achieve a 12.3% average improvement in efficiency from 26.7 mpg in 1978 to 30.1 mpg in 1985.
Spain	Agreement between government and industry.	V	1983 to 1986	All new passenger cars.	Agreement to reduce specific fuel consumption by 10% between applicable years.	-

TABLE 5.1: **FUEL ECONOMY TARGETS/STANDARDS FOR PARTICIPATING IN INDUSTRIALISED COUNTRIES - Continued - TABLE 2 OF 1**

COUNTRY	BASIS OF SUMMARY TARGET	MANDATORY VOLUNTARY	TIME PERIOD	SCOPE	TARGET/ STANDARD	COMMENTS
Sweden	Agreement between government and manufacturers pursuant to guidelines for fuel use targets set by Parliament.	V	MY 1980 to 1986	All new passenger cars.	Target vary by individual manufacturer or importer according to vehicle size mix. Range from 27.6mpg to 31.3 mpg for MY 1986 with average of 28.6 mpg intent to reach average of 31.3 mpg by 1990.	Participating producers and importers accounted for 93% of car sales in 1982. Negotiations with car producers and importers for 1990 goals have not yet been carried out.
United Kingdom	Collective agreements across all participating producers based upon Energy Act of 1976 and Car Fuel Consumption Order 1977.	V	1978 to 1985	About 90% of all new passenger cars sold.	Targets set on a national average fuel consumption basis rising from 23.3 mpg in 1978 to 25.8mpg in 1985.	Goals set based upon intent to achieve at least a 10% improvement in national model average mpg by 1985. Recent Government studies indicate that efficiency improvements of 15.3% have already been achieved between 1978 and 1983.
United States	Established in the Energy Policy and Conservation Act of 1975.	M	Annually from MY 1978 on for cars, from MY 1980 on for light trucks.	All domestic and imported passenger cars and light trucks less than 8500 lbs. gross weight.	Car standards set legislatively rising to 27.5mpg on a corporate average basis for 1985 and all subsequent years; light truck standards set by Dept. of Transportation.	Secretary of Transportation has discretion to increase car standards after 1985. Car standards have been rolled back to 26mpg for 1986, 87 and 88. Light truck standards were rolled back to 19.5mpg from 21 mgp for 1985.

Source: Based primarily on information from the International Energy Agency publication, "Fuel Efficiency of Passenger Cars", 1984.

The 1987 fuel economy standards were set in 1979. During the 1980s some of the changes in the automotive industry which may have caused Australia to miss its target included:

- o unleaded petrol technology;
- o catalytic converters; and
- o more stringent ADRs for noise and emission standards.

(FCAI pers comm.,1991)

As far as is now known, few nations participating in the original target setting elected to set new higher post 1985 fuel economy goals (or in the case of Australia and Sweden, post 1987 and 1990, respectively). France, which was not involved in the original goal setting agreements, has negotiated an informal agreement with its manufacturers to improve average new car fuel economy from a base of 7.0 L/100km in 1983 to 6.0 l/100km in 1990 (Bleviss:1988 p162).

5.2.1 Fuel Economy Standards in Japan

The systems of emission standards adopted in Japan is viewed in the same light as fuel economy standards. An important difference from other countries is the legislative basis of the voluntary standards. Others tend to be by agreement.

There is considerably less information available about these, compared with that available in other countries. Reasons for this include:

- o although it originated about 1979, publication of results in English is much more recent;
- o that society is not given to debate in public forum as is the case in Australia or other western countries;
- o there have been recent changes which are quite significant, hence the policy appears to be still maturing.

Appendix C contains such detail as is available about the programme. However, the major difference is the focus on weight categories. A manufacturer places product(s) in one of four weight categories and these are assessed against a national standard prescribed for each category.

The programme is driven by a perceived need for emission and noise controls, rather than fuel economy goals.

Supplementary programmes of vehicle labelling are in place.

There is a recent tendency for manufacturers' corporate performance to decline, as the manufacturers start to build cars in higher weight categories. The Study considers that this should be seen as a loophole in any national programme which pursues fuel economy through standards set by weight class. Some supplementary action may be necessary as the policy matures.

5.2.2 Conclusion

Thus voluntary fuel economy targets have ceased to be the dominant policy tool in today's world that they were for the previous decade.

5.3 TYPES OF MANDATORY FUEL ECONOMY STANDARDS

There are two perspectives of how mandatory standards can be applied:

- o compliance standards for which a failure to meet the standard means that the vehicle cannot be registered. The ADRs fall into this category;
- o regulatory standards for which a failure to meet the standard means that although the vehicle can be registered, some person (manufacturer, distributor, end user) is required to suffer some sanction (usually but not necessarily a financial penalty). The mandatory CAFE programme which operates in the US falls in this category.

There is also a possibility of contingency provisions. For example, Canada had a legislative provision that made its voluntary fuel economy targets mandatory in the event of serious noncompliance by the automobile industry. However, this provision was never used, because Canada's 1985 guidelines (which are identical to the US CAFE standards) were met.

5.4 CASE STUDIES OF MANDATORY STANDARDS

For the purposes of this Study, the example of the Australian ADRs, particularly ADR 37 (emissions) is a good example of compliance standards in action. These are discussed in Section 2.3.1.

For regulatory standards, the US system of Corporate Average Fuel Economy (CAFE) standards is the only example.

5.4.1 The US CAFE System

A discussion about the system of CAFE regulation is included in the main report and Appendix B. The main points to note about the system are:

- o its aim was to encourage manufacturers to introduce new technology into the fleet;
- o it is a regulatory requirement for automakers to achieve a prescribed standard of fuel economy for their individual fleets;
- o it applies to companies producing more than 10,000 cars a year;
- o the US EPA undertakes the necessary testing;
- o the two CAFE figures are obtained as sales weighted averages of all domestic and all imported cars sold by a manufacturer;
- o similar calculations are done for trucks;
- o if a manufacturer fails to meet the standard, a fine is incurred equal to US$50 per MPG of the margin per vehicle sold;
- o manufacturers and importers can earn fuel-efficiency credits by exceeding the standards for three years in a row, or may borrow on future performance if they can satisfy the NHTSA that they will exceed the standards in any of the next three years.

Supplementary programmes of vehicle labelling are in place.

Note that there is no regulation which places a upper limit on fuel consumption, in the way that ADR37 places an upper limit on emissions.

There has been a great deal of debate about the merits of the policy and whether it should be extended or discontinued beyond 1994. In summary, the debate is:

- an environmentalist argument that command and control over manufacturers' production is the only certain way to force a reduction in fuel consumption of new vehicles. The situation in respect to fuel security and risk of climate change makes such assurance essential; versus...
- the economic rationalist argument that economic instruments would be more effective. Welfare economists hold that there are very large losses of consumer surplus accumulated as a result of restriction on choice arising from CAFE. The industry believes that domestic producers are disadvantaged because of the switch to small cars which are the strength of Japanese producers.

Other factors which are relevant to the evaluation of CAFE standards include:

- whether the improved fuel economy of individual vehicles induces consumers to move to larger cars and to travel more distance annually, thus offsetting the fuel saving;
- whether a net reduction in employment arose from the growth in imports of small vehicles, or whether the move of Japanese manufacturers to Japan led to a net increase.

It is clear that the response of manufacturers to the measure varies with the market position of the manufacturer and may be unpredictable in the absence of very detailed knowledge about that position.

If CAFE were removed in the absence of alternative policies, fuel economy would decline.

The current debate about requirements beyond 1994 is extensive, and being conducted in a production and operating climate very different to that which existed in 1978, when the legislation was first introduced.

Although the debate is continuing, US Legislators had not resolved the issues at the date of this WP.

5.5 CRITERIA FOR ESTABLISHING FUTURE FUEL ECONOMY STANDARDS

The US Energy Policy and Conservation Act (EPCA-P.L.94-163) which established mandatory fuel economy standards provided criteria with which the Department of Transportation should use to set future fuel economy standards (Difiglio et al:1985,p.7). These are:

- standards should reflect maximum technological feasibility;
- standards should be economically practicable;
- standards should account for the need of the nation to

conserve energy;

- o standards should account for other Federal regulations which affect fuel economy.

The following principles were advanced as being consistent with EPCA requirements (Difiglio et al:1985,p.8):

1. Fuel economy standards should encourage that level of fuel economy technology which is paid for by private and national benefits;
2. Economic practicality must be evaluated in terms of the manufacturers' ability to raise the capital required to finance the implementation of new automobile designs and technological innovations.
3. Considerations of principle 2 can be regarded as constraints which would justify fuel economy standards below that required to achieve a maximisation of net social benefits as measured by the consumer cost of new technology, consumer savings due to reduced fuel costs and associated National benefits result from a reduction of petroleum imports.

More recently, CAFE standards have been defended as a means of reducing environmental damage caused by automobile emissions (Kleit:1990 p 151).

Proponents of new US legislation for the 1990s are considering alternative criteria as well as substantially higher fuel economy targets. These include identifying standards by different types of product offering; by size class; or weighting by interior volume. A preliminary evaluation of these is given in McNutt and Patterson (1986). The last appears to be most favoured at present, but decisions are a long way off.

5.5.1 Application of Mandatory Fuel Economy Standards in Australia

In this Study, one must be careful of drawing too many parallel with the results obtained in the US or other countries.

In an Australian context, criteria must be considered in the widest plane, including the impact on the economy especially the outlook for oil imports; the costs of new technology and the impact on employment especially the automotive manufacturing industry; the Government commitment to greenhouse targets (including the proviso) and the optimisation of net social benefits and costs imposed on consumers; all within the practicability of achieving the mandated fuel economy standards within the lead times provided by programme rules.

There is a great deal of work required to put in place a system of mandatory fuel consumption standards in Australia, only some of which would have to be done if alternative instruments were used. Some of the items which immediately come to mind include:

- o establish within Government, subject to consultation of the industry, the aims of the programme and the evidence that the goals cannot be achieved by less costly and restrictive instruments;
- o establish the Constitutional mechanism under which the policy would be implemented;

- o establish the structure of the standard and the tolerances of measurement to be allowed;
- o establish the necessary test facilities and ensure that they can be resourced;
- o establish the relationship between the standard and other instruments especially the ADRs and the Car Plan;
- o consider what to do about commercial vehicle derivatives;
- o consider the nature of and scope of sanctions;
- o consider the nature of and scope of credits and debits, and how these relate to export credits under the Car Plan;
- o consider the nature, type and resources required for supplementary policies especially information programmes including vehicle labelling.

Some advice about these and allied matters will emanate from this Study, and subsequent discussions among agencies and within the industry. However, there are still many questions to be answered, some of which need a policy input.

The size and nature of the Australian industry may make it difficult to achieve averaging across a company, because of the limited scope for intrafirm adjustment on a product basis. This problem caused the Japanese to adopt weight based standards.

On the other hand, weight based standards clearly need a supplementary instrument if the propensity to upsize classes is to be avoided.

Within a class, some form of bankable credit is required, and a marketable credit seems appropriate. This would be close to, but not identical with the US system.

The FCAI (1978) argues that mandatory fuel consumption standards cannot be prescribed annually in Australia, because model changes are not made annually and the market situation is too small to permit this. This is a difficulty, but does not appear insurmountable.

Drawing a parallel with export credits available under the PMV Plan, a system of marketable "fuel economy entitlements" might be a way to encourage innovation within the Australian industry, and possibly limit unwelcome increases in concentration that might occur as above- and below-average model producers merge to internalise the externality created by the standard.

The econometric testing showed that downsizing could well remove all the gains to consumers obtained from the Maximum Technology Scenario. This is not a bad thing provided that is the intention and a conscious decision has been made to penalise consumers as a tradeoff for improved fuel economy.

A problem with mandatory fuel economy standards as applied in the US is their tendency to produce downsizing where none was originally intended, and to improve the relative competitive position of importers.

It seems clear that improperly applied fuel economy standards could engender a downsizing of new vehicles sold in Australia which would impose substantial loss of consumer surplus and risk of loss of market share of by Plan Producers' locally manufactured models. Worse, the magnitude these impacts may not be predictable.

There are also several issues which may affect the administrative load under existing or new arrangements:

- o no Plan Producer makes a full range of vehicle classes locally, and the ebb and flow of imports resulting from mandatory fuel consumption standards could substantially disrupt local production programmes. This will induce a plethora of enquiries, paperwork arising from the PMV Plan and ADRs, as well as new paperwork arising from the supervision of mandatory standards;
- o applying a standard "on average", rather than specifically to every make or model (or even manufacturer) allows for greater product diversity within an overall fuel economy goal (JTEP:1986,p.44). However, this leaves room for administrative loopholes such as outlined in Section 5.4.2;
- o there are Constitutional issues to be addressed. Use of instruments under the Motor Vehicle Standards Act or the PMV Plan are readily implemented by the Commonwealth, subject to Ministerial concurrence. However, if the objectives are seen to be in the nature of environmental controls analogous to those administered by environmental protection agencies within the States, then there may be a need for supplementary legislation.

On balance, it is probably not desirable to explore these matters in depth until further consideration has been given by others to the results of the Study, because:

- o the options available for implementing mandatory fuel economy standards (or indeed any other policy) require consultation between the automotive industry and Government before being introduced;
- o this suggests that detailed design of administrative arrangements is a waste of time unless such consultation is virtually complete;
- o there is a risk of counterproductive duplication between this Study and the Industry Commission's response to its reference on Greenhouse, and the fact that the emphasis of this Study is on new technology engineering matters to be addressed under WPs 1 and 2;
- o the legal issues involved in Commonwealth State negotiation around respective Constitutional powers to implement mandatory fuel consumption standards are beyond the scope of the Brief.

6. TOWARDS EVALUATION OF POLICY INSTRUMENTS

At the outset, it is clear that if the Commonwealth and the States wished to pursue a policy of fuel economy determinisation, the Commonwealth could immediately amend the ADRs to prohibit the sale or registration of any vehicle with a fuel consumption exceeding, say 5.5 l/100 km. This would remove from the market all vehicles except the Daihatsu Charade, Hyundai Excel and Suzuki Swift.

Similarly, legislation could be brought down to require fuel consumption tests on all vehicles now registered, and to deregister all those with a fuel consumption exceeding an equally arbitrary maximum.

While such draconian legislation is not likely to happen, such thoughts quickly bring forward the main issues relevant to the evaluation of policies which affect fuel economy.

6.1 EVALUATION FROM WHOSE POINT OF VIEW?

There are a wide range of issues which bear on the desirability or otherwise of particular policy options and outcomes. There also a risk that particular options may bear heavily on a segment of the community, such as the already vulnerable automotive industry, or impose high social losses on consumers by removing their freedom of choice or access to products of high utility.

This is a particular concern in respect to regulatory options, especially if the same impact on greenhouse gas emissions could be achieved by a simple but more widely applied policy instrument like increased fuel taxes, or more understandable policies such as "user pays".

From an policy analysis perspective, it is necessary to identify the main players in the game and the issues which are important to them.

The main players are taken to be the Commonwealth and State Governments, the automobile manufacturers including component manufacturers, and the public - opinion leaders and transport users.

This is probably a very coarse classification, because one might distinguish political and bureaucratic elements within Government; and various groups within the public arena, for example the environmental lobby, unions, the corporate sector, communities which rely on the automotive industry for their economic support, and so on.

However, is not feasible for the Study to address the issues at this level of detail because:

- o the resources available to the Study were to be directed towards new technology engineering for passenger cars and the effect of prospective new technology on NAFC. The Brief identified only one output indicator required for policy analysis; viz. a table which indicates fuel consumption in relation to technical options. Such results are included in

WP1.

- the Steering Committee and perhaps the Ecologically Sustainable Development Working Groups on Transport will have views about who ought to be seen as the main players, and their consideration is necessary after the Study is complete;
- this Study should not prejudice the findings of the Industry Commission in its Reference on Greenhouse, by introducing value judgements which are of a non technical nature.

6.2 WHAT ISSUES ARE IMPORTANT TO EVALUATION

It is to be expected that each of the players will be concerned about a set of issues, which are not necessarily convergent. Examples might be greenhouse emissions, fuel economy, retention of an employment base, company profits, market share and so on. It is difficult, if not impossible for the Study to consider all the issues from the point of view of all the players. Rather, the Study should deliver information required within its Brief, and present it in such a way as to facilitate others making their own assessment.

Thus policy analysis is necessarily not comprehensive. For example, manufacturer comment might focus on the wide range of actions available in the transport system other than additional controls on new vehicles (Berg:1991). Environmentalist comment might point to apparent successes of US CAFE standards without taking into account the greenhouse implications which would have to be considered outside this Study.

When determining the issues which are important to this evaluation, we refer to the context and objectives of the Study as stated in the main report.

6.3 SUGGESTED POLICY EVALUATION CRITERIA

Evaluation criteria need to be identified at two levels:

- evaluation "factors" which address broad areas of concern to the players - six are usually the maximum which can be comprehended within human span of attention, viz: engineering, energy management , environmental, socio-economic, macroeconomic and financial;
- within each factor there are a number of specific evaluation "elements" each of which lends itself to a dimensioning of the impact within its evaluation factor.

This makes it possible to address the problem of ranking policy alternatives in order of preference within each criterion (which takes account of points of view), and then to address the problem of ranking policy alternatives across criteria.

Table 6.1 summarises the chosen evaluation factors and elements. Where possible, the Study produced quantitative information, but it is noted that this is not always necessary for sensible choice of courses of action.

TABLE 6.1: EVALUATION ELEMENTS AND INDICATORS BY EVALUATION FACTOR

EVALUATION FACTOR	EVALUATION ELEMENT	INDICATOR
Engineering	Availability of Technology	Yes/No
	Feasibility of Production	Yes/No
	Production Cost	$ or $/vehicle
	Production Volume	Units/year plant
Energy Management	Effects on NAFC	1/100km
	Effects on FAFC	1/100km
	Australian Fuel Use	megalitres
	Manufacturing use	
	Fuel Quality	
Environmental	Greenhouse Emissions	Correlate with Co_2 FAFC
	Other Emissions	Meets ADR limits (HC, CO, NO_x, PM)
	Noise	Exhaust, tyres
	Net Resource Consumption	Recyclability
Socio-Economic	Safety Protection	Meets ADR limits
	Cost of Ownership	$/year
	Cost of Operation (1)	$/year
	Space, Comfort, Benefits to Consumers	$
National Economy	Balance of Exports and Imports	$/year (Oil)
	Impact on GDP	$/year
	Auto Industry Employment	Jobs
Financial	Government Tax Revenue	$/year
	Administrative Costs	$/year

Note: Includes externalities such as traffic congestion.

Thus there is an accounting to be done, where the various costs and benefits are summarised against each of the technical option/policy mix combinations. This accounting is provided in the Main Report.

APPENDIX A: CASE STUDY - APPLIANCE ENERGY LABELLING

Appliance energy labelling programs have now been developed for electric refrigerators and freezers, dishwashers, airconditioners, clothes washers and dryers. A similar program has been introduced for gas space and water heaters. Programs are under development for electric cookers and water heaters, solar water heaters and gas central heaters. Examples of the labels are shown in Figure A.1.

The labelling of all the abovementioned electrical appliances has been mandatory in Victoria for some time, and has recently become mandatory in South Australia. Labelling of refrigerators, freezers, airconditioners and dishwashers is mandatory in New South Wales. The gas labelling program is voluntary in all states, and is enforced to markedly different degrees in different states.

The labelling of electrical appliances has been developed at a State level, with the NSW Energy Authority (now Department of Minerals and Energy), the Victorian Government Department of Industry, Technology and Resources (now Department of Manufacturing and Industry Development) and the State Electricity Commission of Victoria taking lead roles. The voluntary gas scheme has been developed under the umbrella of the Australian Gas Association.

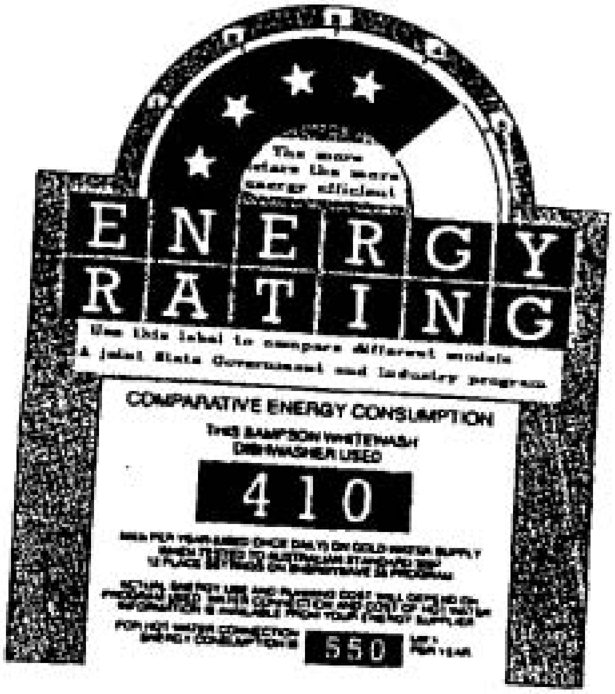
While appliance energy labelling is often viewed as one program, this is an inadequate perspective. Each appliance type has its own market characteristics, and the label plays differing roles and varies in its effectiveness depending on these.

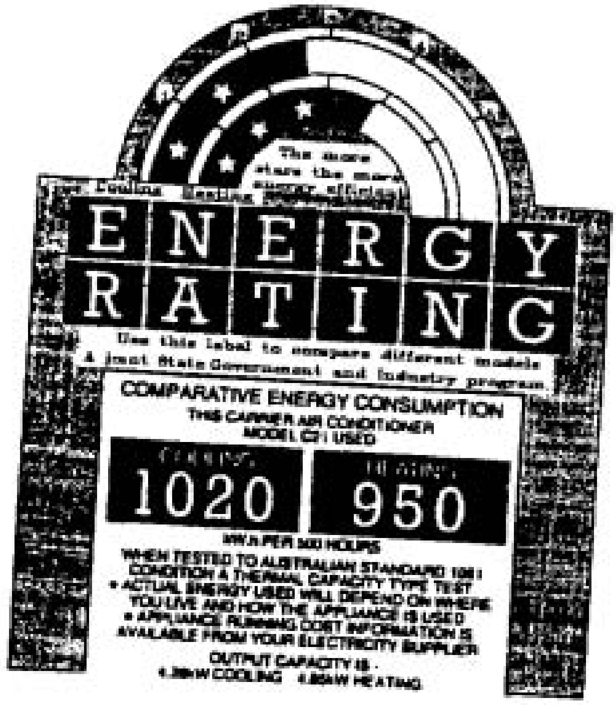
For example, dishwashers are often described as a "guilty" purchase. Women, on whom the main burden of dishwashing still falls, despite the blurring of roles in the home, are very motivated to buy dishwashers. Yet they are also, as a group, highly motivated towards environmental improvement. They also often have to convince sceptical male partners that the purchase is a worthwhile investment. A high energy rating provides a strong justification for the purchase.

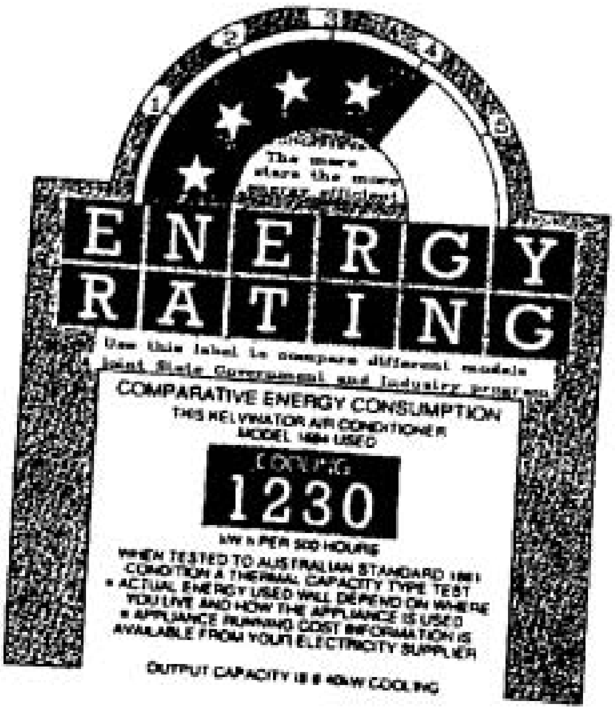
Manufacturers have been quick to take advantage of the energy rating in their marketing of dishwashers. For example, Vulcan have recently released the 5.4 star rated "Eco" model that is promoted as environmentally friendly.

In contrast, the majority of water heaters are sold via tradesmen and builders. These people have little interest in appliance running costs, and a strong interest in minimising the capital cost. In Victoria, energy labelling of gas water heaters has made some impact on the replacement market, where the building owner is often involved in the purchase decision. However, impact in the new homes sector has been limited.

FIGURE A.1: EXAMPLES OF LABELLING







The Content

The appliance energy labelling scheme is based on the use of Australian Standard tests. Tests are specified for determination of energy consumption and important aspects of performance. For example, to be permitted to carry an energy label, a refrigerator must be able to operate satisfactorily in the SAA 43 degree Celsius test. Similarly, a dishwasher must achieve a set standard of cleaning performance using the program on which its energy rating is awarded.

This approach provides protection against manufacturers optimising energy efficiency at the expense of other important consumer performance criteria.

The energy rating of the product is calculated from the results of the energy consumption test and other relevant information, such as the storage capacity of a refrigerator. The energy rating is a crude measure of appliance efficiency, which is intended to be relatively independent of appliance capacity or size.

The energy consumption figure on the label is calculated from the test results, multiplied by an appropriate number to reflect typical annual usage.

Effective Communication

How does the appliance energy rating scheme approach the issue of effective communication? The fundamental element is the label itself. The Australian energy label differs from all other energy labels used in other parts of the world through its use of the star rating. Other labels emphasise energy consumption or running cost, expressed in numerical form. The star rating was chosen because it is a non-numerical, widely recognised and easily understood rating scale.

Market research (ANOP, 1985) showed that consumers had a strong preference for the star rating over other labels with numerical or other graphical rating systems.

The star rating has some additional virtues. First, its strong image allows it to compete for recognition in the aggressive showroom environment. Second, some consumers associate a high star rating with an image of a modern, high technology, high quality product. This broadens the impact of the label on purchasers beyond the narrow issue of energy efficiency. It also increases the importance of ensuring that products with high star ratings also perform well by other important consumer criteria, so that the credibility of the scheme is not undermined. This is achieved by the requirement that labelled products satisfy relevant SAA performance criteria.

The numerical information on the label adds to its credibility (as does its Government status), but seems to be used by a relatively small proportion of consumers. Thus, for the majority of users, it is important to create a context in which a difference in star rating is believed to be important by most consumers. The financial savings are not well understood by the majority of label users except in broad terms.

A limitation of the label is its lack of comparative information. Seen in isolation, a four or five star rated product may be considered "good enough". For effective comparison, labelled products must be seen side by side, or a list of products and their energy ratings must be easily accessible. In Victoria, the State Electricity Commission publishes such lists and distributes them through retailers and the Energy Information Centre.

The Significance of the Message

Another essential element of the energy labelling scheme is a promotional strategy that emphasises the importance of the label in terms that are meaningful to the majority of consumers. In Victoria, extensive promotion has been carried out, including media advertising, point of sale materials, special awards, talkback radio and brochures. Emphasis of the promotion has varied, including reference to reducing the greenhouse effect, saving hundreds of dollars over the life of the appliance, and discerning shopping behaviour.

The State Electricity Commission's promotion of the scheme has been amplified by manufacturers of energy efficient products, and inclusion of information on energy labelling in consumer oriented shopping guides in newspapers and magazines.

The high profile of energy labelling has resulted in a high awareness of the label among prospective appliance buyers and the general public. The label's prominence and effectiveness in the showroom environment has meant that manufacturers have had to take labelling into account in their product development and marketing strategies, or risk losing market share. The effectiveness of the label is enhanced by the wide availability of lists of ratings, which encourage comparison of product performance.

APPENDIX B: MANDATORY FUEL ECONOMY STANDARDS IN THE UNITED STATES

B1. History of CAFE Standards

In 1975, American consumers were not paying the true cost of the petrol they consumed (Henderson:1980,p.47). Consumers responded rationally by overconsuming.

In 1975 the U.S. Congress responded to the "energy crisis" by passing the Energy Policy and Conservation Act. One of its provisions was to impose mandatory average fuel economy standards on the automobiles produced by each manufacturer. The purpose of Corporate Average Fuel Economy (CAFE) standards was to lessen the national dependence on foreign oil.

At the same time, the Government acted to control the maximum price of oil, thus preventing an increase in line with the world market.

The rationale for CAFE standards was that a regulatory requirement for automakers to achieve a stringent standard of fuel economy for their individual fleets, would encourage the development of fuel-economy technology (Leone et al:1990.p,1).

Under CAFE, an auto company producing more than 10,000 cars a year was required to meet prescribed average fuel economy standards for that year's production of cars, and for its light trucks.

CAFE regulation first took effect in 1978. In 1979, energy prices rose sharply due to an unexpected oil shock. One result of this energy price rise was that the cost of CAFE standards was far smaller than critics of the policy might have anticipated (due to the increased demand for small cars due to the higher prices). The opposite occurred when petrol prices fell during the mid to late 1980s and more stringent CAFE standards were in operation. This was thought to increase the cost of CAFE regulation.

In 1981, one of President Reagan's first official acts was to abolish oil price controls and end the subsidy of oil imports. Following these changes the pump price of gasoline became closer to being based on world parity and the marketplace provided the incentive to conserve (Henderson:1980,p.47). The opponents of CAFE claimed that the original need for CAFE no longer existed.

In 1985, the two largest manufacturers (GM and Ford) failed to meet the targets and, under an escape clause in the CAFE legislation, petitioned the NHTSA for relief from the standards (Kleit:1990.p.151). GM and Ford claimed that meeting the standards for model year 1986 would have caused significant economic damage and requested that the 1986 model standard be lowered from 8.5 to 9.0 l/100km. GM and Ford made similar requests in 1986 for model 1987 and 1988 and in 1988 for model years 1989 and 1990. Opponents of the petition claimed that granting the petition would substantially increase energy consumption with little or no gain to the economy. The auto manufacturers' requests were granted in 1985, 1986, and 1988, but not before substantial public debate.

B2. The 1975 US Legislation

Through the Energy Policy and Conservation Act of 1975 the National Highway Traffic Safety Administration (NHTSA) is responsible for writing and enforcing the CAFE regulations.

B2.1 Annual Targets

Table B.1 lists the annual targets which have been set since 1978. All standards are set for a 55/45 mixture of urban and highway driving according to the US Federal Test Procedure.

TABLE B.1: NHTSA SET FUEL ECONOMY STANDARDS

YEAR	STANDARD (l/100km)
1978	13.1
1979	12.4
1980	11.8
1981	10.7
1982	9.8
1983	9.0
1984	8.7
1985	8.6
1986	9.0
1987	9.0*
1988	9.0*
1989	8.9*
1990	8.6*

* Standard was reduced from 27.5 mpg.

B2.2 The Calculation Procedure

CAFE is calculated in MPG (miles per US gallon) as a sales weighted average taken over all models produced. The calculation must be done separately for domestic production and imports.

If a company imports a small car instead of producing it locally then it is excluded from the company's domestic CAFE calculation. This makes it more difficult to meet the domestic level, because only the larger models are included. This provision was designed explicitly to prevent US manufacturers from meeting the CAFE standard by importing small foreign cars.(Kleit:1990,p.152).

Thus the average fuel economy of domestically produced cars would be increased by the domestic production of a small car, and to some extent the CAFE regulations act as a form of protection for US producers.

Similarly, CAFE legislation severely limits the ability of domestic auto makers to produce small cars in joint ventures abroad (Henderson:1980,p45-46). This could explain why Ford dropped its Fiesta in the late 1970s due to the car's potentially large market. Ford may have feared its German made Fiesta would steal sales from its U.S. made Escort, thus lowering its domestic CAFE average.

B2.3 The System of Fuel Efficiency Credits

Manufacturers and importers can earn fuel-efficiency credits by exceeding the standards for three years in a row, or may borrow on future performance by convincing regulators that they will exceed the standards in any of the next three years. This occurred in 1983 when both GM and Ford avoided fines by drawing on credits from prior years when they had exceeded the standards (Henderson:1985,p.47).

This carry forward/back provision of the CAFE program was designed to increase firms' flexibility.

B2.4 Penalties for Non-Compliance

A company that fails to meet the CAFE standard is fined on all the cars it produces in the year in question. The fine per car is $US5 for every tenth of a mile per gallon shortfall (Henderson:1985 p47). For example, if GM fell one mpg below the standard, it would pay $50 x 4,000,000 cars = $200 million.

B3. EVALUATION OF CAFE PERFORMANCE

There is a great deal of literature which has contributed to the debate on the merits of CAFE legislation. Impacts on the industry, the economy and on fuel conservation have been assessed.

B3.1 Impacts on Fuel Conservation

The literature suggests that the historical (1978-1989) impact of CAFE standards on average fuel economy fell somewhere in the range 1.0 and 4.0 MPG higher than 1978, depending on analyst quoted.

This appears not to have impressed the economic rationalists in the US. Leone et al (1990,p.2) point out that to assess the success or otherwise of CAFE regulation it is necessary to focus on the original (fuel use) objectives. Using definitions of:

- Fuel economy refers to the number of kilometres per litre (KPL) an automobile achieves; and
- Fuel use refers to the number of litres of petrol an automobile actually consumes;

the following comments were made.

The distinction between fuel economy and fuel use is significant because an increase in fuel economy (higher KPL) means the marginal cost to drive has decreased. The effect of this is consumers drive more, drive larger vehicles and drive less conservatively. These consequences serve to offset some of the anticipated reductions on fuel use we expected from higher KPL levels.

In other words, one must be confident of the relative elasticities to be confident that if our objective is to reduce fuel use, then improvements to fuel economy levels will not increase fuel use.

This argument is extended in favour of economic rather than command and control instruments. If for some reason oil or petrol are underpriced, a tax on these commodities would readjust the market more efficiently than performance standards placed on cars. Cars, after all, represent only one (among many) sources of demand for oil.

With the decontrol of gas prices (1981), US consumers attracted incentives to conserve. Henderson (1990,p.47) argued that CAFE only hurts consumers by preventing them from buying the kinds of cars they really want. In his words, cutting choices on the menu is no way to run a CAFE!

B3.2 Impacts on the US Car Industry

The designers of CAFE regulations expected that, in order to comply with CAFE, corporations would make relatively large design changes in the motor vehicles they sell. These included reduced vehicle weight and other modifications which will affect motor vehicle prices and their performance, handling and perceived luxury characteristics (Cardell et al:1980,p.423).

This did not necessarily occur. Within the context of meeting the standards, producers faced essentially two options. They could maintain:

1 the same model line, but adjust relative prices so as to sell a higher proportion of their more fuel-efficient models; or

2 the same pricing strategy, but adjust their model line so as to raise the average fuel efficiency.

Presumably each producer would have used a combination of both options (JTEP:1986,p.31).

Three U.S. automobile producers adopted a strategy of adjusting relative automobile prices in order to meet the CAFE standard at some time during the period 1978 to 1980 (Ford and GM in 1978, Ford and Chrysler in 1979). However by the end of the period it appeared that the standards were being met partly by producers adapting the characteristics of their automobiles to enhance their fuel economy, and partly by shifts in demand (towards smaller models) as a result of events in the oil market (JITEP:1986,p.44).

Other events since the introduction of CAFE standards and which cloud the assessment include:

- by extending production of small fuel-efficient cars, GM in one year saved $150 million in fines;
- by redefining a vehicle upwards (eg. station wagon to a light truck), a company could improve its average fuel economy on both cars and light trucks.

Thus a manufacturer has many ways to respond to mandatory fuel economy regulation which are probably not predictable by the designers of the regulation. One way is simply to pay the fines associated with producing vehicles over the standard.

The literature suggests that US car manufacturers are reluctant to be seen as lawbreakers (Kleit:1990 p151). General Motors and Ford have stated on numerous occasions in 1985, 1986 and 1988 before Congress and in submissions to NHTSA that they viewed the standards as binding and would not contemplate paying fines.

The only firms that have actually paid CAFE fines are Jaguar and Mercedes-Benz. However, when Jaguar was spun off from British Leyland it was explicitly stated in Jaguar's articles of incorporation that Jaguar expected to pay CAFE fines. This apparently reduced the legal cost to Jaguar of paying the fines.

Kleit (1990) concludes that while the US economy as a whole appeared to be adversely affected by CAFE, his analysis shows that firms in the proper position in the marketplace may find the imposition of CAFE standards to be highly advantageous.

However, the CAFE standard in itself did not place domestic producers at a disadvantage. The smaller-sized, more fuel efficient Japanese imports were not directly affected by the standard, but the results of the standard for domestic producers included lower prices for the models most directly in competition with imports.

CAFE encouraged large producers to replace small foreign cars with small domestic cars, for no other reason other than to balance the CAFE equation of production. This would have imposed on some, costs which otherwise could have been avoided; for others, such as Chrysler who were set up for small car production, a lead on competitors would have been obtained.

The impact on individual manufacturers also appears to be dependent on the type of vehicle being manufactured at the time the policy is introduced. Indeed, this may well be an unstated intention of the policy.

B3.3 Impacts on Welfare

The rationalist argument against CAFE standards assumes that consumers know that there are many ways to reduce their use of petrol, for example form car pools, drive less, work at home etc. Changes in the price of gasoline affect the consumers' valuation of miles per gallon in new cars, and the perceived social benefits of reduced oil imports.

The argument for CAFE that a shortfall in oil self sufficiency is countered by the point that shortages will be reflected in the price, and price will supply the right incentive to conserve.

There is little doubt that consumers can and do find their own ways to save petrol. A study in 1983 by Daly and Mayor indicated that when the US price of petrol rose sharply in early seventies, and then again in the late seventies, prices of fuel-inefficient cars fell substantially relative to prices of fuel-efficient cars. One reason for this could be that consumers do take fuel economy into account when they buy cars.

Consumers may be advantaged by CAFE regulation not because they are unable to assess the value of fuel economy, but because they cannot predict future petrol prices correctly.

The important issue in considering the welfare implications of CAFE standards is the consequences of the restrictions on consumer choice.

CAFE and the gas guzzler tax (GGT) probably hurt almost all US car buyers, because they place a high value on style, performance and size (Henderson:1980 p47). One claim concerning CAFE standards is that it helps small car buyers by lowering the price of small cars. It is arguable whether this is the case, because of the tacit protection afforded to domestic producers by the policy. However, one would expect small car buyers to become worse off, because one assumes here that the imports are better or cheaper (otherwise large producers would be making small cars already).

Difiglio et al (1990) comments that in order to maximise national benefits of the fuel economy standards program, the cost of the last increment of fuel economy improvement stimulated by the program should equal the sum of consumer benefits and national benefits, also resulting from the last increment of fuel economy improvement. This condition ensures that the fuel economy program is cost-effective at the margin.

Comparing CAFE and taxation policies delves into a degree of uncertainty (due to predicting CAFE social costs and oil import reduction benefits). However, Cardell et al (1980 p430) concluded that:

- o even with liberal estimates of the 1977 gains from reduced oil imports and with conservative estimates of incremental vehicle manufacture cost, CAFE regulations are not in the public interest;
- o gasoline taxes are a more effective instrument for reducing oil imports than are auto industry regulations.

From a different perspective, those results indicated that the use if CAFE rather than gasoline taxes to achieve oil import reductions cost consumers in the order of $20 billion per year.

The debate about loss of consumer surplus as a consequence of CAFE standards is still under way in the US, with some organisations proposing substantially more stringent CAFE standards for the future, and the Administration being opposed.

B4. Effect of Removing CAFE

Henderson (1985,p.47) argued that removing CAFE standards would have little effect, noting that in 1982 an average domestic fuel economy of 24.6 mpg was achieved, higher than the 24 mpg then required. However, this argument is unpersuasive, because in later years, when fuel economy credits had been accumulated, GM and Ford used them instead of meeting the standard. Again in 1987 through 1990, the standard was raised because of difficulties being faced by manufacturers.

Not only do manufacturers incur additional costs from CAFE, but also they have an eye to consumer demands for large cars.

Thus without CAFE (or a compensating policy), it can be assumed that car fuel efficiencies would decline, at least in the short term. The 1982 achievement can be explained by car manufacturers choosing models which would satisfy the new expected CAFE requirements. A reasonable conclusion is that average fuel economy without the standards would have been in the low 20s, substantially above the 1973 level of 14.2 mpg but well below the 27.5 level required for 1985.

B5. The Debate Over the 1991 Standards

Circumstances concerning CAFE standards have changed in at least three important ways since 1975 (Leone et al:1990 p 1):

- the US manufacturing capacity in 1990 is very different to the 1978 situation. Today, automakers have the capacity to build as many fuel-economic vehicles as consumers choose to buy, this was not the case in 1978. Additionally automotive technology is very different. Today, many larger vehicles achieve fuel-economy levels attainable only by small vehicles in 1975;
- US petrol prices were falling, not rising between 1975 and 1990. In 1975, government action saw petrol prices well below world market prices. Today there is more concern that petrol prices are too low;
- Social objectives have changed over the last fifteen years. Environmental issues are now important, in addition to the 1975 objective of reducing the nation dependence on imported oil.

In 1990, Congress considered boosting CAFE significantly to decrease oil imports and slow the creation of carbon dioxide. This proposal engendered a considerable debate.

Simultaneously, the three big car companies failed to meet 1990 CAFE limits.

In addition, Bills were introduced into the US Senate which would increase CAFE standards. Senator Richard Bryan sponsored a bill (S1224) in the middle of 1990 which would increase fuel economy from 8.5l/100km in 1996 to nearly 6.0l/100km by 2001. These figures were based on the judgment made by the Office of Technology Assessment and the Department of Energy that such increases in fuel economy can be achieved "utilising currently available technology and without significant changes in the size mix or performance of the fleet". This bill was defeated but later reintroduced. Another bill, introduced by Senate Energy Committee, refers to "maximum technologically feasible" rather than a set percentage.

During the debate on the proposed legislation motor vehicle manufacturers argued that increases in fuel economy of the scale suggested by US energy policy advisers would be extremely costly.

At the time of writing this report, one report had indicated that the responsibility for setting standards had been passed to the Secretary for Transportation, but subsequent enquiry made it unclear whether that was the final outcome. It is understood that the Administration is opposed to CAFE regulations, and it will be interesting to see how the issue is treated in the future.

It appears that CAFE standards will remain a controversial policy issue for some time.

APPENDIX C: MANDATORY FUEL ECONOMY STANDARDS IN JAPAN

In 1979, the Japanese Government proclaimed the "Rationalisation of Use of Energy Act" which, inter alia, specified motor vehicle fuel targets. The Act was based on:

- o establishing target values for improvements in fuel consumption of new passenger cars;
- o a programme of passenger car labelling.

At this time, the Act was applied to gasoline fuelled passenger cars only because of the availability of measurement systems, customer trends towards less larger and better equipped vehicles, and the perceived need for emission and noise controls (Kobi:1991).

The test specification defines a 10-mode system (correspond to device cycle). More recently, a 10/15 mode has been prescribed, which takes account of increased idling due to traffic congestion, and running modes for highway traffic.

Establishment of corporate standards for each manufacturer similar to the US CAFE were avoided because of a diversity in production models between manufacturers. Rather, the standards are established according to inertia weight category. Refer Table C.1.

TABLE C.1: JUDGMENT STANDARDS FOR MOTOR VEHICLE FUEL EFFICIENCY

Vehicle Weight (kg)	w<577.5	577.5>=w<827.5	827.5>=w<1265.5	1265.5>=w<2015.5
Target Value by 10-mode (km/l)	19.8	16	12.5	8.5
		13.0 in case that both categories are produced		

Legend w = weight

Source: Miyazaki 1990

Although each manufacturer met the target in the target year, the government continues to require manufacturers to report the status of improvement of fuel efficiency after the target year, as it is concerned about the extent of improvement.

This arises because the fuel efficiency of each model of passenger car is still improving, but the overall fuel efficiency of each firm has declined, because of a propensity to manufacture heavier and larger passenger cars as well as the propensity to introduce power assisted systems such as automatic transmission system and power assisted steering system. These add weight to the vehicle.

WORKING PAPER NO. 7
DEFINITIONS, PROCESS AND PROCEDURES

PREPARED FOR:

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

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CONTEXT

Within the context of developing a comprehensive policy response to the Government's planning target to reduce greenhouse gas emission, the Department of Transport and Communications acting in concert with a number of other government agencies commissioned Nelson English, Loxton and Andrews Pty. Ltd. (NELA) to assess the potential to reduce fuel consumption by new passenger cars sold in Australia.

Interim information is being presented to the Steering Committee by way of a series of seven Working Papers as follows:

Working Paper No.	Title
1	Available Options for Fuel Efficient Technology
2	Documentation of Technologies Available to Improve Vehicle Fuel Economy
3	Production and Marketing Factors Affecting the Introduction of Fuel Efficient Technology
4	Population, Passenger Car Stocks and Fuel Consumption Performance
5	Report on International Conference on Tomorrow's Clean and Fuel-Efficient Automobile, Berlin, 25-28 March, 1991
6	Review of Policy Instruments Available to Governments
7	**DEFINITIONS, PROCESS AND PROCEDURES**

1. INTRODUCTION

1.1 BACKGROUND

The Brief required, inter alia, that the Study assess the effectiveness of alternative policy instruments available to Governments, their impact on industry structure, operations and performance, and the likely market response.

Specifically, it required an assessment of the economic implications (particularly for the motor vehicle industry and the consumer) of meeting national average fuel consumption targets for new vehicles (i.e. a NAFC) of 8 l/100km to 5 l/100km (in unit decrements) by the year 2005.

These requirements together with the requirement for an analysis of possible policy options for improving fuel economy, indicated that a complicated analytical process was required, with subsequent analyses depending on preceding results.

1.2 OBJECTIVES

The objective of this Working Paper 7 is to provide a compendium of the policy related analytical procedures and data sources used for the Study [1].

Particularly, Appendix C includes a report from the Institute of Transport Studies on the econometric procedures used.

1.3 STUDY APPROACH

The Study undertook four streams of investigation:

- **Stream 1: A <u>Technical Analysis</u>** which identified and described possible technical options and their expected fuel conservation capabilities. It also examined the production structures of Plan Producers and prepared estimates of manufacturing cost for those technical options considered feasible within the period to 2005;
- **Stream 2; A <u>Marketing Analysis</u>** which, on the basis of information available in the literature and discussion with manufacturers, assessed the product and pricing features which affect consumer demand for motor vehicles, and forecast the penetration of new vehicles into the fleet, and vehicle use;
- **Stream 3: A <u>Specification of Known Policy Instruments</u>** which defined and described fiscal and regulatory instruments set down in the Brief, plus other relevant ones available to Governments here and overseas. It also examined the nature, type and effectiveness of consumer information which has been used to encourage energy efficiency and environmental goals;

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1. Procedures for developing and costing technical options are included in WPs 1 and 2, and the analysis of manufacturing capability is included in WP3.

Stream 4: An Specification of Policy Analysis which planned and controlled the development of modelling tools and processes, the implementation of Tasks (especially specification and control over information flows between Tasks) and delivery of outputs. Based on interim results, a test pattern (i.e. combinations of technical options and policy instruments) was developed This Stream also identified an understandable format for the results.

1.3.1 Tasks in the Study Process

A simplified view of the work programme is as follows, with the contribution made by subconsultants identified. NELA undertook all items not specifically identified.

At the outset, the Study received certain basic data about the future environment for the sale and use of passenger cars in Australia, for the period to 2015.

Using those as a part of departure, the work programme pursued a number of complex analyses and estimations towards the requirements of the Brief. These included:

1. A large literature review (see bibliography). In addition, information was obtained from agencies and discussions with Plan Producers. Agencies and others who contributed source material included Departments represented on the Steering Committee, the AIA, and ABARE.

2. The ITS applied its basic data set of attributes of all vehicles sold in Australia 1970 through 1988. This was supplemented by 1990 data obtained from manufacturers.

2. EEA extracted technical data needs from its internal files and vehicle specifications provided by Plan Producers, considered the suitability of PAXUS classes, and recommended a new classification more suited to the estimation of future fuel economy by vehicle class. This information is summarised in WPs 1 and 2, and the main Report.

3. EEA also drew on its international information base about new technology in the motor vehicle industry overseas, participated in discussions arranged with all Plan Producers, and recommended a list of feasible technical options likely to be introduced into Australian production to the year 2005. EEA also visited a Conference in the Clean and Fuel Efficient Motor Vehicle in Berlin in March, 1991. These results are summarised in WPs 1, 2 and 5.

4. On this basis, EEA defined the Product Plan and Maximum Technology Scenario, taking current specification of Plan and imported vehicles, and Plan Producer production status, as a point of departure. An estimated trend of new vehicle fuel consumption for each class of vehicle was prepared. prepared a target NAFC for each class. This information is also included in WP1.

5. The literature and discussions with manufacturers was also used to examine the marketing view of determinants of consumer choice, and the factors affecting the production of motor vehicles in Australia. This was supplemented by information from Cullen Egan Dell about typical purchasing patterns adopted by companies. Refer WP3.

6. Advice from EEA about which technical options were most effective in influencing fuel economy was considered in conjunction with trends in fuel consumption policy development identified in the literature, and the requirements of the Brief, to identify a outline specification of policy options for testing in conjunction with the Maximum Technology Scenario. Advice in this area was received from Production Solutions and Chuck Chapman. Results mostly appear in the main report.

7. The technical devices incorporated into the Product Plan and the Maximum Technology Scenario were costed by EEA and Jack Kelly, who also estimated the additional capital programme required to deliver the Maximum Technology Scenario.

8. The ITS developed and tested an econometric model which was used to estimate product mix under the Product Plan and Maximum Technology Scenario, and the consumer surplus which would accrue from implementation of the latter under various policy instruments set down in the Brief. A technical description of this model is included in Appendix C.

9. Estimates of new vehicle sales, fleet fuel consumption and other minor estimating processes were prepared using elasticities available from the literature, usually ITS sources. A commentary on policy evaluation was undertaken by Alister Watson.

10. Advice on vehicle labelling and other matters associated with information programmes was prepared by Alan Pears.

2. STUDY PARAMETERS

2.1 DATA SOURCES

The Study accessed a wide range of data sources. See Bibliography. Especially, data was obtained from Government agencies represented on the Steering Committee, the AIA, the AIP, FCAI, ABS, ABARE, VICROADS, SPCC, and others as relevant and available. This basic data included forecasts of population, urban/rural distribution, number of motor vehicles on register, fuel availability and price, and some less significant variables. This information is mostly summarised in WP4.

At the outset, it is important to note that the statistics describing the automotive industry in Australia are not as well publicised or as extensive as found overseas, particularly in the United States.

Especially, the absence of hard data about the fuel economy performance of new vehicles sold in Australia, or the basis for calculation of NAFC by the industry was a major impediment to any assessment of the comparative position of new vehicles sold in Australia. This issue is discussed at length in WP4.

Such data as is available in Australia should be used with caution, for example:

- o the dates of collection are not necessarily consistent (refer Section 2.2);
- o PAXUS is sometimes referred to as the official industry statistician but its definitional and classification systems are somewhat obscure (e.g. refer Section 3.4);
- o fuel consumption testing of individual vehicles undertaken by manufacturers is held on a confidential basis and the results published by the <u>Guide</u> are masked by low discrimination of the figures. This discrimination applies both to the number of significant digits used in published results (compared to the US EPA) and the rules for rounding the results;
- o correlation testing of manufacturers' test facilities appears to be irregular and not promptly reported;
- o while the DPIE is entitled to audit the test facilities and data, this does not appear to have been done for many years;
- o State Governments in New South Wales and Victoria are the only ones which undertake check testing but these tests are focused on emissions rather than fuel economy. The Study was surprised to find that test procedures in the SPCC test facility (not now in operation) do not conform to the requirements of AS 2877-1086, although they claim to do so.

In addition, there are considerable restraints on research into the industry, arising because:

- o the virtual monopoly on industry statistics held by PAXUS is reinforced by an inability to access registration information centrally, an absence of historical records on registrations, and Government policy on charging for statistics. Both ABS and State registration data is extremely expensive in terms of computer charge structures;
- o available sources do not keep data about engine power and

transmission type and even if asked, manufacturers typically are not in a position to deliver information about all makes and models now in the existing fleet, particularly the older vehicles.

It was concluded that these uncertainties and restraints on access to data which are required for proper governance of the industry should be a matter of concern to those who might wish to base policy actions on the results of studies such as this, no matter how robust the analyses may be.

2.2 BENCHMARK YEARS

The base year of the Study was 1988. This was chosen rather than 1990 for a range of reasons, including:
- o 1988 is the base year for policy positions taken by the Commonwealth and Victorian Governments in respect to containment of Greenhouse emissions;
- o information about the transport task was best defined in that year, through the 1988 SMVU;
- o ITS could readily update its 1970-1985 data base of vehicle attributes to 1988, whereas it would be more difficult to update to 1990;
- o various types of industry, taxation and other statistics were more readily available for 1988.

No attempt was made to define the base year in terms of a specific date, because:
- o data is not available on which to reconcile variation in dates among different data sets;
- o the rate of change of data within the year was considered to be too small to warrant the effort involved.

The 1988 data has various dates of relevance as follows:
- o SMVU data applies to the year ended 30th September, 1988;
- o Government revenues except FBT statistics are relevant to the year ended 30th June, 1988;
- o FBT statistics are relevant to 30th April;
- o PAXUS statistics can be obtained by month (at a cost) but statistics relevant to 31st December in each year were used.

Benchmark years for estimation were taken at 1995, 2000, 2005.

Estimates of present value were in constant 1988 dollars as at 30th June, 1988.

2.2.1 Base Year for Technical Options

Although the analysis required a 1988 base year, several difficulties prevented use of that year as the base for developing technical options and forecasting vehicle class fuel consumption for each target year:
1. the very detailed technical (mechanical) specifications of all vehicles sold in Australia for 1988 were not readily available, while they were for 1990;
2. data on engine/transmission mix for models was unavailable for 1988, while at least some (but not all) data for 1990 was available;

3. market changes and new models are not well captured by utilising the 1988 baseline, but are better captured by a 1990 baseline;
4. the issue is significant only if specific characteristics of the fleet are to be "frozen" at 1988 levels. This is not the case and in any event, it is relatively easy to adjust the data and forecasts from a 1990 base if desired, as 1988 data becomes available.

As a result, the analysis of future fuel economy improvements was formulated using a 1990 baseline.

2.3 UNITS OF MEASUREMENT

2.3.1 Energy Conversions

The following energy content of relevant liquid fuels were used:

Fuel	By Volume MJ/L
Automotive Gasoline	34.2
Automotive Diesel Oil	38.6

2.3.2 Fuel Consumption Conversions

All fuel consumption information used by the Study, except some comparisons of US/Australian fuel consumption, were quoted in litres per 100 kilometres (l/100km). The exception was adopted because the Study was using MPG test results obtained from the US EPA, which may not be readily available to readers and has a higher discrimination than the results in the Guide, which was the source of Australian data.

In a Study such as this, there are many instances where it is necessary to convert MPG estimates quoted in the literature to l/100km.

Accounting for US rather than imperial volumetric measures, the conversion for US estimates of MPG is:

$$l/100km = \frac{235.21}{MPG}$$

Note that estimates of US NAFC or CAFE expressed in MPG can be validly converted to units equivalent to Australian NAFC or CAFC (l/100km) using this formula.

2.3.3 Cost Conversions

Because the estimation of market penetration obtained from the econometric model is based (inter alia) on retail price, it was necessary for the Study to estimate base year price for new vehicles and technical options.

For new vehicles with base year technology, it was assumed that value added in manufacturing, distribution and transport to end users remained constant in real terms for the period of the Study.

Variations to the real price of new base year vehicles and components arise from a number of factors including:

- o whether the item is sourced in Australia or offshore (offshore implies currency variation, a tariff and possibly a transport penalty);
- o whether the item is a vehicle or a component;
- o the variation in tariffs over time, as set down in the Car Plan;
- o the variation in sales taxes applicable;
- o typical industry profit margins.

The Australian dollar was assumed to fall in value by 15 percent during the period to 1995 (i.e. to 70 cents US).

Tariffs were assumed to fall in line with the Government's March Industry Statement.

Sales taxes on new motor vehicles were assumed to be 20 percent on new vehicles up to $45,000, and 30 percent beyond that (i.e. upper luxury under the Study classification only). Variations due to new policy intervention over the Study period were assumed not to occur unless expressly considered in a policy analysis.

Profit margins are confidential to the industry. However, industry and Government agencies were consulted in an attempt to determine an simple relationship which addresses all variables yet is convenient for computation in a modelling environment. It was assumed that the wholesale price of cars including sales tax was 70 percent of the retail price. No allowance was made for sales discounting strategies.

A rough comparison of new vehicles sold in the US with those in Australia suggested that if US State sales taxes are ignored, retail prices in the US are about half those in Australia. US retail markups are about 15 percent.

For forecasting future new vehicle sales, and other policy analyses, details of price variation other than the above are addressed through the WPs as necessary.

2.4 VEHICLE CLASSES

The classification system for passenger cars most commonly used in Australia is that derived by PAXUS, which classifies new vehicles each year into small, medium, large, luxury, upper luxury. PAXUS do not publish a written description of these classes but it is understood that in 1990 they may have been based as shown overleaf.

PAXUS CLASSIFICATION FOR MOTOR VEHICLE (1)

Vehicle Type (2)	Description
Small	<2 litres, no purchase price limit
Medium	4 cylinders and <$26,000 purchase price
Large	6 cylinders and =<$30,000 purchase price
Luxury	<$36,000, cylinder size irrelevant
Upper Luxury	>$36,000, cylinder size irrelevant

Source: Personal Communication Paxus - March 1991

Notes: (1) Paxus use the Glass's Dealers Guide as a benchmark for car prices.

Viewed from the perspective of a study which must address how technical options affect the price, sizing and fuel efficiency of new passenger cars in the future, there are a number of problems with the PAXUS classification:

- o some of the classifications are not intuitively obvious; e.g. it is difficult to conceive the VW Golf as a luxury vehicle (so classified in 1990);
- o anomalies arise because the same vehicle can be in different classes in different years;
- o price and number of cylinders is an imprecise indicator of market positioning, weight/size and fuel consumption;
- o the classification system does not appear to be sufficiently correlated with fuel consumption to be directly useful.

Alternatives to the PAXUS classification were sought which would serve to roughly define average characteristics of each market segment. Possibilities were:

- o the Automotive Industry Authority classification, which aggregates PAXUS classes into small, medium, large and luxury. This does not improve the problems which the Study sought to overcome;
- o create classes especially for the purpose of the Study. Suitable indicators of a market class would be size, KW/Weight ratio, price.

This work was inhibited by the shortcomings of Australian automotive industry data as discussed under Section 3.1.

Acting on the advice of EEA, the Study defined mini, small, medium, upper medium, sports, luxury and upper luxury classes.

The PAXUS small car class was divided into a mini and a small car class to account for the increased popularity of what is really a new car class that has emerged in the last few years. Sports cars, that were included in the PAXUS classifications as luxury vehicles, were separated to account for their unique characteristics. In addition, some models in the PAXUS classifications appeared to belong to another class based on the definitions described below, and were moved on the advice of EEA to what is believed to be a more appropriate classification.

A Mini car class was newly defined to capture the fact that vehicles like the Holden Barina, Mazda 121, etc. are significantly smaller and lighter that the traditional small cars like the Ford Laser or Toyota Corolla. Typically, the vehicles are priced from A $12,500 to A $16,000, weigh 830 ± 50 kg and feature engines smaller than 1.5 litres. The three most popular models in this class are the Barina/Swift, the Daihatsu Charade and the Hyundai Excel.

The Excel actually straddles the mini and small car groups as it weighs 980 kg and has a 1.5 L engine, but was placed in mini class due to its price and market positioning, which is below that of traditional "small" cars.

The Small car class corresponds closely to the PAXUS car class with the mini-cars excluded. Typically vehicles are priced from $17,000 to $22,000 although there is a price leader Corolla/Nova model with a 1.4L engine below $16,000.

With the exception of this model, all vehicles have 1.5L to 1.8L engines, and weight 1025 ± 25 kg. The three most popular models are the Holden Nova/Corolla, the Ford Laser/Mazda 323 and the Nissan Pulsar, which account for over 70 percent of this car class sales. A few small 4-wheel drive wagon such as the Honda Civic, Corolla and Subaru Liberty were included in this class, as are high performance versions of small cars such as the Laser TX3, Mazda 323 Astina and the Corolla SX.

The Medium car class corresponds closely to the PAXUS car classification with some individual models moved from the PAXUS luxury car classification. These models include the Honda Accord, the Mazda 626, the Toyota Camry V-6 and Hyundai Sonata 4/6 cylinder. This is because some of the cars already included by PAXUS in this class are identical in price and size to the cars named above.

Most cars in this class range in price from A$18,500 to A$24,000 with "high-line" versions such as the Ford Telstar Turbo, Mitsubishi Magna Elite, etc priced up to A$32,000. Engines range from 2.0L to 2.6L and the typical weight is 1220 ± 50 kg. The Mitsubishi Magna is a model that straddles the medium and upper-medium classes.

Upper-medium class - With the phase out of the Nissan Skyline, this class consists of only two models, the Ford Falcon/Fairmont and the Holden Commodore/Lexcen. Both cars are uniquely Australian. Base prices start at A$24,000 with "highline" versions such as the Commodore Berlina priced at A$31,000. The Ford Falcon Fairmont utilises a 3.9L engine, while the Commodore uses a 3.8L V-6, but also offers a 5.0L V-8 option that accounts for 10 percent of Commodore sales. The Holden Commodore is a very weight efficient design with the base car weighing only 1315 kg, compared to the base Falcon weight of 1480 kg. Both vehicles offer very high levels of acceleration performance relative to the other non-luxury classes.

Sport - This class separates the 2-door sports coupes from the PAXUS luxury class, as they are typically much smaller and more fuel efficient. The three top selling models are the Ford Capri, Toyota Celica and Honda Prelude. Engine sizes range from 1.6L to 2.2L, and offer higher specific output than engines used in other classes. Prices range from A$26,000 to A$33,000.

Luxury - This class deletes sports and "high-line" medium size cars priced below $35,000 but adds the Mazda 929 and BMW 318 classified by PAXUS as upper luxury. All cars in this class are priced between A $35,000 and 45,000. The three most popular models are the Ford Fairlane, Holden Statesman, and Toyota Cressida. The Ford and Holden are stretched versions of basic Falcon and Commodore in the upper-medium class. All of the popular import models (except the BMW 318) have 6-cylinder 3.0L engines.

Upper luxury - This class contains a few European models and Japan luxury models priced on $45,000. Since sales in this class are less than 3 percent of total sales, no effort was made to study this class in detail.

WP1 lists all makes and models sold in Australia by class in 1990.

3. MEASURES OF FUEL CONSUMPTION

Because of the wide variation in size, load and performance specification of individual vehicles, and the driving characteristics of the general public, indicators of fuel consumption must be considered at three levels:

- o the fuel consumption of each make and model sold in a particular year (FC for each make and model);
- o the national average of fuel consumption of all new passenger vehicles sold in a given year (NAFC);
- o the total fuel used per vehicle on register in Australia, or the fleet average (FAFC).

A moment's thought will make it clear that when contemplating policies which might reduce Australia's total fuel consumption, one must take into account which if any of these three should be operated upon, and the extent to which one type of indicator has consequential or flow-on effects for the others.

It is to be noted that experts around the world are expressing concern about the artificiality of test procedures when compared to "real world" conditions (OECD/IEA:1990a,p.6). One issue relating to the NAFC test for Australia is addressed in WP4, Section 5.2.1). Experts have advised the development and adoption of a new test based on real driving conditions.

3.1 MEASURES FOR INDIVIDUAL MAKE/MODELS

Each country has a standard procedure for testing the fuel consumption of each new vehicle sold. This procedure(s) have strictly controlled rules over standard loading, performance and consumer driving cycle, and a different figure may be calculated which purports to correspond to city or highway (country) driving.

The test used in Australia is *AS 2877-1986* which is of US origins and uses the US 1975 FTP and US HWFET, weighted 55 percent urban and 45 percent highway. NAFC for 1978 to 1985 was originally measured using the US 1973 FTP rather than the 1975 FTP and can be corrected using a factor of 2.75 percent (55 percent of 5 percent).

The 55/45 weighting purports to account for the proportion of city and highway driving, and which is possibly correct for the US, but not for Australia.

Appendix A provides some insights into the source and complexities of tests of fuel consumption of individual vehicles, which has led to series breaks in historical statistics (DPIE:1990,p.27).

3.2 NATIONAL AVERAGE FUEL CONSUMPTION (NAFC)

The National Average Fuel Consumption (NAFC) is a weighted average of the fuel consumption relevant to all new vehicles sold in a given year. This consists of the Guide figure weighted by the number of vehicles sold.

3.2.1 Factors Affecting NAFC

Simply stated, the factors affecting calculation of national average fuel consumption (NAFC) for new motor vehicles include:

- o technical factors affecting the fuel consumption of individual vehicles;
- o changes to the mix of new vehicles sold in Australia.

For example, given that FC for small vehicles is lower than for large ones, we can reduce NAFC not only by technical options for new power plants, transmissions etc., but also by encouraging consumers to buy a mix of new vehicles which have a higher proportion of small vehicles in the 450,000 or so that are added to the national fleet each year.

3.3 FLEET AVERAGE FUEL CONSUMPTION (FAFC)

The Fleet Average Fuel Consumption (FAFC) estimates an actual or "on-the-road" average by dividing the total fuel consumed in Australia by passenger cars, by the aggregate distance travelled by those vehicles. This is the figure obtained by dividing aggregate fuel consumption for Australia (or a region) by the passenger transport task statistics obtained, for example, from the SMVU.

This includes all older vehicles (which are not as efficient now as they were when new)and all types of drivers (leadfoot or not).

3.3.1 Factors Affecting Fleet Average Fuel Consumption

The fleet average fuel consumption is affected mostly by vehicles included in the existing fleet. FAFC can be changed not only by introducing more fuel efficient small vehicles but also be introducing policies which affect the use, efficiency and mix of the total fleet.

Policies which operate on FAFC are likely to have more leverage on fuel economy, and political impact, than policies which operate on FC or NAFC.

3.4 TAKING ACCOUNT OF VARIOUS TYPES OF FUELS

There is a great deal of evidence that diesel powered cars are more fuel efficient in volumetric terms than petrol driven cars of the same size, load and performance specification. The relative nominal differences can be large. In part this is because diesel fuel contains 9-10 percent more energy per unit volume than petrol. Again, diesel fuel produces 73.8 kilotonne of CO_2 per petajoule, compared with 71.2 kt for gasoline.

To obtain a uniform comparison, the volumetric statistics are sometimes transformed into consistent units, e.g. joules give a common unit of energy. Refer Section 3.3.1.

The Brief requires that the Study address petrol and diesel powered passenger cars, but requires comment on the impact on energy used in refining, of changes if any in fuel specifications.

The important issue in this context is: if the Study addresses technical options which significantly increase the proportion of diesel fuel used in passenger cars, what are the implications for total energy use, including that energy consumed in refining.

Crude oil is initially distilled which produces diesel in its final form. Diesel can also be produced through the process of catalytic cracking (this process can produce petrol and diesel depending on the type of cracker). Following distillation, part of the crude oil output requires secondary processing (reforming) to produce petrol. Petrol requires further processing, hence refining a litre of diesel will consume less energy than a litre of petrol.

The overall fuel consumption (i.e. energy in fuel plus energy used in refining) balance is a function of a number of factors beyond the fuel efficiencies of diesel and petrol engines, including efficiency of various refineries, the relative volumes of petrol and diesel fuel produced in the refining process, fuel used in other sectors such as aviation, etc.

Australian refineries will have different conversion factors for producing a litre of petrol and diesel and these rates are dependent upon the issues mentioned above (Shell, pers comm.,1991).

Most Australian refineries are configured to produce maximum levels of petrol, as this is the product demanded in the marketplace. This is in contrast to European refineries, which utilise hydro crackers to produce high levels of diesel (and fuel oils).

Energy consumed in the refining process is estimated as six percent (AIP pers comm., 1991) of total output, but this can not be disaggregated into final products.

Waters (1991,p.27) concluded that for UK conditions, a comparison on a volumetric basis is approximately equivalent to comparing primary energy consumption (i.e. energy in the fuel plus energy consumed in refining).

WP4 shows that in 1988, diesel fuel represented about 1.8 percent of all fuel consumed by cars, measured on a volumetric basis. Proportionately, the diesel use in the UK and Europe is higher that the figure (up to 15 percent). Thus the UK experience may not be directly transportable.

Discussions with AIP representatives produced advice that it was not possible to distinguish refinery loads between diesel and gasoline. This was because Australian refineries used different sources of crude, and may produce to different specifications.

In these circumstances, it was decided to obtain information from the literature. Bang and Holden (1991) confirm that variation in efficiencies between plants is substantial and suggest that the efficiency of crude - petrol and crude - diesel products are in the order of 88-90 percent and 90-95 percent respectively.

It was concluded that if the Study were to advise that fuel economies can be achieved by encouraging the use of diesel powered vehicles, the volumetric estimate of diesel use should be weighted upwards by 1.05 to account for loses in refining.