Case Study

CNG(SPARK-IGNITION ENGINES)

TRIAL SUMMARY

	Fuel benefit (L/100 km)	GHG benefit (g/km CO_2-e)	Economic benefit ($/100 km)
The purpose of this trial was to assess the economic and environmental performance of CNG spark-ignited engine technology relative to conventional compression-ignition diesel technology. The trial involved the comparison of the fuel consumption data derived from the in-field operation of three diesel trucks with two CNG trucks. All five vehicles were concrete agitators operating in the Greater Sydney region of New South Wales.	3.12 DLE ↓	392.1 ↓	7.32 ↑

↓ performance worse than conventional vehicle ↑ performance better than conventional vehicle

The *Green Truck Partnership* is designed to be a forum for the objective evaluation of the merits of clean vehicle technologies and fuels by heavy vehicle operators. This report discusses the results of a trial of compressed natural gas (CNG) vehicles for concrete agitator application. The trial was conducted in 2011.

1 CNG SPARK-IGNITION TECHNOLOGIES

The lower unit cost and reduced GHG intensity of natural gas suggests that this fuel can deliver significant economic and environmental benefits relative to diesel. The full realisation of these benefits, however, assumes that the combustion efficiency of the natural gas engine is equivalent to that of a modern diesel engine.

The higher flammability of natural gas means that it cannot be used in compression-ignition engines unless the fuel is burned in combination with diesel. As a consequence, those vehicles that are fuelled solely with natural gas must revert to spark-ignition technology.

Given that compression-ignition engines have a greater combustion efficiency than spark-ignition engines, particularly under low load and low speed conditions, there is considerable uncertainty in respect of the net energy and environmental benefit of using CNG in spark-ignition engines, relative to the use of conventional diesel in combustion-ignition engines.

2 TRIAL OBJECTIVE

The objective of this trial was to compare the energy and environmental performance of CNG spark-ignition vehicles withconventional diesel vehicles (compression-ignition technology).

The trial involved an evaluation of CNG technology used in concrete agitators operating in the Greater Sydney region of New South Wales.

3 METHODOLOGY

DATA COLLECTION

This trial involved the collection of data from the in-field operationof fivesimilarly configured concrete agitator trucks (three diesel vehicles and two CNG vehicles) running similar routes in urban and outer urban Sydney.

The data for the threedieselvehicles was collected over a 10-month period in 2010–2011. A total of 400 days’ data was collected over this period.

The data for the twoCNG spark-ignition vehicles was collected overa two-month period in 2011, yielding 45 days of information.

During the trial period, data loggers were used to collate drive cycle data relating to the operation of the trial vehicles to ensure validity of the before and after comparison. The data collected by the loggers included:

- **FUEL CONSUMPTION**: total fuel consumed in a daily period.
- **FUEL ECONOMY**: daily fuel economy (km/L).
- **DISTANCE**: kilometres travelled.
- **IDLE TIME**: time spent at idle.
- **ENGINE HOURS**: time spent with engine active.
- **AVERAGE SPEED**: average speed (km/h).
- **STOPS**: number of stops per kilometre travelled.

DATA ANALYSIS

Key descriptors considered in this analysis included average speed, drive fuel economy, engine hours and idle time.The data was used to compare the operating characteristics of the vehicles under conventional diesel operation with CNG operation to ensure that the comparison was valid. Any fuel consumption data collected during periods where significant variation in vehicle driving characteristics was observed was excluded from the analysis.

The diesel and CNG figures were then compared,with the resultant findings discussed in Section 4.

The data analysis process compared two key descriptors of the duty cycle of all vehicles considered in the trial: average speed and idle time.Comparison of vehicle operation was made by considering the degree of correlation between the diesel vehicles and the CNG vehicles for each of these duty cycle descriptors. Where the correlation was poor, the fuel consumption data relating to that time period was excluded from the analysis.

Average speed was first compared in order to confirm that thediesel and CNG vehicles were performing similar runs. Figure 1 demonstrates that the average speed profiles for trial and baseline periods were closely matched.

The nature of concrete agitator application is such that these vehicles spend a significant period of time operating at idle (e.g. loading and pumping out). As a consequence, the idle times of the diesel vehicles and CNG vehicles were also compared by considering idle time as a percentage of engine operating hours. This comparison (Figure 2) revealed good correlation between the idle times of the CNG vehicles and the diesel vehicles.

The above analysis suggested that the operating characteristics of the diesel vehicles and the CNG vehicles were similar and therefore the comparison of fuel consumption data was valid.

4 RESULTS

An analysis of the economic outcomes of using CNG in lieu of diesel was undertaken using market rates, as opposed to the actual fuel rates paid by the participating organisation. This analysis is shown in Figure 3. The analysis reveals that the fuel costs of the CNG vehicles were 10% lower than diesel vehicles when considered on a per kilometre basis and 18% lower when compared on the basis of engine operating hours.

Conversely, the analysis reveals that the lower combustion efficiency of the CNG spark-ignition technology results in higher total energy consumption relative to the compression-ignition diesel technologies. This energy efficiency penalty was observed to be sizeable and resulted in the GHG emissions of the CNG vehicles actually being higher than those of the diesel vehicles.

The analysis summarised in Figure 4 reveals that when considered on the basis of energy equivalence, the GHG emissions of the CNG spark-ignited vehicles were 10% higher than the diesel vehicles per hour of engine operation.

Fuel consumption could not be compared on a volumetric basis, but when considered on an energy equivalence basis theCNG vehicles were found to consume the equivalent of 3.12 litres more diesel per 100 kmtravelled than the diesel vehicles.

5 CONCLUSION

The findings of this case study reveal that when used in lieu of diesel compression-ignition engines, spark-ignited CNG engines deliver economic savings in the vicinity of 18% per hour of engine operation.

This saving, however, is only a consequence of the lower cost of CNG relative to diesel (typical market rates). When considered on the basis of energy efficiency, the CNG vehicles were actually observed to have a higher energy consumption than equivalent diesel vehicles.

This higher energy consumption resulted in the greenhouse emissions generated by the spark-ignited CNG vehiclesbeing 10% higher than those generated by the vehicles equipped with diesel compression engine technology.

Figure 1
Comparison of vehicle average speed across baseline and trial periods

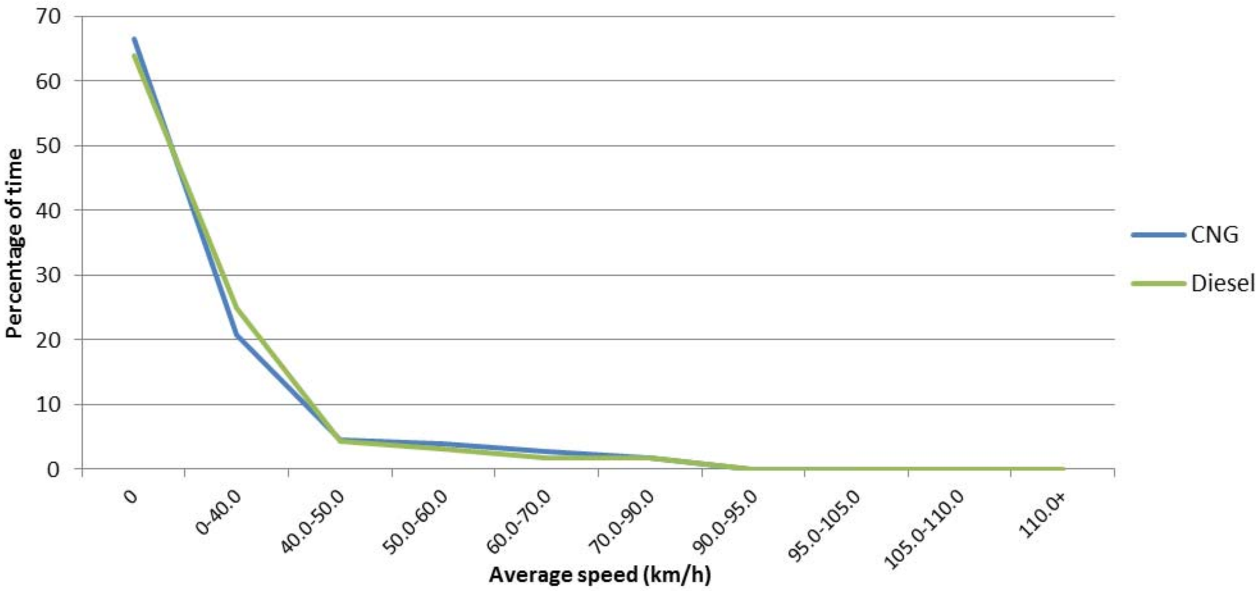

Figure 2
Comparison of vehicle engine hours and idle time

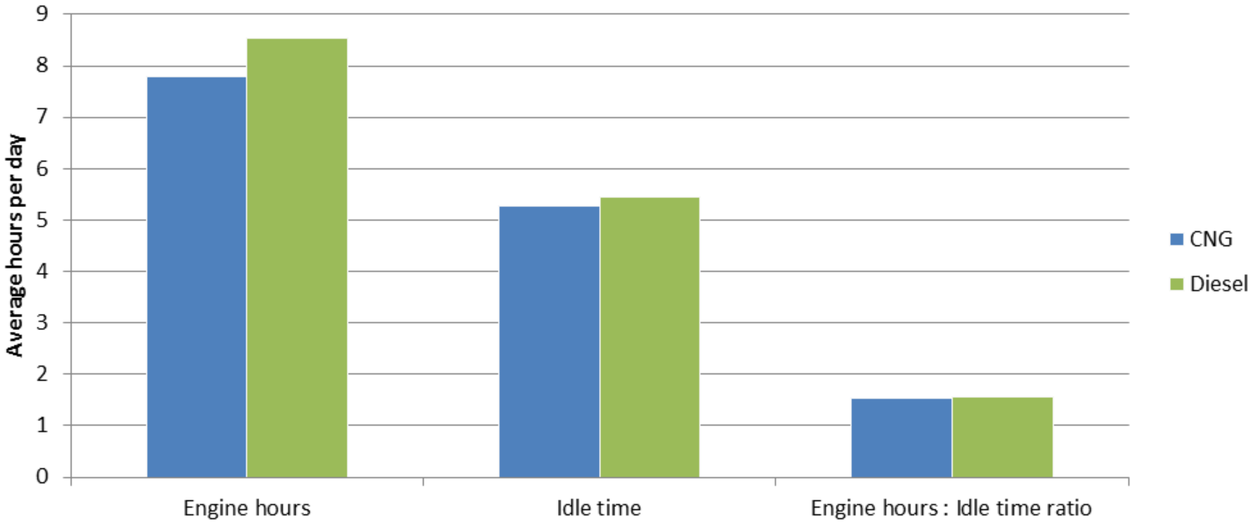

Figure 3
Comparison of CNG and diesel economic benefits

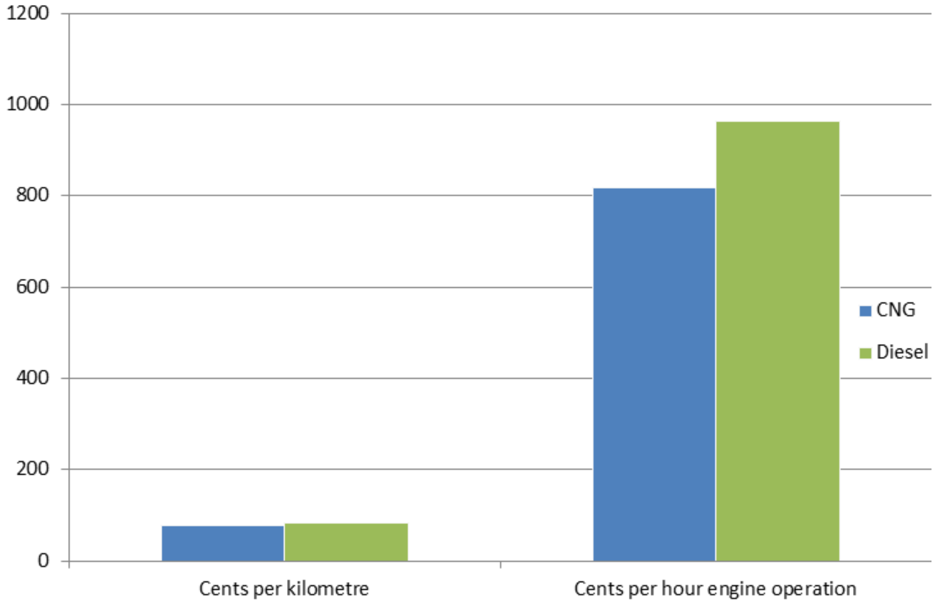

Figure 4
Comparison of CNG and diesel GHG benefits