



TRIAL SUMMARY

<p>The objective of this trial was to assess the economic, operational and emissions performance of a hybrid truck with an electric refrigeration system against a hybrid truck using conventional engine-powered refrigeration technology. The comparison was conducted for two local pick-up and delivery vehicles operating in the Melbourne metropolitan area.</p>	<p>Fuel benefit (L/100 km)</p>	<p>GHG benefit (g/km CO₂-e)</p>	<p>Economic benefit (\$/100 km)</p>
<p>Results were inconclusive, with fuel efficiency 9% better in one period, but no different in another period.</p>			

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 an electric refrigeration technology trial conducted under the program in 2014.

1 OFF-ENGINE REFRIGERATION TECHNOLOGIES

Refrigeration systems on vans and small trucks are often powered by the vehicle’s engine (off-engine). These systems divert engine power to drive a compressor that is part of the refrigerated circuit cooling the payload compartment.

Such systems are simple in that they make use of the truck engine as a power source. However, they can also be inefficient: demand for cooling won’t always match available power (e.g. during engine idling); the truck engine is over-sized for the task of driving a compressor; and internal combustion engines are inherently inefficient.

Electric refrigeration systems are still powered by the vehicle, but an engine-driven generator replaces the engine-driven compressor. Electrical energy from the generator is then used to power an electric compressor. This reduces losses and can be better matched to payload cooling needs.

2 TRIAL OBJECTIVE

The objective of this trial was to assess the economic and environmental performance of an electric refrigeration system relative to a conventional engine-powered system.

3 METHODOLOGY

DATA COLLECTION

The trial involved an in-field assessment of two hybrid local pick-up and delivery vehicles: one fitted with an electric refrigeration system, the other using a conventional directly driven off-engine system. The trucks were operated simultaneously on similar home delivery grocery operations in the Melbourne metropolitan region during a six-month period.

In order to ensure that the operation of the two vehicles was directly comparable, data loggers were fitted to each vehicle to capture key descriptors of vehicle operation. Specifically, information was collected in relation to:

- **IDLE TIME:** time spent at idle.
- **AVERAGE SPEED:** average speed (km/h).
- **STOPPING INTENSITY:** number of stops per kilometre travelled.

Owing to the nature of the vehicles being trialed, instantaneous fuel consumption data could not be captured. As a result, daily fuel consumption data was provided by the participating fleet and aggregated with the drive cycle data for each day of the trial period.

DATA ANALYSIS

The first stage of the analysis involved validating the fuel consumption comparison between both vehicles. This involved comparing the daily operation of both vehicles using the three drive cycle descriptors (i.e. average speed, idle time and stopping intensity). Owing to technical problems with the telemetry equipment on one vehicle, the duty cycle data could only be compared for the September-October period.

As shown in Figure 1, a comparison of the speed profiles for both vehicles over this period revealed a strong level of correlation. Stopping intensities and idle times for both vehicles also show a strong correlation, which suggests the vehicles were undertaking similar routes.

Accordingly, the study team concluded that the operation of the two vehicles – during September and October at least – was very similar; and that direct comparison of fuel consumption of the two vehicles was valid (i.e. there were no significant differences in duty cycle, and any observed differences in fuel consumption were likely to be due to differences in the vehicle technologies).

Following data validation, the fuel consumption of the two vehicles was compared.

4 RESULTS

Comparison of the fuel consumption of both vehicles revealed that trial vehicle operated at 9% better fuel efficiency than the control vehicle in the January to April period. As indicated earlier, duty cycle data for this period could not be compared to verify similar operating conditions.

These results contrasted with the data from September-October when the trucks had the same fuel efficiency – indicating no benefit from the use of the electric refrigeration system.

No reason could be attributed to the conflicting results. The nature of the operations (home grocery deliveries) means there were inherent differences in payload and delivery destinations but, as Figure 1 shows, the speed profiles closely matched during the September–October period.

5 OTHER CONSIDERATIONS

Refrigerants can have a global warming effect tens or hundreds of times greater than CO₂ so the effect of system leakage on climate change could outweigh the benefit from fuel savings. In this respect, a much lower leakage rate of the electric system is claimed to result in less than 10% of the greenhouse gas emissions of a traditional direct-drive system (and lower refrigerant costs).

Similarly, electric drive systems are much more efficient when the truck is idling, achieving close to their maximum cooling capacity (compared with around 50% for a conventional system). This means a smaller system can be specified without sacrificing cooling performance. They can also run on mains power while parked at the depot.

6 CONCLUSION

The findings of this trial are inconclusive. The results suggest that electric refrigeration may offer fuel-efficiency benefits, but that these will vary depending on the duty cycle and specific route/operating conditions.

In addition, the economic performance of this technology should not be considered on the basis of fuel savings alone. Ideally, the assessment should be conducted on a whole-of-operation basis, factoring in different capital costs, maintenance requirements, and equipment life.

