Pilot Green Transport Fund

Final Report On
Trial of Electric Inverter Air Conditioning System for Cross Boundary Bus
(Tong Kiu Traffic Services Limited)

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Final Report
(Trial Period: 1 March 2016 – 28 February 2018)

Executive Summary

1 Introduction

1.1 The Pilot Green Transport Fund (the Fund) is set up to encourage transport operators to try out green and innovative transport technologies, contributing to better air quality and public health for Hong Kong. Tong Kiu Traffic Services Limited (Tong Kiu) was approved under the Fund for trial of one electric Inverter Air Conditioning System (IAS) installed in a single deck diesel bus (coach) for cross boundary bus service. Through the tendering procedures stipulated in the Agreement, Tong Kiu arranged for installation of the system into one Scania single-deck diesel bus with a gross vehicle weight (GVW) of 16,500 kg (IAV) for trial.

1.2 The Hong Kong Institute Vocational Education (Tsing Yi) (IVE(TY)) has been engaged by the Environmental Protection Department (EPD) as an independent third party assessor to monitor the trial and evaluate the performance of the trial vehicle. One Scania single-deck diesel bus (CAV) with a GVW of 16,000 kg serving the same purpose was assigned as the conventional vehicle for comparing with the IAV.

1.3 This Final Report summarizes the performance of the IAV in the 24 months of the trial as compared with their conventional diesel counterpart.

2 Trial and Conventional Vehicles

2.1 Tong Kiu procured one Tai Chang TCD08Z electric inverter air conditioner system which has a power input of 4.92 kW with an Evaporator Air Flow of 4800 m^3/hr for the trial. The IAS is installed in a Scania single-deck diesel bus with a GVW of 16,500 kg (IAV).

2.2 One Scania single-deck diesel bus (i.e. CAV) equipped with a Tai Chang TCH12T conventional air-conditioning system (i.e. CAS) was assigned for comparison with the IAV in the trial. The CAV has a GWV of 16,000 kg.

2.3 The IAV and the CAV were used for cross boundary bus service between Hong Kong and the Mainland. The service hours of the vehicles were from 9:00 am to 6:00 pm on every Monday to Saturday except Sundays and public holidays. Key features of the IAS, IAV and CAV are shown in Appendix 1 and their photos are shown in Appendix 2.

3 Trial Information

The trial started on 1 March 2016 and lasted for 24 months. Tong Kiu was required to collect and provide trial information including the mileage reading at refuelling, date of refuelling and refuelled amount, costs and operation downtime associated with scheduled and unscheduled maintenances of the IAV. Similar monthly data from the CAV were also required. In addition to the cost information, reports on maintenance work, operational difficulties and opinions of the driver and Tong Kiu were collected to reflect any problems of the IAV.

4 Findings of Trial

4.1 Table 1 summarises key operation statistics of the IAV and CAV. The average fuel cost of IAV was HK$0.02/km (i.e., 0.6%) slightly higher than that of the CAV and the average fuel economy of the IAV was about 1% slightly lower than that of the CAV. The IAV and CAV are the same make, model and year of manufacture as well as both drive similar routes. The GVW of IAV is 500 kg heavier than CAV (3%) due to the IAS being installed. There was no fuel saving as the potential energy saving of IAS was offset by the extra energy required for the additional weight of it being installed in the IAV. Taking into account the maintenance cost, the average total operating cost of the IAV was HK$0.02/km (i.e., 0.6%) slightly higher than that of the CAV.

Table 1: Key operation statistics of each vehicle (March 2016 - February 2018)

	IAV	**CAV**
Total distance travelled (km)	281,466	222,678
Average fuel economy (km/litre)	3.28	3.32
Average fuel cost (HK$/km) [1]	3.50	3.48
Average total operating cost (HK$/km) [4]	3.50	3.48
Downtime (working day) [2] [3]	16	16

[1] The market price was used for calculation.

[2] Downtime refers to the equivalent number of working days in which the vehicle is not in operation due to maintenance, counting from the first day it stops operation till the day it is returned to the operator.

[3] Downtime due to traffic accident or incident unrelated to the performance of the vehicle is not counted.

[4] Maintenance due to traffic accident or incident unrelated to the performance of the vehicle was not included for comparison.

4.2 During the trial period, the IAV had 16 scheduled maintenances and no unscheduled maintenance required. The CAV had 16 scheduled maintenances and no unscheduled maintenance required. Both the IAV and the CAV had 16 days of downtime and their utilization rates were both 97%.

4.3 Tong Kiu had a designated driver for the IAV. The IAV driver was generally satisfied with the performance of the IAS as well as the vehicle. But, the driver pointed out that he needed to spend extra time to clear the filters of air conditioning system of IAV as the quantity of filter of IAS is more than that of the CAS. Also, the driver found that the IAV is nosier than CAV when the cooling fan was operated, and felt not quite as cool as CAS. Some passengers supported replacing the existing conventional buses with IAV, and expressed that they were more environment-friendly than the CAV**.** However, some passengers felt the IAV was not as cool as the CAV. Also, it accelerated slower and was noisier than the CAV. There were also passengers who thought the IAV was not beneficial at all

4.4 Tong Kiu agreed that, in general, using IAV was good because it provided a greener and quieter environment compared with the traditional one. Also, Tong Kiu agreed that it could meet their operational requirements.

4.5 To eliminate the effect of seasonal fluctuations, 12-month moving averages were used to evaluate the trend of the IAVs' fuel economy. The fuel economy varied from 3.25 to 3.38 km/litre for the IAV. The data suggests there was no significant deterioration of the IAV due to the installation of IAS in the trial period.

4.6 The carbon dioxide equivalent (CO_2e) emission from IAV was 226,449 kg while the comparable emission from CAV for the same distance travelled as IAV was 223,695 kg. Overall, there was a total increase of 2,754 kg (i.e. about 1%) CO_2e emission by using the IAV during the trial period.

5 Summary

5.1 The driver adapted to the differences in the IAV's operation. In general, the IAV driver was generally satisfied with the performance of the IAS as well as the vehicle. But, the driver pointed out that he needed to spend extra time to clear the filters of the IAS as the quantity of filter of IAS is more than that of the CAS. Also, the driver found that the IAV is nosier than the CAV when the cooling fan was operated, and felt not quite as cool as the CAS. From the point of view of Tong Kiu, they agreed that, in general, using IAS was good because it provided a greener and quieter environment compared with the traditional one. Also, Tong Kiu agreed that it could meet their operational requirements. Some passengers supported replacing the CAS with IAS for the conventional bus and expressed that IAV was more environment-friendly than the CAV. However, some felt the IAV was not as cool as the CAV, accelerated slower and was noisier than the CAV. There were also passengers who thought the IAV was not beneficial at all.

5.2 The IAV incurred a slightly higher average fuel cost of HK$0.02/km (0.6%) compared to that of the CAV. Taking into account the scheduled and unscheduled maintenances, the average total operating cost of the IAV was HK$0.02/km (0.6%) slightly higher than that of the CAV. Also, the total CO_2e emission from the IAV was about 1% slightly higher than that from the CAV. The utilisation rates of the IAV and CAV was 97% for each vehicle. The results revealed that the potential energy saving of IAS was offset by the extra energy required for the additional weight of it being installed in the IAV.

5.3 During the 24-month trial, the variation in fuel economy of the IAV was not significant, indicating that there was no significant deterioration of the IAV in the trial period.

Appendix 1: Key Features of Vehicles Involved in the Trial

1. Trial Coach (IAV) with electric inverter air-conditioning system

Registration Mark	**TT 8728**
Make:	SCANIA
Model:	K Series
Class:	Non Franchised Public Bus
Seating capacity:	Driver + 49 Passengers
Air conditioning system:	Tai Chang TCD08Z electric inverter air conditioning system (IAS) with total cooling capacity of 36kW
Gross vehicle weight:	16,500 kg
Year of manufacture:	2013

2. Diesel Coach (CAV) with conventional air-conditioning system for comparison

Registration Mark	**TU1784**
Make:	SCANIA
Model:	K Series
Class:	Non Franchised Public Bus
Seating capacity:	Driver + 49 Passengers
Air conditioning system:	Tai Chang TCH12T conventional air conditioning system (CAS) with total cooling capacity of 38.35kW
Gross vehicle weight:	16,000 kg
Year of manufacture:	2013

Appendix 2: Photos of Vehicles

1. IAV

	
Front view of IAV	Rear view of IAV
	
Left side view of IAV	Right side view of IAV

2. CAV for comparison

	
Front view of CAV	Rear view of CAV
	
Left side view of CAV	Right side view of CAV