

Pilot Green Transport Fund

Final Report On Trial of Electric Inverter Air-conditioning System (IAS) for School Bus (Express Tourist Bus Company Limited)

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The Monitoring and Evaluation Team's views expressed in this report do not necessarily reflect the views of the Environmental Protection Department, HKSAR.

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**Pilot Green Transport Fund
Trial of Electric Inverter Air-conditioning System (IAS) for School Bus
(Express Tourist Bus Company Limited)**

**Final Report
(Trial Period: 1 February 2017 – 31 January 2019)**

Executive Summary

1. Introduction

1.1 The Pilot Green Transport Fund (the Fund) is set up to encourage transport operators to try out green innovative transport technologies (the green innovative technology), contributing to better air quality and public health for Hong Kong. Express Tourist Bus Company Limited (ETBC) was approved under the Fund for trial of one unit of electric Inverter Air-conditioning System (IAS) on a single-deck bus (coach). Through a tendering procedure stipulated in the Subsidy Agreement, ETBC appointed Tai Chang China Motor Green Power Limited to manufacture and install an IAS with model TCD08Z-II on a new diesel coach (IAV) for trial.

1.2 PolyU Technology and Consultancy Company Limited has been engaged by the Environmental Protection Department (EPD) as an independent third party assessor (the assessor) to monitor the trial and evaluate the performance of the trial vehicle. ETBC assigned another Isuzu diesel coach (CAV) with conventional air-conditioning system (CAS) as IAV's conventional counterpart for comparison in this trial.

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

2. Trial Vehicles

2.1 Key features of the IAS, IAV, CAS and CAV are in Appendix 1 while photos of IAV and CAV are in Appendix 2. Both IAV and CAV were used mainly for providing school bus service for a school in Hong Kong Island East in the first 18 months of trial. From 1 August 2018 up to the end of trial period (six months in total), due to the business operation changed, IAV changed service route from Hong Kong Island East to a fixed round-trip route between the East Rail's University Station and The Education University of Hong Kong, located at Ting Kok, New Territories; while CAV service area was remained in Hong Kong Island East. The average daily traveled distance of the IAV was about 162 km before 1 August 2018 and 392 km after 1 August 2018 while that of the CAV was about 87 km in the 24 months of the trial.

2.2 According to the IAS' manufacturer, the IAS comprises two electric-driven inverter air-conditioners and 4 electric battery packs. The inverter air-conditioners of IAS are driven by the energy stored in the battery packs and the energy output will be controlled by the inverter so as to reduce the fuel consumption. The total cooling capacity of the IAS is 36 kW and the total weight of the IAS is around 690 kg. While the weight of the CAS with model number TCH12U is 243 kg, with cooling capacity of 38.28 kW.

3. Trial Information

3.1 The trial commenced on 1 February 2017 and lasted for 24 months. ETBC is required to collect and provide trial information including the IAV operation data, cost and downtime associated with scheduled and unscheduled maintenance of the IAV. Similar data from the CAV are also required. In addition to the cost information, operational difficulties and opinions of the drivers were collected to reflect any problems of the IAV.

4. Findings of Trial

4.1 Table 1 summarizes the statistical data of the IAV and the CAV in the 24 months of the trial.

Table 1: Key operation statistics of each vehicle (1 February 2017 – 31 January 2019)

| | IAV | CAV |
|---|---|---------|
| Total distance traveled (km) | 131,475 | 47,254 |
| Average daily traveled distance (km/day) | 162 ^[1] / 392 ^[2] | 87 |
| Fuel cost (HK\$) ^[3] | 529,889 | 249,500 |
| Average fuel economy (km/litre) | 3.18 | 2.46 |
| Total operating cost (HK\$) | 529,889 | 249,500 |
| Average fuel cost (HK\$/km) | 4.03 | 5.28 |
| Average total operating cost (HK\$/km) ^[4] | 4.03 | 5.28 |
| Downtime (working day) ^[5] | 0 | 0 |

^[1] The average daily traveled distance of the IAV was about 162 km before 1 Aug 2018

^[2] The average daily traveled distance of the IAV was about 392 km after 1 Aug 2018

^[3] The market fuel price was used for calculation

^[4] In the 24 months of the trial, there was no maintenance required for the air-conditioning system of the IAV or the CAV.

^[5] Downtime refers to the working days the vehicle is not in operation due to maintenance, which counted from the first day it stops operation till the day it is returned to the operator.

4.2 The above data demonstrated the average fuel cost of the IAV was lower than that of the CAV by HK\$1.25/km (about 24%). As there was no maintenance required for both IAV or CAV in the 24 months of the trial, the average total operating cost of the IAV was same as the average fuel cost which was HK\$1.25/km (i.e. about 24%) lower than that of CAV.

4.3 Since there was no downtime for the IAV and the CAV, the utilization rates of both vehicles were 100%.

4.4 The drivers had no problem in operating the IAV in general but they were not satisfied with its performance during going uphill. The possible reason for the poor climbing uphill performance is the additional weight of the battery packs and IAS components. Over 80% passengers interviewed were satisfied or had no comment to the IAV performance. The feedback from ETBC is that the drivers were not satisfied with the IAV's performance during going uphill. Meanwhile, ETBC was informed by the IAS manufacturer that the IAS's model has already phased out and no spare parts will be provided.

4.5 To eliminate the effect of seasonal fluctuations, 12-month moving average was used to evaluate the trend of the fuel economy of the IAV. The fuel economy was constant and increased a little bit in the first half trial period, the fuel economy further increased and stabilized in the continued trial period, indicating that there is no deterioration in fuel economy in the trial period. The possible reasons for the average fuel economy of IAV increased, could be 1.) the IAV drivers were get used to the IAV driving mode and the drivers' good driving habit would improve the fuel saving performance, 2.) the IAV service route changes from mountain road to a fixed round route in high way in the last 6 months of the trial period.

4.6 The carbon dioxide equivalent (CO₂e) emission from IAV was 106,734 kg, while that from CAV was 141,276 kg. Hence replacing CAS by IAS on the diesel bus could reduce 34,542 kg CO₂e (i.e., about 24.5%) in the trial.

5. Summary

5.1 During the 24 months of the trial, the operation data collected showed that the IAV had lower fuel cost than that of the CAV, with an average fuel cost saving of HK\$1.25/km (about 24%). As there was no maintenance required for both IAV and CAV in the 24 months of the trial, the total operating cost of the IAV was same as its average fuel cost, so does the CAV. Thus, these two kinds of costs of the IAV were HK\$1.25/km (i.e. about 24%) lower than those of the CAV. The utilization rates of both vehicles were 100%.

5.2 There is no indication that the fuel economy of the IAV has deteriorated during the trial period.

5.3 The drivers had no problem in operating the IAV, but pointed its climbing uphill performance poorer than that of the CAV which is possibly due to the additional weight of the battery packs and IAS components. When the IAV is fully occupied and goes uphill, the problem is obvious. Same opinion was also reflected from the subsidy recipient. Over 80% passengers interviewed were satisfied or had no comment to the IAV performance. The subsidy recipient was not satisfied the performance of IAV, and they will not replace their conventional air conditioning system with this inverter air conditioning system.

Appendix 1: Key Features of Vehicles and Air-conditioning System Involved in the Trial

1. Diesel Vehicle (IAV) Installed with Trial Electric Inverter Air-conditioning System (IAS)

(a) Trial Electric IAS

| | |
|---------------------------------|---|
| IAS : | 2 sets inverted air-conditioner and 4 battery packs |
| Model : | TCD08Z-II |
| Make : | Tai Chang China Motor Green Power Limited |
| Total cooling capacity : | 36 kW |
| Weight of IAS : | 690 kg (450 kg for 2 sets inverted air-conditioner, 240 kg for 4 battery packs) |

(b) IAV

| | |
|-------------------------------|------------------------|
| Registration mark : | GM9909 |
| Make : | Isuzu |
| Model : | LT434PF-6S-V |
| Class : | Public bus |
| Gross vehicle weight : | 14,800 kg |
| Seating capacity : | driver + 65 passengers |
| Cylinder capacity : | 7,790 cc |
| Year of manufacture : | 2015 |

2. Diesel Vehicle (CAV) Installed with Conventional Air-conditioning System (CAS) Used for Comparison

(a) CAS

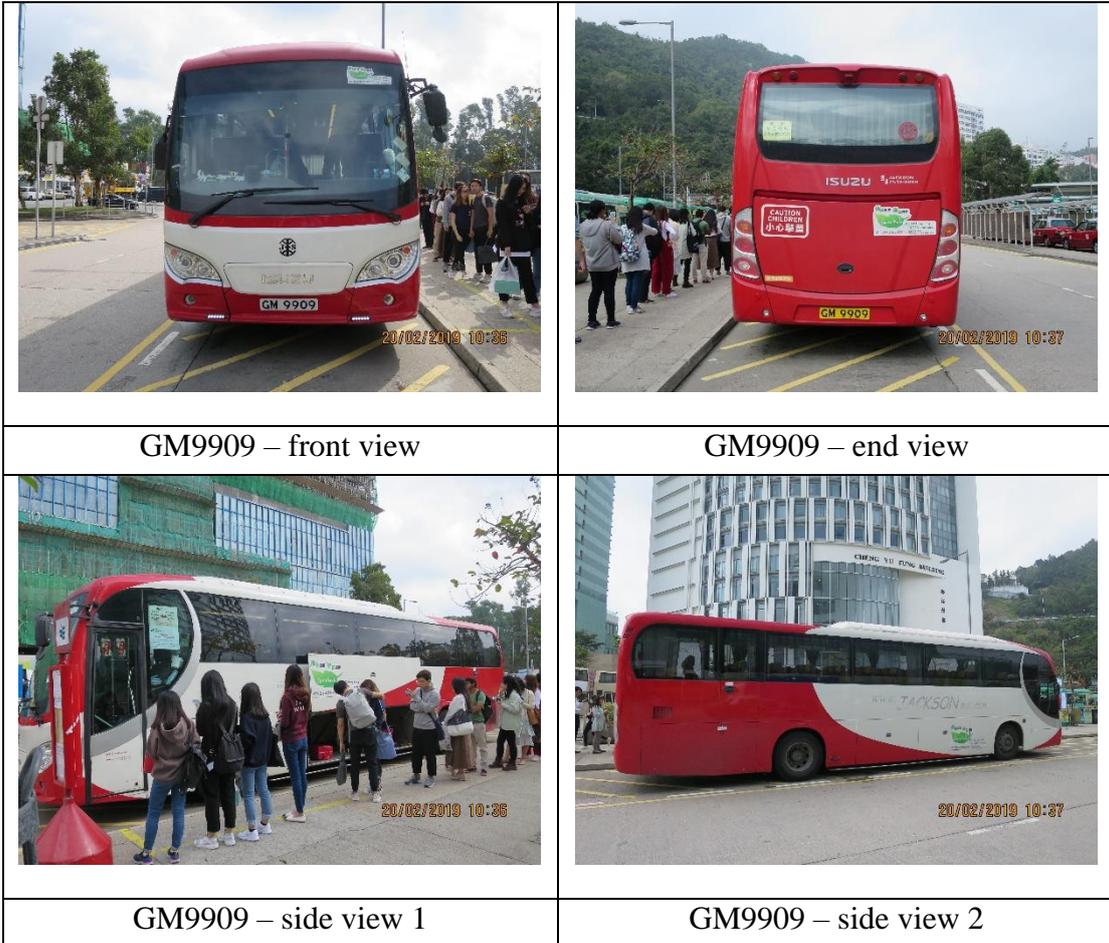
| | |
|---------------------------------|--|
| CAS : | 1 set conventional air conditioner |
| Model : | TCH12U (provided upon purchase of the CAV) |
| Total cooling capacity : | 38.28 kW |
| Wight of CAS : | 243 kg |

(b) CAV

| | |
|-------------------------------|------------------------|
| Registration mark : | KH5755 |
| Make : | Isuzu |
| Model : | LT134P-6S-V |
| Class : | Public bus |
| Gross vehicle weight : | 14,500 kg |
| Seating capacity : | driver + 60 passengers |
| Cylinder capacity : | 7,790 cc |
| Year of manufacture : | 2012 |

Appendix 2: Photos of Vehicles

1. IAV installed with IAS



2. CAV installed with CAS





KH5755 – side view 1



KH5755 – side view 2