

# **Pilot Green Transport Fund**

## **Interim Report On Trial of Electric Inverter Air-conditioning System (IAS) for School Bus (Jackson Coach Hire Service Limited)**

(6 May 2019)

PREPARED BY:

Ir. Dr. C. Ng

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

## **List of Monitoring and Evaluation Team Members**

**Dr. C.S. Cheung (Team Leader)**

Professor

Department of Mechanical Engineering

The Hong Kong Polytechnic University

**Dr. W.T. Hung (Deputy Team Leader)**

PolyU Technology and Consultancy Company Limited

The Hong Kong Polytechnic University

**Ir. Dr. C. NG**

Senior Technical Officer

Department of Mechanical Engineering

The Hong Kong Polytechnic University

**Pilot Green Transport Fund**  
**Trial of Electric Inverter Air-conditioning System (IAS) for School Bus**  
**(Jackson Coach Hire Service Limited)**

**Interim Report**  
**(Pair 1 Trial Period: 1st Sep, 2016 – 28th Feb, 2017)**  
**(Pair 2 Trial Period: 1st Feb, 2017 – 31st Jul, 2017)**

## **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, contributing to better air quality and public health for Hong Kong. Jackson Coach Hire Service Limited (JCHS) was approved under the Fund for trial of installing two units of electric Inverter Air-Conditioner system (IAS) on two single-deck buses (coaches). Through a tendering procedure stipulated in the Subsidy Agreement (the Agreement), JCHS appointed Tai Chang China Motor Green Power Limited to manufacture and install two IAS with model TCD08Z-II on two new diesel coaches (IAVs) for trial.

1.2 PolyU Technology and Consultancy Company Limited (PolyU) have 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 vehicles. JCHS assigned an Isuzu diesel coach and a Daewoo diesel coach (CAVs) both installed with conventional air-conditioning system (CAS) as IAVs' conventional counterparts for comparison in this trial.

1.3 This Interim Report summarizes the performance of the IAVs in the first six months of the trial as compared with their conventional counterparts.

### **2. Trial Vehicles**

2.1 Key features of the IAS, CAS, IAVs and CAVs are in Appendix 1 while photos of vehicles are in Appendix 2. IAV1 was used mainly for providing school bus service for staffs and students of the Chinese University of Hong Kong (CUHK) and schools in Hong Kong Island East; while CAV1, IAV2 and CAV2 were used mainly for providing school bus service for staffs and students of the schools in Hong Kong Island East. In the first 6 months of the trial, daily average traveled mileage for providing such services are around 146 km and 93 km for the IAV1 and IAV2, respectively.

2.2 According to the IAS' manufacturer, the IAS comprises an electric- driven compressor and 4 electric battery packs with an inverter connected. The compressor of IAS is 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 maximum cooling capacity of the IAS is 36kW. The total weight of the IAS is around 690 kg, while the weight of the CAS with model number TCH12U is 243kg, with cooling capacity of 38.28kW.

### 3. Trial Information

3.1 Pair 1 trial (IAV1 and CAV1) commenced on 1 September 2016 and pair 2 trial (IAV2 and CAV2) commenced on 1 February 2017. Both trials would last for 24 months. JCHS is required to collect and provide trial information including the IAVs' operation data, cost and downtime associated with scheduled and unscheduled maintenance of the IAVs. Similar data from the CAVs were also required. In addition to the cost information, operational difficulties and opinions of the drivers were collected to reflect any problems of the IAVs.

### 4. Findings of Trial

4.1 Table 1 summarizes the statistical data of the IAVs and CAVs in the first 6 months of the trial.

Table 1: Key operation statistics of each vehicle (September 2016 – February 2017 for IAV1 and CAV1 and February 2017 – July 2017 for IAV2 and CAV2)

	IAV		CAV	
	IAV1	IAV2	CAV1	CAV2
Fuel cost (HK\$)	111,371.3	66,905.7	50,318.7	60,435.9
Maintenance cost (HK\$) <sup>[1]</sup>	0	0	0	0
Total operating cost (HK\$) <sup>[2]</sup>	111,371.3	66,905.7	50,318.7	60,435.9
Total traveled mileage (km)	26,489	16,986	11,149	9,971
Average fuel cost (HK\$/km)	4.20	3.94	4.51	6.06
Average total operating cost (HK\$/km)	4.20	3.94	4.51	6.06
Downtime (working day) <sup>[3]</sup>	0	0	0	0

<sup>[1]</sup> In the first 6-month trial, there was no maintenance required for IAVs or CAVs.

<sup>[2]</sup> The market fuel price was used for calculation.

<sup>[3]</sup> 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 costs of the IAV1 and IAV2 were lower than those of CAV1 and CAV2 by HK\$0.31/km (i.e., about 7%) and HK\$2.12/km (i.e., about 35%), respectively. As there were no maintenance required for IAVs or CAVs in the first 6-month trial, the average total operating costs of IAV1 and IAV2 were same as their average fuel costs which were HK\$0.31/km (i.e., about 7%) and HK\$2.12/km (i.e., about 35%) lower than that of CAV1 and CAV2, respectively.

4.3 Since there were no downtime for the IAVs and CAVs, utilization rates of four vehicles were 100%.

## 5. Summary

5.1 During the first 6-month trial, the operation data collected showed that IAV1 and IAV2 had lower fuel cost than the corresponding CAV1 and CAV2, with the average fuel cost savings of HK\$0.31/km (i.e., about 7%) and HK\$2.12/km (i.e., about 35%), respectively. As there were no maintenance required for both IAVs and CAVs in the first six months of the trial, the total operating costs of the IAVs were same as their average fuel costs, so do the CAVs. Also, these two kinds of costs of the IAV1 and IAV2 were HK\$0.31/km (i.e., about 7%) and HK\$2.12/km (i.e., about 35%) lower than those of CAV1 and CAV2, respectively. The utilization rates of all vehicles were 100%.

5.2 The drivers had no problem in operating the IAVs, but opined its climbing uphill performance is poorer than that of the CAV, which is possibly due to the additional weight of the battery packs and IAC components. When the IAV is fully occupied and goes uphill, the problem is more obvious.

5.3 Fuel saving of IAV1 was much less than that of IAV2. There are three possible reasons causing a higher fuel consumption of IAV1: (i) IAV1's driving speed was low on CUHK campus; (ii) frequent acceleration and deceleration of IAV1 when providing shuttle bus service on CUHK campus; (iii) all coaches are Isuzu except CAV2 which is Daewoo, a much better fuel efficiency of IAV2 in pair 2 could be owing to the abnormally high fuel consumption of CAV2.

5.4 The findings of this Interim Report only reflect the performance of the IAVs in the first six months of the trial. More time is needed to test the performance and reliability of the IAVs.

## Appendix 1: Key Features of the Vehicles and IAS/CAS Involved in the Trial

### 1. Diesel Vehicles (IAVs) Installed with Trial Electric Inverter Air-conditioning System (IAS)

#### (a) Trial Electric IAS

Number of IAC :	2 sets
Model :	TCD08Z-II
Make :	Tai Chang China Motor Green Power Limited
Number of battery :	4 battery packs for 2 sets IAC
Total cooling capacity :	36 kW
IAC weight :	450 kg for 2 sets IAC
Battery packs weight :	240 kg

#### (b) IAVs

<b>Registration mark:</b>	<b>CR765 / CH3278</b>
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 Vehicles (CAVs) Installed with Conventional Air-conditioning Systems (CAS) Used for Comparison

#### (a) CAS

Number of CAS:	1
Model	TCH12U (provided upon purchase of the CAV)
Total cooling capacity	38.28kW

#### (b) CAVs

	<b>CAV1</b>	<b>CAV2</b>
<b>Registration mark:</b>	<b>TA8220</b>	<b>SZ8009</b>
Make:	Isuzu	DAEWOO
Model:	LT134P-6S-V	BH117L
Class:	Public bus	Public bus
Gross vehicle weight:	14,500 kg	16,000 kg
Seating capacity:	driver + 65 passengers	driver + 65 passengers
Cylinder capacity:	7,790 cc	7,640 cc
Year of manufacture:	2013	2014

## Appendix 2: Photos of Vehicles

### 1. IAV installed with IAS

#### IAV1



#### IAV2





CH3278 – side view 1



CH3278 – side view 2

## 2. CAV installed with CAS

### CAV1



TA8220 – front view



TA8220 – rear view



TA8220 – side view 1



TA8220 – side view 2

CAV2



SZ8009 – front view



SZ8009 – rear view



SZ8009 – side view 1



SZ8009 – side view 2