

Pilot Green Transport Fund

Final Report On Trial of Single-deck Electric Buses for Residents' Service in Discovery Bay (Discovery Bay Transit Services 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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Trial of Single-deck Electric Buses for Residents' Service in Discovery Bay
(Discovery Bay Transit Service Limited)

Final Report
(Trial Period: 1 January 2015 – 31 December 2016)

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. Discovery Bay Transit Services Limited (DBTSL) was approved under the Fund for trial of two single-deck electric buses (EVs) for residents' service in Discovery Bay, Lantau Island.

1.2 The Hong Kong Institute of Vocational Education (Tsing Yi) has been engaged by the Environmental Protection Department as an independent third-party assessor to monitor the trial and evaluate the performance of the EVs. DBTSL assigned two single-deck diesel buses (DVs) providing the same service in Discovery Bay as the conventional vehicles for comparing with the EVs.

1.3 This Final report summarizes the performance of the EVs in the 24 months of the trial as compared with their conventional counterparts.

2. Trial and Conventional Vehicles

2.1 Through the tendering procedures stipulated in the Subsidy Agreement, DBTSL procured two Shandong Yixing Feiyan single-deck electric buses (EVs: EV-1 and EV-2) which have a gross vehicle weight (GVW) of 17,500 kg and 150 kW rated power, for the trial. The EVs were used to provide residents' service in Discovery Bay.

2.2 Two Alexander Dennis Enviro single-deck diesel buses (DVs: DV-1 and DV-2) with GVW of 12,960 kg were assigned for comparison with the EVs in this trial. The DVs were also used to provide residents' service in Discovery Bay.

2.3 Key features of the EVs, DVs and the charging facilities are shown in Appendix 1 and their photos are shown in Appendix 2.

3. Trial Information

3.1 The trial started on 1 January 2015 and lasted for 24 months. DBTSL was required to collect and provide trial information including the EVs' mileage reading at recharging, date of recharging and recharge amount, costs and operation downtime associated with scheduled and unscheduled maintenance of the EVs. Similar monthly data from the DVs were also required. In addition to the cost information, reports on maintenance work, operational difficulties and opinions of the drivers and DBTSL were collected to reflect any problems of the EVs. The service hours of the EVs and DVs were from 05:30 to 24:00 on Monday to Sunday.

4. Findings of Trial

4.1 Table 1 summarises the key operation statistics of the EVs and DVs. The fleet average fuel cost of the EVs was HK\$4.77/km (74%) lower than that of the DVs while the fleet average total operating costs of the EVs were HK\$4.79/km (74 %) than that of the DVs.

Table 1: Key operation statistics of each vehicle (January 2015 – December 2016)

		EV-1	EV-2	DV-1	DV-2
Total mileage (km)		16,876	23,159	94,818	93,717
Average fuel economy	(km/kWh)	0.65	0.73	-	-
	(km/litre)	-	-	1.62	1.74
	(km/MJ)	0.18	0.20	0.04 ^[5]	0.05 ^[5]
Average fuel cost (HK\$) ^[1]		1.76	1.55	6.66	6.20
Fleet average fuel cost (HK\$/km) ^[1]		1.66		6.43	
Average total operating cost (HK\$/km) ^{[3][4]}		1.76	1.55	6.66	6.24
Fleet average total operating cost (HK\$/km) ^{[3][4]}		1.66		6.45	
Downtime (working day) ^{[2][3]}		437	304	13	8

[1] The market rates were adopted for calculation.

[2] Downtime refers to the equivalent number of working days in which the vehicle is not in operation due to charging, and the period 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] Maintenance due to incident unrelated to the performance of the vehicle was not included for comparison.

[4] Both the EVs and DVs were under warranty.

[5] Assuming lower heating value of 36.13 MJ/litre for diesel fuel.

4.2 During the trial period, the EVs and DVs had no scheduled maintenance. There were 34, 44, 19 and 13 unscheduled maintenances for EV-1, EV-2, DV-1 and DV-2 respectively. It led to 437, 304, 13 and 8 days of operation downtime for EV-1, EV-2, DV-1 and DV-2 respectively. The utilization rates of the EV-1, EV-2, DV-1 and DV-2 were 40%, 58%, 98% and 99% respectively. On the other hand, no maintenance was reported for the charging facilities.

4.3 DBTSL did not have designated drivers for the EVs. Overall, the drivers adapted to the differences in the EVs' operation and did not have much difficulty in operating the EVs. The passengers expressed that the EVs were quieter and more environment-friendly than the DVs, and supported replacing DVs by greener and cleaner EVs.

4.4 However, DBTSL was very dissatisfied with the performance of the EVs as too much time was wasted to deal with frequent breakdowns & unscheduled maintenances. For example, the performance of batteries, air-conditioning system and air compressor were unstable and poor. After the first year of the trial, both of the EVs suffered from frequent breakdowns and eventually were hard to support DBTSL's daily operations. DBTSL opined that the EVs could not meet its daily operational requirements.

4.5 To eliminate the effect of seasonal fluctuations, 12-month moving averages were used to evaluate the trend of the EVs' fuel economies. The fuel economy varied for EV-1 from 0.58 to 0.66 km/kWh and for EV-2 from 0.68 to 0.74 km/kWh (i.e. 12% and 8% variation respectively). The average fuel economy did not vary significantly for either EV during non-breakdown/maintenance period. However, the EV-2 batteries had deteriorated to a level that made it hard to function properly at the end of the second year, which was further confirmed in the massive breakdown and maintenance records provided by DBTSL in the third year.

4.6 The carbon dioxide equivalent (CO_{2e}) emission from EV-1 was 14,077 kg and from EV-2 was 17,028 kg while that from DV-1 was 27,461 kg and from DV-2 was 35,109 kg. Compared with the DVs, there was a reduction for EV-1 of 13,384 kg (49%) CO_{2e} emission and a reduction for EV-2 of 18,081 kg (51%) CO_{2e} emission. Overall, there was a reduction of 31,465 kg (50%) CO_{2e} emission by using the EVs in the trial.

5. Summary

5.1 The drivers did not have much difficulty in operating the vehicles. The passengers felt that the EVs were quieter and more environment-friendly than the DVs, and supported replacing DVs by EVs.

5.2 However, DBTSL was very dissatisfied with the performance of the EVs as too much time was wasted to deal with frequent breakdowns and unscheduled maintenances. After the first year of the trial, both EVs suffered from frequent breakdowns and eventually were hard to support normal daily operations. DBTSL opined that the EVs could not meet its daily operational requirements.

5.3 The utilization rates of EV-1, EV-2, DV-1 and DV-2 were 40%, 58%, 98% and 99% respectively. The usage of the EVs was on the low side as reflected by the difference in the total mileages between the EVs (16,876 km and 23,159 km, i.e. 23 & 32 km on average per working day) and the DVs (94,818 km and 93,717 km, i.e. 130 and 128 km on average per working day) in the trial. During the trial period, the variation in the fuel economies of the EVs was not significant during non-breakdown/maintenance period. However, the EV-2 batteries had deteriorated to a level that made it hard to function properly at the end of the second year, which was further confirmed in the massive breakdown and maintenance records provided by DBTSL in the third year.

5.4 The fleet average fuel cost of the EVs was HK\$4.77/km (74%) lower than that of the DVs. Taking into account the maintenance costs, the average total operating cost of the EVs was HK\$4.79/km (74%) lower than that of the DVs. The total CO_{2e} emission from the EVs was 31,465 kg (50%) lower than that from the DVs during the trial period.

Appendix 1: Key Features of Vehicles and Charging Facilities

1. Trial EVs

Registration Mark	TA3408 (EV-1) & TA4407 (EV-2)
Make:	Shandong Yixing Elect. Auto Ltd.
Model:	Feiyan
Class:	Public Bus
Gross vehicle weight:	17,500 kg
Seating capacity:	Driver + 26 passengers
Standing Capacity	31 passengers
Rated power:	150 kW
Travel range:	250 km (air-conditioning on and fully loaded)
Maximum speed:	70 km/h
Battery Type:	Lithium ion phosphate
Batteries capacity:	360 kWh
Charging time:	8 hours (Max. current 16A)
Year of manufacture:	2013

2. EV charging facilities

Charging Standard:	IEC62196
Charging Mode:	Single Phase 16A

3. DVs for comparison

Registration Mark	SP8992 (DV-1) & SP9663 (DV-2)
Make:	Alexander Dennis
Model:	Enviro 200 Dart4
Class:	Public Bus
Seating capacity:	Driver + 27 passengers
Standing Capacity	32 passengers
Gross vehicle weight:	12,960 kg
Year of manufacture:	2013

Appendix 2: Photos of Vehicles and Charging Facilities

1. EV-1



Front view of EV-1



Rear view of EV-1



Left side view of EV-1



Right side view of EV-1

2. EV-2



Front view of EV-2



Rear view of EV-2



Left side view of EV-2



Right side view of EV-2

3. EV Charging Facilities



Charging Station A for EVs







Charging Station B for EVs



Rectifier of the Charging Facility

4. DV-1 for comparison

 A front-facing view of a white and purple bus. The front features a large windshield, a purple grille, and the text "DBAY 27" and "SP 8992" on the bumper.	 A rear-facing view of the bus. The back features a large rear window, a purple bumper, and the text "ENVIRO 200", "DbAY", "DBAY 27", and "SP 8992". A timestamp "23/05/2017 00:00" is visible in the bottom right corner.
<p>Front view of DV-1</p>	<p>Rear view of DV-1</p>
 A side profile view of the bus from the left. The side features large windows and the "DbAY" logo on the lower part of the body.	 A side profile view of the bus from the right. The side features large windows and the "DbAY" logo on the lower part of the body. A timestamp "23/05/2017 18:08" is visible in the bottom right corner.
<p>Left side view of DV-1</p>	<p>Right side view of DV-1</p>

5. DV-2 for comparison



Front view of DV-2



Rear view of DV-2



Left side view of DV-2



Right side view of DV-2