

Pilot Green Transport Fund

Final Report On Trial of Electric Vans for Servicing Passenger Transport Industry (Kwoon Chung Motors)

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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 Vans for Servicing Passenger Transport Industry
(Kwoon Chung Motors)**

**Final Report
(Trial Period: 1 April, 2013 – 31 March, 2015)**

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. Kwoon Chung Motors Company Ltd (Kwoon Chung) was approved under the Fund for trial of two electric van-type light goods vehicles for servicing passenger transport industry. Through the tendering procedures stipulated in the Subsidy Agreement Kwoon Chung entered into with the Government, Kwoon Chung procured two Micro-Vett Electric Doblo light goods vehicles (EVs) for trial.

1.2 PolyU Technology and Consultancy Company Limited (PolyU) has been engaged by the Environmental Protection Department as an independent third party assessor to monitor the trial and evaluate the performance of the trial vehicles. Two diesel vehicles (DVs) providing similar services were assigned as the conventional vehicles for comparing with the two EVs.

1.3 This report summarizes the performance of the EVs in the 24-month trial as compared with their conventional diesel counterparts.

2. Trial Vehicles

2.1 Key features of the EVs and DVs are in Appendix 1 and photos of the vehicles are in Appendix 2. They are referred to as EV-1, EV-2, DV-1 and DV-2 in this report. These vehicles were used to provide patrol and mobile repair services to Kwoon Chung's passenger transport fleets. Each EV is designed to carry 425 kg payload. According to the manufacturer, the EV has a travel range of 190 km with its battery fully charged and air-conditioning off.

2.2 EV-1 and DV-1 were parked at public car parks in Tin Shui Wai (TSW) at night and were driven mostly along highways to Kwoon Chung's Siu Ho Wan (SHW) depot every morning. They served Tung Chung, Hong Kong International Airport and Tsing Yi. EV-2 and DV-2 were parked at Kwoon Chung's TSW depot and served Yuen Long, TSW and Tuen Mun areas.

2.3 At SHW depot, EV-1 took over the functions that were previously provided by DV-1 which has been redeployed elsewhere. At SHW, Kwoon Chung did not have any other conventional vehicle of the same class of EV-1 for comparison. As Kwoon Chung has maintained the record of DV-1 on maintenance from its first registration day (May 2009) to June 2012 and on fuel consumption from April 2011 to January 2013, relevant extract from such data was used to compare with the data collected from the EV-1 trial.

2.4 Kwoon Chung has set up a 16-ampere outlet with electricity consumption meter at each of the two depots to charge the batteries of the EVs. It takes about 6 hours to charge the batteries from 0 to 100%. The EVs were only charged at their respective depots. The driver of EV-1 charged the vehicle almost daily, normally in the afternoon for a few hours. EV-2 was charged once every 2 or 3 days from 18:00 to the next morning, around 14 hours each time. Occasionally, it was charged twice a day when it needed to travel longer distances. Photos of the charging facilities are in Appendix 2.

3. Trial Information

3.1 The trial started on 1 April 2013 and lasted for 24 months. Kwoon Chung was required to collect and provide trial information including the EV mileage reading before charging, amount of electricity consumed and time used in each charging, operation downtime due to charging, and cost and downtime associated with scheduled and unscheduled maintenance of the EVs and the charging facilities. Similar 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 Kwoon Chung were collected to reflect any problems of the EVs.

4. Findings of Trial

4.1 Operating Costs

4.1.1 Table 1 below summarizes the fuel cost data of the EVs and DVs. The fuel cost savings were as follows: EV-1 \$0.503/km (62%) lower than DV-1; and EV-2 \$0.482/km (58%) lower than DV-2.

Table 1: Average fuel economy and average fuel cost of each vehicle

		Electric vans		Diesel vans	
		EV-1	EV-2	DV-1 (historical)	DV-2
Total distance travelled / km		47,700	34,919	44,917 ^[1]	25,792
Average fuel economy/	(km/kWh)	3.88	3.34		
	(km/litre)			15.2	14.7
	(km/MJ)	1.08	0.928	0.421 ^[2]	0.408 ^[2]
Average fuel cost /(\$/km)		0.306	0.354	0.809	0.836

[1] Total distance traveled by DV-1 from 6 April 2011 to 24 December 2012

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

4.1.2 Table 2 below summarizes the total operating cost data of the EVs and the DVs. During the trial period, EV-1 had one scheduled maintenance and four unscheduled maintenance, with 59 days of downtime. EV-2 also had one scheduled maintenance and four unscheduled maintenance, with 113 days of downtime. For DV-1, the historical record showed two scheduled maintenance with 13 days of downtime and one unscheduled maintenance with unknown downtime. For DV-2, there was no reported maintenance during the trial period. Utilization rates of EV-1 and EV-2 were 92% and 85% compared with nearly 100% for both DVs.

4.1.3 EV-1 was immobilized while travelling along the highway outside SHW depot on 26 May 2013 and again on 1 October 2013 while travelling from TSW to SHW. The EV was towed to its supplier for repair in both occasions. The local service agent had to spent long time to convince the EV user that there was no problem with the EV after the repair, leading to the very long downtime. In the other two cases, one occurred in February 2014 and the other occurred in May 2014, the EV could not be charged and the EV was returned to the vehicle supplier for repair.

4.1.4 EV-2 had problem with the charging cable in June 2014. The EV was not in use while waiting for the replacement of the charging cable. It took very long time to wait for the charging cable replacement and hence there was a very long downtime associated with this incident. Starting from January 2015, EV-2 had problems with the starting and braking system. It failed to start occasionally and the braking power was weak. The EV was returned to the local service agent for repair. The EV was not in use in the last two months of the trial period, leading to a downtime of 58 days. Two other cases occurred in October 2014. In one case, the EV failed to operate due to failure of the 12V battery. The other case involved repair of the air conditioning system.

4.1.5 Scheduled maintenance of EVs was simpler than the DVs since the DVs required replacement of filters and engine oil and passing the smoke test, all of which were not required for the EVs. Reviewing the unscheduled maintenance history of the EVs, if the problems were handled promptly, the downtime could be reduced significantly. Since the problems occurring to each EV are not the same, they could be due to the quality problem of the individual vehicle instead of design defect or limitation of the technology.

4.1.6 Apart from the fuel costs, the table also shows the average total operating costs which include maintenance costs and other indirect costs such as towing fee, vehicle replacement fee. The EVs and the DVs incurred only fuel and maintenance costs in this trial. The average total operating cost is \$0.387/km for the EVs and \$0.93/km for the DVs. As compared with the DVs, the average total operating cost for the EVs was lower by 58%, given that Kwoon Chung did not pay for the repair under the vehicle warranty.

Table 2: Average total operating cost and downtime of each vehicle

		EV-1	EV-2	DV-1	DV-2
Total operating cost/\$		17,069	14,901	36,352 ^[1]	21,567
Average total operating cost/(\$/km)		0.358	0.427	0.985	0.836
Downtime/day ^[2]		59	113	13	0
By vehicle type	average total operating cost/(\$/km)	0.387		0.930	
	average downtime/day	86		6.5	

[1] Total fuel cost for DV-1 from 6 April 2011 to 24 December 2012.

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

4.2 Performance and Reliability

4.2.1 The driver of EV-1 found no problem in operating EV-1 and was satisfied with its performance. However, the drivers of EV-2 were not satisfied that EV-2 could not hold its position automatically during hill start, even on gentle slopes.

4.2.2 Overall, Kwoon Chung agreed that using electric vehicle is good because it can provide a greener and quiet environment as well as its much lower fuel cost. However, they would not recommend replacing all existing conventional vehicles with the green vehicles because (a) the price is too expensive, (b) the battery life is still an uncertainty, (c) only a few models are currently available to choose from, (d) driving range is rather short for commercial use, and (e) it is not easier and cheaper to maintain the EV.

4.2.3 To remove the effect of seasonal fluctuations, 12-month moving averages are used to evaluate the trend of the EVs' fuel economy. The results show a narrow variation from 3.75 km/kWh to 3.99 km/kWh for EV-1 and from 3.33 km/kWh to 3.43 km/kWh for EV-2. In both cases, there is no indication of fuel economy deterioration during the trial period.

4.2.4 The charge could reach the rated value even in the last few months of the trial. There is no indication that the battery has deteriorated resulting in lower charge amount.

5. Summary

5.1 The trial showed that both EV-1 and EV-2 had lower fuel cost as compared with their conventional diesel counterparts, with saving of \$0.503/km (62%) and \$0.482/km (58%) respectively. The total operating cost for EV-1 and EV-2 were 65% and 49% lower than DV-1 and DV-2 respectively, given that Kwoon Chung did not pay for the repair of the EVs which were still under warranty.

5.2 The EV drivers found no problem in operating the EVs. Each EV involved four unscheduled maintenance that needed repair by the local service agent. The breakdowns were related mainly to the braking system and the starting system, which could be due to the quality problem of individual vehicle instead of the design of the EV. Moreover, there was insufficient technical support from the local service agent and both EVs took excessively long time to repair. As a result, utilization rates of EV-1 and EV-2 were 92% and 85% respectively.

5.3 The average fuel economy of all vehicles involved hardly changed during the trial. For the EVs, the stable fuel economy did not indicate deterioration of the batteries.

5.4 The vehicle manufacturer should provide better technical support to the EVs to avoid excessive downtime for repair and maintenance.

Appendix 1: Key Features of the Vehicles Involved in the Trial

1. Trial EV

Registration Mark:	RY7284 & RY8213
Make:	Micro-Vett
Model:	Electric Doblo
Class:	Light goods vehicle
Gross vehicle weight:	2,510 kg
Seating capacity:	driver + 4 passengers
Rated power:	40 kW
Travel range:	190 km (air-conditioning off)
Maximum speed:	110 km/h
Battery material:	lithium polymer
Battery capacity:	44.4 kWh
Charging time:	slow charge, 9kW, 100% full, approx. 7 hours quick charge, CHAdeMO 1.5C, 80% full, approx. 40 minutes
Payload:	about 425 kg

2. DVs used for comparison

Registration Mark:	DU1734 & NV2639
Make:	Fiat
Model:	Doblo 1.9 Multijet 105
Class:	Light goods vehicles
Gross vehicle weight:	2,010 kg
Payload:	about 600 kg
Seating Capacity:	driver + 4 passengers
Cylinder capacity:	1,910 cc
Year of manufacture:	2009

Appendix 2: Photos of Vehicles and Charging Facilities

1. Trial Electric Vans and charging facilities

 <p>10/05/2013 11:52</p>	 <p>10/05/2013 11:52</p>
<p>EV-1 – front view</p>	<p>EV-1 – end view</p>
 <p>10/05/2013 11:52</p>	 <p>10/05/2013 11:54</p>
<p>EV-1 – side view 1</p>	<p>EV-1 – side view 2</p>
 <p>10/05/2013 11:55</p>	 <p>28/03/2013 11:24</p>
<p>EV-1 – odometer</p>	<p>EV-1 – Charging station at SHW depot</p>



EV-2 – front view



EV-2 –end view



EV-2 – side view 1



EV-2 – side view 2



EV-2 – odometer



EV-2 – Charging station at TSW depot

2. Diesel Vehicles for comparison



DV-1 – front view



DV-1 – end view



DV-2 – front view



DV-2 – end view