

Pilot Green Transport Fund

Interim Report

On

Trial of Diesel-Electric Propulsion System for Ferry II
(The “Star” Ferry 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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(Reporting Period: 1 June 2020 – 31 May 2021)**

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. The “Star” Ferry Company, Limited (Star Ferry) was approved under the Fund for trial of one diesel-electric propulsion (DEP) system by retrofitting it to an existing ferry (Morning Star). The DEP system replaced the ferry’s original diesel engine. The DEP system was expected to mainly lower the air pollutants emissions of the ferry. Through the tendering procedures stipulated in the Subsidy Agreement entered into with the Government, Star Ferry appointed Leung Wan Kee Shipyard to retrofit the DEP system on Morning Star (hereafter called DEP ferry) for trial.

1.2 Star Ferry assigned a conventional ferry, Northern Star, providing the same service as the DEP ferry as the conventional counterpart for comparing with the DEP ferry. Northern Star is referred to as conventional ferry in this report.

1.3 PolyU Technology and Consultancy Company Limited has been engaged by the Environmental Protection Department as an independent third party assessor to monitor the trial and evaluate the performance of the green innovative technology under trial as compared with its conventional counterpart.

1.4 This report summarizes the performance of the DEP ferry in the first twelve months of the trial and compares it with the performance of the conventional ferry.

2. Trial Ferry and Conventional Ferry

2.1 The DEP system includes two 275 kW Caterpillar diesel generators, two frequency inverters and two 350 kW electric motors and the associated control equipment. The two 275 kW generators meet International Maritime Organization (IMO) Tier II and United States Environmental Protection Agency (USEPA) Tier III emission standards. One diesel generator is used to power the electric motors to propel the ferry. Another diesel generator is for stand-by purpose as required by Marine Department for safety reason. The two frequency inverters are used to control the operation of the electric motors. The DEP system replaced the ferry’s original 357 kW pre-1990 diesel engine.

2.2 Key features of the DEP system, the DEP ferry and the conventional ferry are in Appendix 1, and photos of the DEP system, the DEP ferry and the conventional ferry are in Appendix 2. The DEP ferry provides round trip service from Tsim Sha Tsui Pier to Wan Chai Pier or Central Pier.

3. Trial Information

3.1 The trial started on 1 June 2020 and will last for 24 months. Star Ferry was required to collect and provide trial information including the DEP ferry operation data and maintenance records. DEP ferry operation data include passenger carried, operating hours, amount and cost of diesel fuel consumed. Maintenance records include cost and downtime associated with scheduled and unscheduled maintenances of the DEP ferry related to the performance of the DEP system. Similar data were also required from the conventional ferry. In addition to the cost information, reports on maintenance work, operational difficulties and opinions of the captains of the DEP ferry, passengers and Star Ferry were collected to reflect any problems of the DEP ferry.

3.2 Since the Government tightened the statutory fuel sulphur content from 0.5% to 0.05% in 2014, the sulphur dioxide (SO₂) emission in the exhaust gas has dropped significantly and the DEP system's contribution to the SO₂ emission reduction has been small. Hence, the DEP system is mainly used to reduce the emissions of nitrogen oxides (NO_x) and particulates (PM). The exhaust emissions had been measured before Morning Star was retrofitted with the DEP system and measured again in the first month of trial (June 2020) and then in the 12th month of trial (June/July 2021). The exhaust emissions measured mainly included the concentrations of NO_x and PM, as well as smoke opacity. Meanwhile, concentrations of carbon monoxide (CO) and hydrocarbons (HC) were also measured in this trial for reference. Star Ferry commissioned an expert team of The University of Hong Kong (HKU) as their contractor to conduct the aforesaid emission measurements.

4. Findings of Trial

4.1 The trial was considered to be in a preliminary trial stage for the months of June 2020 to August 2020 as Star Ferry was familiarizing/testing the performance and characteristics of the engine and the ferry though it started providing services. Since the DEP ferry was on trial runs, it was not operated every day and the operating hours varied from 2 to 13 hours and the data collected were not representative. The DEP ferry resumed to normal operation from September 2020 onwards and the evaluation was therefore taken from September 2020 onwards.

4.2 Table 1 summarizes the statistical data of the DEP ferry and the conventional ferry from 1 September 2020 to 31 May 2021. The average fuel cost of the DEP ferry was HK\$2 per hour (i.e., 0.3%) lower than that of the conventional ferry. The average total operating cost of the DEP ferry was HK\$191 per hour (i.e., 21%) lower than that of the conventional ferry.

Table 1: Key operation statistics of ferry (1 September 2020 – 31 May 2021) ^[1]

	DEP Ferry	Conventional Ferry
Total time travelled (hour)	2,693	2,726
Average fuel consumption (litre per hour)	33.5	33.9
Average fuel cost (HK\$/hour) ^[2]	654.2	656.2
Average total operating cost (HK\$/hour)	730	921
Downtime (no. of working day) ^[3]	32.5	49.5

^[1] As June 2020 – August 2020 were in preliminary trial stage and the data of the DEP ferry were not representative, therefore, the evaluation was taken from September 2020 to May 2021.

^[2] Based on the listed price

^[3] Downtime refers to the working days the ferry was not in normal operation, which is counted from the first day it stopped normal operation till the day it resumed normal operation.

4.3 In the period of 1 September 2020 to 31 May 2021, the DEP ferry had 4 scheduled maintenances and 8 unscheduled maintenances with a total of 32.5 days of downtime, while the conventional ferry had 3 scheduled maintenances and 13 unscheduled maintenances with a total of 49.5 days of downtime. The utilization rates were 88.1% for the DEP ferry and 81.9% for the conventional ferry.

4.4 Three captains were interviewed for performance of the DEP ferry in the period of September 2020 to May 2021. They had different opinions on the operation of the DEP ferry. Two of them did not have problem in operating the DEP ferry and were satisfactory with its performance. Another one had problem in operating the DEP ferry (sometime may trip when using one DEP engine) and hence did not like driving the DEP ferry although he has been operating the DEP ferry for about a year. As advised by Star Ferry, the DEP ferry was operated normally with two engines from September 2021 onwards. In addition, two of them reflected that the DEP ferry was noisy compared with the conventional ferry. Star Ferry agreed that the DEP ferry could help improve the air quality but had reservation in retrofitting the diesel engines of all existing conventional ferries with the DEP systems because it would not help reduce fuel cost and it might not be easier to maintain. The passengers' feedback was in general positive, feeling that it is cleaner and quieter, and support retrofitting the existing ferries with the DEP system.

4.5 In the beginning of the trial, the ferry has trouble in operating with one engine. At high engine load and during manoeuvring operations, the frequency inverter alarm might be actuated causing tripping to the frequency inverter(s) and the motor(s). Such conditions rarely happen when operating with two engines. Hence, the DEP ferry was operated normally with two engines from September 2021 onwards.

5. Reduction of Air Pollutants Emissions

5.1 The DEP system is mainly used to reduce the emissions of NO_x and PM compared to the old engine. The emissions were measured in March and April 2019 for the original ferry (i.e., before retrofit). The emissions were measured again in June 2020 for the DEP ferry (i.e., after retrofit) and also in June/July 2021 which was about 12 months after the retrofit. The measurement results obtained in June/July 2021 were similar to those obtained in June 2020.

5.2 The NO_x emission was reduced by 74% in 12 months after the retrofit.

5.3 The PM emission was reduced by 87% in 12 months after the retrofit while the smoke opacity was reduced by 58%.

5.4 CO and HC emissions were also measured in this trial for reference. About 12 months after the retrofit, the CO and HC emissions were reduced by 38% and 70% respectively.

6. Summary

6.1 The trial was considered to be in a preliminary trial stage in the first three months of the trial (June to August 2020) as Star Ferry was familiarizing/testing the performance and characteristics of the engine and the data collected were not representative. Therefore, the evaluation was taken from September 2020 to May 2021 in this report.

6.2 The average fuel cost and the average total operating cost of the DEP ferry were 0.3% and 21% lower than those of the conventional ferry respectively. The DEP system is mainly used to reduce the emissions of NO_x and PM compared to the old engine. The measurement results obtained in the twelfth month after the retrofit were similar to those obtained in the first month after the retrofit, reflecting that the emission reduction efficiency of the DEP system remained unchanged. The measurement results reflected that the replacement of the old engine with the DEP system reduced the emissions of NO_x and PM by 74% and 87%, respectively and the smoke opacity by 58%, after 12 months of operation. Meanwhile, CO and HC emissions were also measured in this trial for reference. The CO and HC emissions were reduced by 38% and 70% respectively, after 12 months of operation.

6.3 The performance and reliability of the DEP ferry will be continuously monitored in the 24 months of the trial.

Appendix 1: Key Features of the Ferries Involved in the Trial and the Diesel-electric propulsion system

1. Diesel-electric propulsion (DEP) system for DEP ferry

Main Generator Set (two sets)

Maker:	Caterpillar
Model:	C9.3 Marine Generator Set
Rating:	275 kW @1800 rpm
Engine:	6-cylinder in line diesel engine
Emission standard:	EPA Tier 3/IMO II

Auxiliary Generator Set (two sets)

Maker:	Perkins
Model:	1004TGM
Rating:	52 kW @ 1500 rpm

Propulsion Motor (two sets)

Maker:	Dezhou Hengli
Model:	YVF2-4003-6-H
Rating:	350 kW @ 1190 rpm

2. DEP Ferry

Name of vessel:	Morning Star
Type:	Class I Ferry Vessel
Port of Registry	Hong Kong
Length overall:	35.61 meters
Extreme breadth:	8.57 meters
Light Ship Displacement:	235.47 / 250.10 tonnes(without balast / with ballast)
Gross Tonnage:	206 / 164.01 tonnes (after retrofit / before retrofit)
Net Tonnage:	100 / 39.69 tonnes (after retrofit / before retrofit)
Passenger capacity:	399 / 540 people (after retrofit / before retrofit)
Year of manufacture:	1965; retrofitted with DEP in 2020

3. Conventional Ferry for comparison purpose

Name of vessel:	Northern Star
Type:	Class I Ferry Vessel
Length overall:	35.63 meters
Extreme breadth:	8.57 m
Light Ship Displacement:	248.55 tonnes
Gross Tonnage:	164.01 tonnes
Net Tonnage:	39.69 tonnes
Passenger capacity:	547 people
Year of manufacture:	1958
Main engine:	Crossley/6HRN; 340 rpm, 357.33 kW
Generator set:	2*Perkins 1004TGM; 52 kW @ 1500 rpm

Appendix 2: Photos of the Ferries and the Diesel Electric Propulsion System

DEP Ferry and DEP system

	
<p>Front view of DEP Ferry</p>	<p>Side view of DEP Ferry</p>
	
<p>#1 main diesel generator (for propulsion)</p>	<p>#2 main diesel generator (for propulsion)</p>
	
<p>Auxiliary diesel generator</p>	<p>Propulsion motor</p>

Conventional Ferry



Northern Star