

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH  
TECHNICAL VISIT TO “MADE BY HONG KONG” PURE ELECTRIC BUS  
ON 5/12/2015



Hong Kong has always been a market challenging to many bus suppliers in the world. The hilly terrain, frequent start-stop and overloading, air-conditioning (air-con) provision, to name a few, have imposed very stringent demands on the design and engineering of buses operating in the territory. There has been a say in the bus industry that “if your vehicle works well in Hong Kong, it works well anywhere else”, outlining Hong Kong is an ideal ground for demonstrating technical excellence of buses to the markets beyond.

Buses in Hong Kong, which operate about 120 km per day on average, have all been designed by foreign companies to meet the demands and requirements set by the local bus operators. However, it does not equate that Hong Kong is unable to provide its own solution for meeting its own transport needs in the form of passenger-carry vehicle. Championed by the Hong Kong Productivity Council (HKPC), for the first time Hong Kong has delivered its first solution in pure electric form, which prototype vehicle 25 members of Institution of Mechanical Engineers in Hong Kong (IMechE-HKB) were very honoured and privileged to be offered an opportunity to view in the closest distance in the morning of 5<sup>th</sup> December, 2015.

*Background*

It has appeared that for the targeted class of buses, the European vehicle manufacturing companies have invested significantly into the stringent Euro 5 and 6 emission standard-complying diesel power-trains, they would not consider worthwhile investing equally heavily into pure electric technologies for bus applications. As a result, there has been no matured, readily available project offered by the European vehicle manufacturing companies, and so has not been from those in Japan. This has created an opportunity for some technology companies in Hong Kong to serve the local market with a product which would fully meet the requirements, featuring close

bus stop interval as close as average 585 metres and high demand on air-con set at 21 °C with energy consumption as high as over 40 % of total vehicle power consumption.

The project of developing an air-con single deck purely electric-driven bus for the purpose of carrying out research and development, functionality checks and performance tests has been championed by Hong Kong Automotive Parts & Accessory Systems R&D Centre of HKPC funded by the Innovation and Technology Fund of the Innovation and Technology Commission of the Hong Kong SAR Government (ITC) and sponsored by Green Dynamic Electric Vehicle Limited (GDEV). The five (5) men project steering committee has comprised the Chief Engineer of the largest bus operator in the world, The Kowloon Motor Bus Co. (1933) Ltd., Ir Prof. Ching-Chuen Chan and member of the Chinese Academy of Engineering, Prof. Zhi-Hua Zhong.



One (1) of the 16 lithium polymer batteries installed on the prototype

The collaborative project commenced in August 2013 and completed in November 2015 for a total amount of HK\$38 million with the prototype technologies owned by the Hong Kong SAR Government. In addition to ITC, GDEV and HKPC, South China University of Technology has been partnered in the performance of finite element analysis and the assistance in 70 % of the design of chassis and body.

The prototype bespoke for operations in Hong Kong has featured to be 10 % to 15 % lighter in weight and 20 % to 66 % longer range than the current pure electric bus models, plus intelligence with remote diagnosis capability and transmission of the bus's operating data to headquarters instantly for better vehicle maintenance and fleet management. Road tests to GB and IEC standards by a third party of over eight (8) month 6,000 km in Chongqing in the mainland China, where the four (4) prototype

vehicles were built, followed by 1,500 km full laden test in Hong Kong, have been completed, recording acceleration to 70 km/h could be made in 20 seconds and negotiation of 1:8 (12.5 %) gradient at 5 km/h. The 1:7 gradient in Chinese University Hong Kong has also been trailed.

HKPC has forecasted the break-even point of the electric bus would be six (6) years, when the capital cost plus the operating cost of which would be comparable with the diesel equivalent, on the assumption that the oil, electricity and liquefied natural gas prices would remain at the current level.

Basic specifications are tabled below:-

Passenger number	35 seats and 40 standees
Vehicle dimensions (L × W × H)	11,750 mm × 2,500 mm × 3,000 mm
Net weight	12.5 tonnes
Gross weight	16.5 tonnes
Cruise range (with air-con in operation)	380 km
Maximum speed	70 km/h
Motor name-plate/maximum power	100/300 kW
Motor name-plate/maximum torque	800/2,400 Nm

#### Battery and Power Train

The prototype vehicle has adopted lithium polymer batteries (GZ85333181) with rated capacity of 3.7 V/50 Ah. Amounting two-third of the total unit cost of vehicle, 16 batteries of total 2.5 tonnes which deliver 296 kWh of electricity are arranged in a 6-4-6 configuration with respect to the front, middle and rear section of the vehicle. The batteries in the respective compartments are installed back-to-back to avoid vibration. Power is supplied to traction motor and air-con by separate routes.



Batteries and Battery Management System at the rear of the vehicle

Quick full charge is possible in four (4) hours with the Chinese national standard (GB) industrial-grade charging plug, though currently the charger plug governed by the IEC, SAE and GB standards have covered cars only. The battery management system (BMS), with due care taken to prevent over-heat during charging, or “thermal run-away”, which is a cause of the undesired battery explosion, has been developed by HKPC indigenously.

The single air-cooled, variable frequency permanent magnet synchronised motor (PMSM) installed has provided traction of the vehicle in direct drive arrangement. PMSM, sourced from Hong Kong-based supplier, features high energy efficiency at high speed range which results in low heat dissipation requirement, or otherwise high temperature would lead to de-magnetisation of the motor. The motor control unit, together with the BMS, comprise the vehicle system control is also HKPC indigenous design. Shaft power from motor is transmitted through differential gear to the rear wheels on the ZF-made axle as specified by the end-user.

#### Under-floor and Body Structure

Constructed above the carbon steel-made chassis, the bus body was made of T6-grade aluminium alloy and monocoque amounting 1.9 tonnes in weight, versus 1.4 tonnes of an ordinary taxi on roads. Both the chassis and body were designed by Hong Kong with partnership with a U.K. firm. The production model would be envisaged to have assembling in a location closer to Hong Kong, such as Zhuhai in Guangdong Province.



GB industrial-grade charging plug adopted for the prototype

#### Performance

For power consumption, the prototype has been tested according to GB/T 18386-2005, where the vehicle was tested at constant speed of 40 km/h, full loaded and air-con off, and 0.52 kWh/km has been achieved. Conversely, 0.78 kWh/km has been made when the vehicle was subject to the testing conditions predefined by the bus operators in Hong Kong, whereby speed was kept constant at 30 km/h, vehicle was fully laden and air-con at 23 °C was on.

#### Future

Commercial launch of the single deck design in the second quarter of 2016 has been targeted. In parallel, with government funding of maximum HK\$40 million, HKPC has embarked on the design of the double deck variant, which would feature total payload of 23 tonnes and wireless opportunity charging.

Remark

For the first time, Hong Kong has been able to put forward its own design of a passenger-carry vehicle in meeting the needs of its highly arduous operating conditions. “Made by Hong Kong” in the context of buses has become reality. It is by all means exciting news to the mechanical engineering community in Hong Kong, and IMechE-HKB has been fortunate to be able to make encounter with the prototype, which may become the origin of many such electric buses on Hong Kong roads in future.



First “Made by Hong Kong” pure electric bus prototype developed by HKPC

IMechE-HKB would thank Dr. Lawrence Poon of HKPC and Mr. Andrew Yung of GDEV for their kindness and hospitality in facilitating the technical visit.

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<http://nearyou.imeche.org/near-you/north-east-asia/hong-kong/events>

Masterpiece of automotive engineering and research and development of Hong Kong, the latest pure electric bus developed The Hong Kong Productivity Council, "e-bus" features the top-class technologies and design which fully caters to the unique passenger transport needs. IMechE members are privileged to be offered exclusive access to the "e-bus" and learn its technical excellences and the "Made by Hong Kong" story.



**Date: 5 December 2015**  
**Time: 09:30 to 12:30**

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Successful applicants will be informed

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