R&D of Parallel Hybrid Electric Transit Bus with Complete Chinese IPR

Limin Zhu [1], Qun Deng [2], Liqing Sun [3], Min Li [4], and Yufang Li [5]

[1] *Zhu Limin, EV Sector, Xiangtan Electric Manufacturing Corporation, zlmcn@vip.sina.com*
[2] *Deng Qun, EV Sector, Xiangtan Electric Manufacturing Corporation, zlmcn@vip.sina.com*
[3] *Sun Liqing, School of Mechanic and Vehicular Engineering, Beijing Institute of Technology, sunlq@bit.edu.cn*
[4] *Li Min, School of Mechanic and Vehicular Engineering, Beijing Institute of Technology, nomad0657@sina.com*
[5] *Li Yufang, School of Mechanic and Vehicular Engineering, Beijing Institute of Technology, li_yufang@126.com*

Abstract
The hybrid electric vehicle has been paid more and more attention by Chinese government since the small batch production of PRIUS and its sale in both Japan and North America, especially after the small batch demonstration info of H-bus projects in New York, Seattle and Long Beach of California was released. Chinese government has launched the 10-th Five Plan and will continue support the R&D EV. Although the planning economy covers less and less sector of Chinese economy, the Policy of Chinese Auto Industry plays an important role in the future trends of Chinese auto industry. The R&D and industrialization of HEV has been listed as a major part that Chinese government will fund. The paper presents the R&D of a parallel hybrid electric transit bus (PHET-bus) with complete Chinese IPR. The background of the PHET-bus, the configuration and drive mode analysis and primary test results will be included in the paper.

Keywords
R&D, PHET-bus, configuration, drive mode, test result

1. INTRODUCTION
The EV drive in China is due mainly to the following reasons, a potential energy crisis, environmental protection and the leap-over development of Chinese auto industry. It took 48 years for the number of vehicles in Beijing to increase from 0 to 1 million and then another 6.5 years from 1 to 2 million vehicles with an increase rate of over 20% annually. It is predicted that the total number of motor vehicles in China will be over 1.2 billion by the end of 2020. They will cover a major energy consumption sector in energy structure. To improve fuel economy and to realize the diversity of energy sources are matters of great importance. Vehicle emission is still one of most major parts to contribute to environment pollution in metropolitans. The emission standard is becoming stricter, especially with the commitments to IOC because of the Olympic 2008 in Beijing and corresponding efforts on account of World Expo 2010 in Shanghai. Why should hybrid electric buses be used public transportation in China? The reasons can be summarized as follows:

(1) The Euro III emission standard will be required in Beijing next year.
(2) The seles tax will be cut by 30% for vehicles, which reach the Euro II.
(3) The related tax will be counted by fuel price; improvements to fuel economy will be paid more attention than ever.
(4) The HEV is more practical than any other kind of electric vehicle with the background of an energy crisis and the ever rising price of oil.
(5) The government's policy will promote EV R&D and its industrialization, it was said that the import tax would be cut by 20% for EV sold in China.
(6) The R&D and industrialization of HEV has been listed as a major part of Chinese government funding.
(7) The price difference between engines with Euro II and Euro III standards respectively is about over US$10,000 for a 12-mmeter bus.
(8) The time length for the existence of HEV as a kind of transition vehicle will be enlarged greatly because of the non-breaking through of battery technology.
(9) HEV technology is relatively mature with respect to fuel cell and battery vehicle technologies and the demonstration projects' launching in America by US government and the demonstration base with 400 SHET-buses in Brazil by UN will surely promote the HEV industry throughout the world.
(10) The opportunities of HEV development offered by Olympic 2008 in Beijing and World Expo in 2010 in Shanghai.
(11) It was reported by an English oil company that the oil on earth is only available for mankind until 2045 with the total amount of only 1,150 billion tubes available for exploiting.

Under the energetic support of Hunan Province and sup-

Fig. 1 The appearance of the XD6120-PHET bus

Fig. 2 The interior of the XD6120-PHET bus

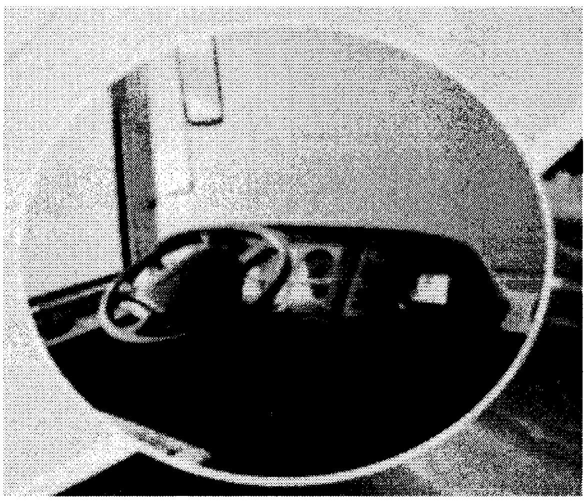

Fig. 3 The IP of the XD6120-PHET bus

port from CES and other related units, a parallel electric hybrid bus named the XD6120-PHET bus has been developed and attended two big bus expos and was given rewards for both new technology and new production. The bus has finished over 10000km's trial test and the formal test will be performed later on. The appearance of the XD6120-PHET bus is shown in Figure 1 to Figure 3.

2. CONFIGURATION AND MAIN PARAMETERS

After comparisons between the Serial Hybrid plan, Parallel Hybrid Plan and Serial-Parallel Hybrid Plan, a typical parallel electric hybrid bus plan was selected and past the assessment of EV experts from nation-wide. The parallel electric hybrid bus named the XD6120-PHET bus was finished after 6 months of hard work. The con-

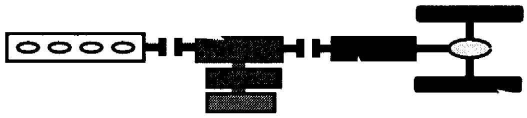

Fig. 4 Configuration of XD6120-PHET bus

Table 1 Main para. and perf. of XD6120-PHET bus

L×B×H (mm)	11500×2480×3150
Axle Space (mm)	5600
Wheel Space F/R (mm)	2020/1860
Front/Rear Hang (mm)	2700/3200
Curb Weight (Kg)	11500
Passengers (Persons)	36+1+24(standing)
Max. Weight (Kg)	15500
Max. Speed (Km/h)	90(Km/h)
Grade-ability (%)	20%
Acc Time (s)(0 to 50Km/h)	<25
Brake distance (s) (30Km/h)	<9.5
Min. Wheel Diameter (m)	<20
Outside noise lower than ICE vehicle	3dB(A)
Emission	Euro III
Gearbox	Multi-shift mechanical
Engine	Euro II Diesel
Clutch	Electric Controlled
Motor Type	AC
Power (kW)	60/120
Rated Speed (rpm)	2000
Max. Speed (rpm)	3800
Controller Peak output (A)	400
Controller Dimension (mm)	400×380×240
Controller Weight (Kg)	20
Efficiency	>87%
Battery Type	Lead acid
Battery Management System Type	XD-EMS
Conditioning system	Piston
Power (Kw)	15
Ability of cooling	30000kcal/h
Tire Type	11.00R20-16PR

figuration is shown in Figure 4.

The main parameters and performance of the hybrid bus are shown in Table 1.

3. DRIVE MODE ANALYSIS

In total, five drive modes are categorized as follows:

(1) Start and light load mode

When starting and working at a low load, the bus is powered by a motor and the battery supplies electric energy. The hybrid electric bus works in pure electric driving mode.

(2) Normal cruising mode

The bus goes to the state of closed clutch, at that moment, the engine is the power source. To make sure of fuel economy, the engine must work in the most effective area. When velocity goes up to the value set in advance, the engine starts. But at this moment, the bus still depends on the motor to drive

(3) Acceleration and climbing up mode

When overtaking or accelerating, the bus will ask for additional energy from batteries so that the motor can assist the engine. In battery being prior control strategy, the bus gets assistance energy from the battery pack while accelerating or upgrading.

(4) Deceleration and regenerative braking mode

When the bus is decelerating, regeneration brake energy can be stored in ultra capacitors for following drive. Since ultra capacitors have the ability to absorb large amounts of power in a short time, regeneration rate is high. Now the clutch opens, the bus charges ultra capacitors through motor and controller.

(5) Stop and battery charging mode

When the bus stops, check the SOC of energy storage to make sure the batteries' charge as required SOC indicated , otherwise, to keep the condition of SOC0, if not, the engine drives the motor (acting as a generator) to charge.

Advantages of the XD6120-PHET bus

The PEH-Bus has fully met the requirements of the indices of 863 as follows:

Saving 30% of energy consumption

Euro III emission

3-5 dB (A) lower than ICE vehicle (outside noise)

Maximum speed is over 80Km/h

Acceleration performance corresponding to GB / T13043-92 and GB/T 13044-91

Gradability over 20%

Range over 400Km

And the PEH-Bus has additional advantages as follows:

Low cost for maintenance

High reliability

Regenerative braking and energy recycling

Stability while acceleration

Competitive cost and mature technologies for mass production

New technologies employed

Many new technologies were employed, among them the most important two are as follows:

Motor Propulsion and APU shown in Figure 5 and Figure 6.

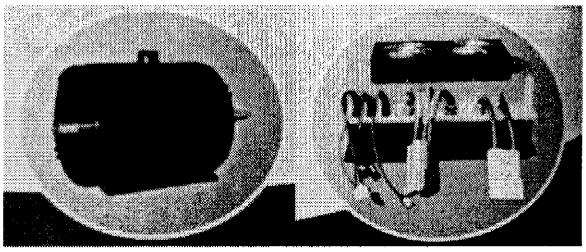

Fig. 5 Motor and controller

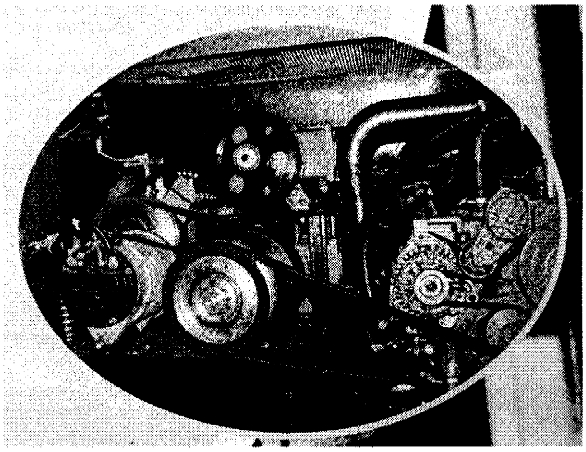

Fig. 6 Engine and APU CTRL unit

b. Smart Energy Management System

Industrialization analysis

Analysis shows that the hybrid bus is feasible for industrialization. The price comparison is shown in Table 2.

Table 2 Price comparison (50 sets) 10 thousand RMB

Item for Com.	Traditional ICE	PEH-BUS
Body	20	20
Engine	9	6
Retarder	2	/
Chassis	16	16
Air Cond.	6	6
Battery	/	2.2
Motor and CTRL	/	13.3
Air Cond. Motor and CTRL	/	2.5
Electric steering and braking	/	2.2
Rest	/	2.5
Cost	53	70.5
Sale price	56	74

4. PRIMARY TEST RESULTS

The fuel consumption tests can be categorized as two kinds as follows:

(1) One is to measure the fuel consumption at constrained workings according to GB/T12545-90,

(2) The other is to measure the fuel consumption at real working conditions (stopping at an average distance of 1.7Km, 31-time stops followed by pure electric starting up, total voltage of battery pack is 347 and 350 Volts before or after test). The test results shows that the XD6120-PHEV can save on diesel by 28-30%.

The fuel consumption test was made according to GB/T12545-90. The test results can be seen in Table 3.

The data show that the XD6120-PHET bus does work better as far as fuel consumption is concerned. An in-depth study is now underway and the complete test will be performed according to the draft HEV standards to be released by CATARC this year.

Table 3 Fuel consumption test results

	Constant speed (50Km/h)		Start-Stop (1.7 Km)
Length (Km)	54	52	53.5
Average speed (Km/h)	50.5	50.6	26
Fuel consumption. (L)	16.4	16.8	23.8
Fuel consum. Per100Km (accordingly)	20-22		32-35
Shift times	15	13	/
Braking times	20	22	/
Stop times	4	4	31

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