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Strategy and Construction of Electric Refueling System for Electric Scooter in Taiwan

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Abstract

There are about 33,000 electric scooters (ES) have been sold into the market, including 26,000 ESs in the domestic and 7,000 ESs in the overseas, up to May 2013 in Taiwan. Although, the selling amount of ES did not meet the target of government expectation, plentiful measures and promotion activities have made Taiwan a most vital electric scooter country in the world. In addition, Taiwan Government had proposed a common charging interface and lithium ion battery swapping business models in 2012. It encouraged the ES makers to set up one standard common specification of charging interface as well as the lithium ion battery. Hopefully, the lithium ion battery swapping business models could improve the charging infrastructure and increase the value of cost/performance ratio of lithium ion battery. Moreover, for the common charging interface, a specification of smart charger has been proposed by three major ES makers. On the other hand, there have two kinds of lithium ion battery swapping business model been established. One swapping business model is operating manually by an alliance consisting of the ES maker, convenience store, and car rental company in Penghu County, Taiwan. The other is a 10Ah capacity of lithium ion battery swapping business, which is operating by vending machine. Additionally, a 20Ah capacity specification of swapping battery module is also under discussing for further improving the performance of electric scooter.

Keywords: battery swapping business, common charging interface, charging infrastructure, electric scooter

1 Introduction

Motorcycle has long time been the main transportation vehicle of Taiwanese people and nearly 15 million internal combustion engine (ICE) motorcycles have been registered thus long being an issue of air pollution in the metropolitan area.

In 2009, accompanied the announcement of subsidization policy for electric scooter (ES) equipped with lithium ion battery, Taiwan Government had also issued one pronouncement, Taiwan Electric Scooter Standard (TES), for testing the ES performance and safety [1]. So far there are twenty nine models of ESs have been approved to get subsidy, NT$7,200 for small light ES and NT$10,000 for light ES after purchasing each ES by consumer, as shown in Table 1 and 2 [2]. Up to May 2013, there are about 33,000 ESs have been sold into the market, including 26,000 ESs in the domestic and 7,000 ESs in the overseas. Although this selling amount did not meet the target of government expectation, plentiful measures and promotion activities have made Taiwan a most vital electric scooter country in the world.

The expectation drop may be attributed to the inconvenient charging infrastructure and the lower value of cost/performance (C/P) ratio of lithium ion battery. In order to amend these two problems, Taiwan Government had proposed the common charging interface [2] and lithium ion battery swapping business models [3] in 2012 and encouraged the ES makers to set up one standard common specification of charging interface as well as the lithium ion battery. Hopefully, the lithium ion battery swapping business models could increase the C/P value of lithium ion battery.

Table 1. TES certified small light ES Models

	Small light category (13 models)					
Makers	E-TON		KYMCO	SYM	KENTFA	
Models	e-MO EV3A	e-Moving EM198	SUNBOY EA10BB	e-star EA1LU	CC-888	e-Moving EM1A6
Range	30 ~ 45 km (under city driving pattern modified ECE47)					
Speed	38 ~ 43 km/hr					
Climbing	10~24 km/hr@12% gradient					

	Small light category (13 models)						
Makers	E-TON		YAMAHA		KENTFA	TGV	
Models	e-MO EV3C	e-Moving EM198(B)	EC-03	e-Moving EM198 (YA140)	CC-888-6	TC502	GD-031-T
Range	30 ~ 45 km (under city driving pattern modified ECE47)						
Speed	38 ~ 50 km/hr						
Climbing	12 ~ 24 km/hr @12% gradient						

Table 2. TES certified light ES Models

	Light category (16 models)					
Makers		E-TON	db-Life 東陽	EVT	E-TON	
Models	e-Moving EM1A6 (Type B)	IBA 3	DBX	EVT-4000E-BLM1	IBA 3 (TW)	e-Moving EM1A6 (YA11P-A)
Range	31 ~ 53 km (under city driving pattern modified ECE47)					
Speed	46 ~ 53 km/hr					
Climbing	18 ~ 39 km/hr@18% gradient					

	Light category (16 models)					
Makers	SYM	KYMCO		EVT	KYMCO	
Models	ED1LU2 E-Woo	EA10FA	e-Moving EM1A6 (YA11P-B)	EVT-168-BLM1	EA10EA	EM3AT
Range	38 ~ 53 km (under city driving pattern modified ECE47)					
Speed	47 ~ 54 km/hr					
Climbing	19 ~ 39 km/hr@18% gradient					

	Light category (16 models)			
Makers				db-Life 東陽
Models	EM3A6	EM3A8	EM3AR	DBX-A
Range	31 ~ 49 km (under city driving pattern modified ECE47)			
Speed	44 ~ 53 km/hr			
Climbing	18 ~ 24 km/hr@18% gradient			

2 Strategy and Construction of Electric Refueling System

2.1 Improvement of charging infrastructure

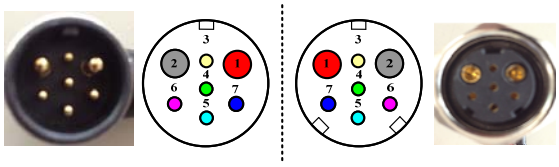
In order to improve the charging infrastructure, it had been announced that a maximum subsidy of NT$100,000 for establishing one charging station in the places of government, organizations, companies, schools, and enterprises by Taiwan Government since 2009. So far, there are 1562 charging points has been established by the aid of government subsidization. However, the consumers still feel inconvenience to recharge their ES at these charging ports due to the different

specifications of charger which made by different ES makers. This results in decreasing the usage of these charging ports. Therefore, the Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA) of Taiwan Government requires the three major ES makers (China Motor Co., KYMCO, and SYM) to set up one unified specification of charger for their ESs. This charger specification will be set as the necessary condition of subsidization for establishing the charging facility in the future. Meanwhile, for the common charging interface, the specification of one smart charger has been proposed by three major ES makers in Taiwan, as listed in Table 3 and Figure 1. The smart charger could also be compatible with present on-road ESs in the market that sold from these three major ES makers. At the same time, this smart charger has passed the test by these three ES makers and is applying the certification of CNS (Chinese National Standards).

Table 3. Specification of smart charger

Items	Recommended Specification
Charger	Output Power 1,000W; Input Voltage 90~240Vac
Communication Protocol	CAN bus 2.0B,
Connector Pins	2 big pins for charging current, 5 small pins for signal
Lithium ion battery	Capacity 10～25 Ah, nominal voltage 48V Output message of BMS should include temperature, voltage, and state of charge, abnormal signal, charging times, and battery identification.

*CAN: (Controller Area Network) is a vehicle bus standard



Pin1: DC+; Pin2: DC-; Pin3: Spare; Pin4: 12V trigger; Pin5: DC+ trigger signal or ground trigger signal (recognized by charger); Pin6: CAN*-H; Pin7: CAN-L

Figure 1. The frame of connector in smart charger

2.2 Establishment of common specification for swapping lithium ion battery

For cutting the ES cost, extending the driving range of ES, and increasing the C/P value of lithium ion battery, the establishment of swapping lithium ion battery business model has been supported by EPA (Environment Protection Agency) in Taiwan. Since 2011, two companies (City Power and Kent-Fa Technology) have been subsidized a trial project by EPA to set up the swapping lithium ion battery stations. However, City Power and Kent-Fa Technology battery swapping vending machine can only serve their specified batteries. Therefore, EPA of Taiwan Government started to initiate a common battery idea and to promote the establishment of common specification for swapping lithium ion battery after the trial project since 2012. After one and half years, one common specification of swapping lithium ion battery has been set up, as listed in Table 4 and Figure 2 and 3. In addition, for attracting more makers of two-wheel electric vehicle to invest on the battery swapping business, EPA of Taiwan Government is considering to issue a subsidization policy for subsidizing the converting fee of present two-wheel electric vehicles to adopt common swapping battery. Meanwhile, the common swapping battery will be set as the necessary condition to get the subvention for purchasing a new two-wheel vehicle from EPA of Taiwan Government since December, 2014. Hopefully, the aggressive promotion of EPA can speed up the replacement of ICE scooters by two-wheel electric vehicles and reduce the environment pollution.

Table 4. Common specification of swapping lithium ion battery

Item	Specification
Nominal voltage	DC48V
Nominal capacity	Not specified
Battery weight	<10 kg
Dimension	270 L x 95 W x 160 H (mm)
Working voltage	40~54 V
Charging current	10A
Continuous discharging current	30A
Peak Discharging Current	40A (30 Sec.) @50% SOC
Lithium ion battery safety	meet CNS15387 and

Item	Specification
	CNS15424-1
Protocol interface	CAN bus 2.0B
Connector	4 power pins (30A/pin) and 6 signal pins (2A/pin); B+*2,B-*2,CAN*2,KeyOn*2, GND*1 , +12V*1
Environmental requirement	IP65

Figure 2. Appearance of common swapping lithium ion battery

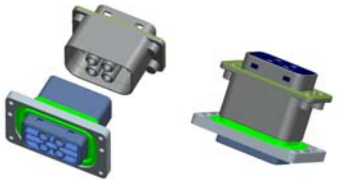


Figure 3. The frame of connector in swapping lithium ion battery

In the meantime, the capacity of common specification of swapping lithium ion battery is around 10~13Ah. It can only drive a relatively low performance electric scooter or electric bikes. Therefore, City Power and Kent-Fa Technology have developed a parallel control system of lithium ion battery which can run more than 2 batteries simultaneously. Nevertheless, the functionality and reliability of such system need further verification to be accepted by most of ES makers. In parallel, one larger swapping battery of 20Ah capacity is also under discussing.

3 Examples of battery swapping business model

There are two kinds of lithium ion battery swapping business model has been established in 2012. An alliance of manual battery swapping business was organized by the ES maker (China-Motor Co.), convenience store (7-ELEVEN), and car rental company (I- Sun Green Energy co.) in Penghu County [3]. The operation system consists of one centralized charging station, a distribution channel of delivering lithium ion battery, 66 lithium ion battery swapping stores (23 7-ELEVEN stores, 5 gas stations, 3 travel agencies, 27 accommodations, and 8 car rental stores) as shown in Figure 3.

In order to attract more customers to stay longer time in the convenience store, 7-ELEVEN convenience stores provide an option, either charge battery for free or exchange a fully charged battery for USD1.2.

Figure 3. Manual lithium ion battery swapping business system [4]

Meanwhile, another lithium ion battery swapping business by vending machine has also been setting up by two companies, City Power and Kent-Fa Technology. These two companies have been subsidized a trial project by EPA, Taiwan since 2011. In this trial project, both of these two companies combined the resource of local government to set up the battery swapping stations in their familiar area. City Power and Kent-Fa Technology have established 30 swapping stations in Banciao city, Taipei and 6 swapping stations in Kaohsiung city, respectively. One of the representative swapping vending machine and the procedure of swapping lithium ion battery are shown in Figure 4 [5]. Both of them adopt a parallel control system with more than two lithium ion batteries in their ES as shown in Figure 4(d). Meanwhile, these ES equipped with parallel control system of lithium ion batteries have passed TES test and under the reviewing process by technical group and executive committee.

Figure 4. The procedure of swapping lithium ion battery [5]

4 Future Development Strategy of Taiwan Government

(a) Taiwan Government has announced that the ES industry is included in the list of major industries development strategy till 2020.

(b) Based on the 6th phase emission regulation which reviewed by the EPA of Taiwan Government, all ICE motorcycles are forced to equip an idle-zero-emission device and a self-diagnosis system to decrease the emission. This would much increase the cost of purchasing a new ICE motorcycle and increase the competitiveness of buying a new ES.

(c) The IDB of Taiwan Government is proposing a new project to continuously promote the ES industry within 2014-2017. It includes (1) Keep the subsidization policy of purchasing new ES, NT$7200 for small-light ES and NT$10000 for light ES, (2) Exempt the taxes of license plate and commodity, and (3) Revise the standard of output voltage from 60V to 120V for the lithium ion battery in TES.

(d) The EPA of Taiwan Government would widespread the battery swapping business model to all area of Taiwan as well as Kimmen island.

5 Conclusion

Based on above series of aggressive promotion, encouragement policy, and subsidization by Taiwan Government, a specification of one smart charger has been proposed by three major ES makers in Taiwan. The smart charger could also be compatible with present on-road ESs in the market. In parallel, this smart charger is applying the certification of CNS (Chinese National Standards). In addition, a trial project of establishing the swapping lithium ion battery stations sponsored by EPA has successfully demonstrated the feasibility of battery swapping business model. Moreover, a common specification of swapping battery has been set and is needed further verification to be accepted by most of ES makers. The goal of all strategies and constructions of electric refueling system is to provide more convenient, reliable, economy, and environmental friendly to attract more ES uses in the low carbon emission cities. Although only about 33,000 ESs were sold into the market until May 2013, it is still believed that the ES industry will be prosperously developing in the future accompanied by the plentiful measures and promotion activities by Taiwan Government.

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