Study on Electric Bicycle Use in Vietnam

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Abstract: Electric bicycles (e-bike) are widely used in urban areas where the population density is high. The total number of e-bike users is up to 400,000 units per year and this number tends to increase recently in Vietnam. People use e-bike because of its convenience, cost saving, air pollution reduction and fuel saving. Besides, a significant proportion of e-bike with lead acid batteries affects negatively to the environment and public health. This paper presents (i) an overview of e-bike use in Vietnam, (ii) the benefits and limitations of e-bike use in Vietnam, and (iii) some recommendations to manage e-bike use. To promote the advantages and minimize the constraints of electric bicycles, encouraging the use of lithium iron battery e-bike, building e-bike infrastructure, developing policies and regulations to manage the use of e-bike safely and effectively towards a green and sustainable environment in Vietnam are the main recommendations in this research.

Keywords: Electric Bicycle, Cost Saving, Energy Saving, Environment Pollution, Management

1. RATIONALE

Currently, the use of personal vehicles creates an enormous pressure on transport infrastructure and urban environment in Vietnam. Nationally, 39 million motorcycles, 2.2 million cars and approximately 69 thousand motorcycles are quarterly registered (National Traffic Safety Committee, 2014). The number of vehicles has exceeded the planning by the year of 2020 (Decision No.365 of Prime Minister, 2013). The outbreak of motorcycles in use since 1990 has increased traffic congestion and air pollution in large cities such as Hanoi and Ho Chi Minh City. As the result, it was much damage to the economy and the environment. In Hanoi, the waste of fuel consumption and labor was up to 600 million dollars per year (Phan Duy Toan, 2012), and thousands of tons of CO_2 emission were exhausted into the air, and fuel consumption demand greatly increased.

In recent years, the appearance of electric bicycle (e-bike) as a new personal vehicle has attracted many people to widely use in crowded cities of Vietnam.

According to the National technical standardized regulations for electric bikes by the Ministry of Transport (Circular No.30/2013/TT-BGTVT dated November 1, 2013), the electric bicycle is two-wheeler bicycle which is operated by a direct current motor or by pedal structure with the assistance from a direct current motor, having the largest motor power of no greater than 250W and maximum designed speed of no more than 25 km/h. The weight itself (including the battery) is no greater than 40 kg. The two-wheeler electric vehicles that do not meet one of the above criteria will be classified as electric motor or electric motorcycles. The electric motor has maximum speed greater than 50 km/h or maximum engine power greater than 4kW and the vehicle normally weights greater than 118 kg. Electric motorcycles are required to have maximum speed of no greater than 50 km/h, maximum engine capacity of no greater than 4kW, and vehicle weight of up to 118kg.

The difference between electric bicycle, electric motorcycle and electric motor is distinguished by speed, weight and motor power. The distinguishing between e-bikes and electric motorcycles should be based on the following criteria: motor, vehicle speed and pedal (with or without pedal).

Table 1. Distinguishing between electric bicycle, electric motorcycle and electric motor

Criteria	Electric bicycle	Electric motorcycle	Electric motor
Highest speed (km/h)	< 25	< 50	> 50
Weight (kg)	< 40	≤ 118	> 118
Motor power (kW)	< 0.025	< 4	> 4

Source: MOT, 2013. Circular No.39/2013/TT-BGTVT of the Ministry of Transport dated 11 January 2013: Promulgate national technical regulations on electric bicycles QCVN number 68: 2013/BGTVT, effective from 01 January 2014

From 2011 to October 2013, Vietnam imported 1,510,166 electric motorcycles and e-bikes (Truong Tho, 2014). According to the National Traffic Safety Committee (2014), nearly 70% of imported electric two-wheeler vehicles are electric motorcycles and 30% of those are e-bikes. Based on Vietnam Automobile - Motorcycles - Bicycles Association (VAMOBA)'s report, the number of e-bikes consumed on the Vietnam's market is up to 400,000 units per year. This figure equals to the consumption number of motorcycles in the early outbreak period of 1990 (Nguyen Son, 2013). E-bikes run only on batteries. That's why they have no fuel consumption and zero emissions. The increasing use of e-bikes recently has raised some questions to the authorities and policy makers: whether or not e-bikes is an effective alternative of personal transport mode for motorcycles due to its help of saving fuel and reducing environmental pollution; and should e-bike be encouraged to use in order to reduce and limit personal motorcycles in Vietnam's urban in the near future? Therefore, it is needed to make a research on the practical use of e-bikes, as well as their benefits and disadvantages. Also, some recommendations regarding using e-bikes effectively in Vietnam will be proposed.

2. RESEARCH OBJECTIVE

The main purpose of this research is to review the current situation of e-bikes use in Vietnam and to give some recommendations on managing the e-bikes use in Vietnam effectively and safely. In order to achieve this purpose, the following objectives are specified:

- To investigate the current situation of e-bikes use in Vietnam
- To find out the benefits and disadvantages of using e-bikes in Vietnam;
- To provide some recommendations to encourage the use of e-bike, to manage the use of e-bike safely and effectively, and to develop suitable policies in supporting for e-bike manufacturing.

3. RESEARCH METHODOLOGY AND DATA COLLECTION

The main research of this paper is qualitative method on desk research. The analysis relies on literature and second data from the field of Vietnam's e-bike market; relevant data and documents from magazines and studies of Ministry of Transport (MOT), Department of Transport, and National Traffic Safety Committee, etc. Collected data from government authorities is used to provide an overview and current situation of the e-bikes use in Vietnam.

Nearly 20 international and domestic articles and papers related to e-bike in recent years and several academic and online sources have been reviewed to analyze the current situation of e-bike use in Vietnam more thoroughly. The main articles also consider learning experiences on using e-bike in some other countries.

Based on the collected data, the research makes an assessment and analysis of e-bike use, indicates benefits and limitations of e-bike use in Vietnam, and gives some recommendations to authorities to manage e-bikes as an effective alternative vehicle for travel in order to save energy, reduce air pollution, save cost, develop green and sustainable urban in Vietnam.

4. OVERVIEW OF E-BIKE USE IN VIETNAM

Electric bicycles (e-bikes) are widely used in several crowded cities of Vietnam, such as Ha Noi, Ho Chi Minh, Vung Tau, Hai Phong etc. and the number tends to increase quickly in recent years. The e-bikes account for 30% of total two-wheeler electric vehicles used in Vietnam. Most people using e-bikes in their daily lives are pupils, students, and middle-aged people because of its convenience, its travel cost-saving and its contribution to reduce air pollution.

Imagine source: www.xedapdien.com

Figure 1. Imagines of electric bicycle use in Vietnam's market

Electric bikes come in a range of styles and performance specifications, but the primary technology is the same. The vast majority of them utilize lead acid batteries to provide energy to a hub motor that is usually on the rear wheel. Most electric bikes have two apparent shapes: *scooter style electric bikes* (SSEBs) or *bicycle style electric bikes* (BSEBs). SSEBs appear much like gas scooters complete with headlights, turn signals and horns; with large battery packs under the footboard. BSEBs resemble bicycles, with functioning pedals and usually have smaller batteries and a lower power motor. Electric bikes are capable of speeds exceeding 20-30 km/hour and weigh between 40 and 60 kilograms (Christopher, Jonathan and Davis, 2007)

The number of e-bikes consumed in Vietnam's market is increasing every year. The most e-bike consumption time is usually around school year, increasing about 30% to 50% in comparison with previous months (Duong Nhi, 2013). In May, 2013, the quantity of Chinese bicycle exported to Vietnam reached 117,000 units, increasing by nearly 49% compared to the same period in 2012. The total number of e-bikes was 53,000 units, which is equivalent to an increase of 94% as compared to the same period in 2012 (Nguyen Son, 2013).

According to VAMOBA, electric bicycle currently has two main categories: (i) Imported e-bikes which account for 95 percent of market share, and (ii) domestic e-bikes which account for only 5 percent of market share (see Table 2).

Imported e-bikes are mainly from China, Taiwan and account for 80 percent of market share. They have a variety of design and color, and the average price of an e-bike is approximately 4 to 5nmillions VND. E-bikes imported from Japan, European countries account for about 15% of market share. These e-bikes cost from 10 to 13 millions VND for a new one, and 5 to 6 millions VND for a second-hand one. Consumers' most favorable trade marks presently are Asama, Yamaha, Honda of Japan and Taiwan's Giant with an average price of 6 to 8 millions VND per unit.

Domestic e-bikes have brands of Unified (Thong Nhat Company), Delta (Delta Mechanic-Electric Company), and Hitasa (Hiep Tan Produce & Trade Company) with competitive price from 3.5 to 4 millions VND.

Table 2. Market share and price of electric bicycle in Vietnam

Categories	Market share	Unit price (millions VND/unit)
A. Imported e-bikes	95%	
1. From China and Taiwan	80%	4 - 5
2. From Japan and European countries New e-bike from Japan Second hand e-bike from Japan (remaining 80% of used value)	15%	5 - 15 10 - 15 5 - 6
B. Domestic e-bikes	5%	3.5 - 4

Source: Nguyen Son (2013), and author's collection. Exchange rate on 5 February, 2015 of 21,365VND/US$ or 0.00004681US$/VND

With the diversification of design, style, form and color of e-bikes, the Vietnamese consumers have more choice to match their needs. The e-bike's price currently is consistent with the average income of Vietnamese people. Due to superior advantages of e-bike in comparison with motorcycles and bicycles, the numbers of e-bikes increase quickly in Hanoi and the Northern provinces of Vietnam as well as other parts of Vietnam.

Management of E-bike use in Vietnam: In order to manage traffic safety plus electric bicycle market, and to protect consumers, the Vietnamese government has issued number of decrees and circulars on e-bike technical standards, e-bike technical quality control, helmet wear regulation, inspection fee for safety and environment protection, keeping fee etc. (refer to Appendix 1).

E-bike use in other countries: Compared to other countries, the number of e-bike use in Vietnam is still modest.

In China, the number of e-bike increases rapidly, from 40,000 units in 1998 to 10 million in 2005 (Jonathan, et al, 2007), and up to an estimated 150 million units in 2013 (John and Nicholas, 2014). The overwhelming majority of the world's e-bikes (96%) is concentrated in China. The next largest e-bike market after China is Japan with annual sales of 270,000 bikes in 2006 and 13% average annual growth since 2000 (Weinert, Ma, et al. 2007).

According to the Schenker (2008), there are other small but growing e-bike markets in Japan, Europe, and more recently in India (ADB, 2009). Indian e-bike market is not large, but it is forecasted to have a significant growth. A market survey by AC Nielsen in 2006 estimates the e-bike market in India at 200,000 units for 2007–2008 and later 490,000 units (ADB, 2009). An important aspect of the emerging Indian e-bike market is that most products are Chinese type with low-power motors that make them exempt from motor vehicle classification and consequent safety and emission standards (ADB, 2009).

Based on the data of Beckendorff (2014), in Germany, e-bikes account for 11 percent of market share, with more than 400,000 units sold in 2013. In the United State, the sale is estimated to range from 75,000 units to 159,000 units in 2013 (John and Nicholas, 2014).

Pedelecs (a style of e-bike driven primarily by human power with battery assist) are the dominant type of e-bike. E-bikes in Europe are also mainly pedelec style. Sales in the Netherlands are the highest because of extensive bicycle infrastructure and a deep-rooted biking culture. Germany and Belgium are the next largest markets for pedelecs.

In the United States, the e-bike market is limited mainly to recreational riders who rely on the assistance of the electric motor out of physical necessity. The e-bike is not a common commuter vehicle in most cities because of long commuting distances and bicycle infrastructure nonexistent.

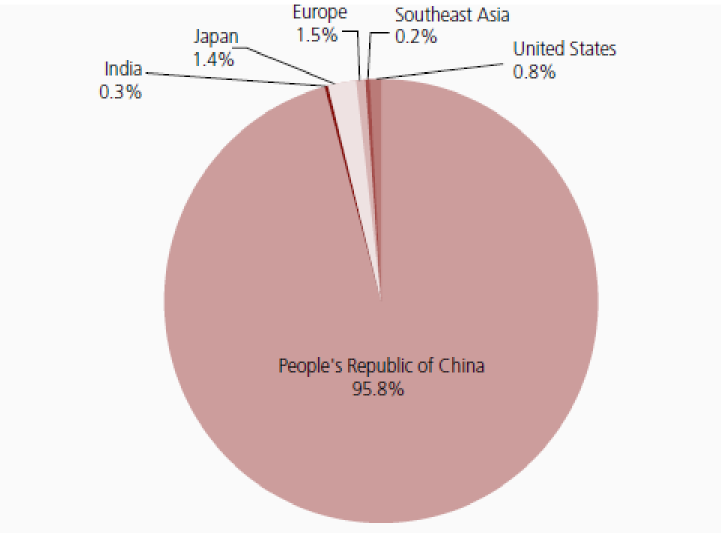

Figure 2. Worldwide Electric Bike Sales, 2006
Source: Asian Development Bank (ADB) and Sida, 2009 derived from Schenker (2008)

5. BENEFITS AND LIMITATIONS OF E-BIKE USE IN VIETNAM

5.1 Benefits of E-Bike Use

The utility of using e-bikes has increased the demand of this vehicle for teenagers, students, and middle-aged people in Vietnam's urban. Benefits of e-bikes are specified as follows:

Light weight, small and compact size: in comparison with motorcycles, average weight of vehicles from 20 to 50 kg is smaller than that of motorcycles. With the traditional shapes, the load of e-bikes can be up to 150 to 180 kg for imported vehicles from the famous and expensive brand, such as Speed Bike, HKBike.

High flexibility and mobility: due to compact size, e-bikes require a smaller space for parking and moving than motorcycles. They can move quickly and conveniently for a short distance and in narrow streets in Vietnam.

Need of less effort: e-bikes have the ability to overcome common barriers of traditional bicycle like climbing steep, going against the wind or moving longer distances. E-bikes can be an optimal solution for the elderly because they move more gently and can be controlled easier than motorcycle.

Diversified style and design, fashionable with youths: currently in Vietnam's market, there are 50-60 different models of e-bikes from many manufacturers, so consumers have a variety of choices. The size and shape of e-bikes are able to fit to the body condition, age, gender as well as the various interests of Vietnamese consumers, especially the youth.

No need to have registration and driver's license: e-bike is the perfect vehicle for pupils and students to travel (Vietnamese people have to wait until 18 years old to be licensed for driving motorcycle). For those who are less than 18 years old, they will not be fined if they did not wear a helmet. E-bikes participate in the same lanes with other motor vehicles.

Saving cost for purchase and annual operation: compares to two-wheeler motor vehicles such as motorcycles, the use cost of e-bike including the initial purchase cost and the annual operational cost is lower than the use cost of motor vehicles. With the same distance, volume of transport, and average speed, the energy cost (petrol) for motorcycle is 14 times higher than the energy cost of e-bike with lead-acid battery and 27 times higher than energy cost of e-bike with lithium-ion battery (see Table 3).

Energy saving: e-bikes tend to save more energy and cause less pollution per traveling kilometer than many other vehicles due to their not using gasoline. Electric motor performance of e-bike is higher (90 - 95% of the energy converted into useful work) than the internal combustion engine of motorcycle (only 30 - 35% of the energy converted into useful work).

Table 3. Comparison of use cost between e-bike and motorcycle

#	Item	Unit	E-bike with lead-acid battery	E-bike with lithium-ion battery	Petrol motorcycle
I	Initial purchase cost of vehicle	millions VND/unit	8 - 12	10 - 19	30 - 40
II	Annual operational cost				
1	Energy consumption cost per km	VND/km	30	15.30	418
	Energy cost for one full charge *	VND	1,350	1,300	62,708**
	Average distance the vehicle travels for a single charge of acid battery/ lithium battery/petrol tank *	km	45	85	150
2	Average replacement cost of battery per km	VND/km	115 - 160	80 - 90	30 - 40
	Total battery set cost ***	VND/ battery set	1,600,000	4,000,000	150,000 - 200,000
	Total travel distance corresponding to durability of battery ***	km	10,000 - 14,000	45,000 - 50,000	5,000
3	Cost of regular oil replacement/km	VND/km	-	-	66.7 - 100
	Cost of an oil replacement	VND/box			100,000
	Total travel distance for an oil replacement	km	-	-	1,000 - 1,500

Source: Data is based on author's collection and calculation for regular E-bike and motorcycle in the Vietnam's market; *Appendix 2; **Petrol price since 21 January 2015 for RON92 of 15,677 VND/liter (4 liters/full charge x 15,677 VND/liter); ***Table 5; Exchange rate on 5 February, 2015 of 21,365VND/US$ or 0.00004681US$/VND.

Less environment pollution: due to using battery, e-bikes emit almost nothing into the atmosphere. In contrast, motorcycle operation generates harmful emissions to the environment and public health, such as VOCs, CO, NO_x, PM, SO_2, SO_3, $PbCl_2$. Hydrocarbon from motorcycle emissions causes genetic mutations and cancer and reproductive health for human.

The potential use of e-bikes can be considered as a clean alternative mode for motorcycles or cars in the tendency of urban development sustainable and friendly environment. However, e-bikes with lead-acid batteries cause environmental pollution in some certain degree. Therefore, the switching from lead battery to lithium–ion technology can reduce the negative pollution caused by lead-acid batteries, and save energy for the nation.

Table 4. Coefficient of emission by vehicle

Vehicle	Concentration of pollutants (g/km.vehicle)		
	VOCs	CO	NO_x
Heavy truck	0.21 - 5.71	11.1 ± 5.3	19.7 ± 5.2
Car	0.04 - 1.97	34.8 ± 15.5	1.9 ± 0.9
Motorcycle	0.00533 - 0.1499	21.85 ± 8.67	0.05 ± 0.02
E-bike *	-	-	-

- = no data available

Source: CETD, Department of Science and Technology Hochiminh, 2013. Research on electric bus uses in Hochiminh city; * Refer to Appendix 3 for the research on electric scooter in Hanoi, 2009.

Safety in traffic: because the prescribed maximum speed of e-bikes is 25 km/hour, their risk of accidents will be less than motorcycles. The involvement of e-bikes in accidents accounts for 30% accidents in Chinese cities (Ch. Luan, 2014) while the involvement of motorcycle in accidents accounts for 80% in the cities of Vietnam (Nguyen Tong, 2013). If there are separated lanes for e-bikes, the percentage of traffic accidents may decrease if switching from motorcycles to e-bikes**.**

Smooth and quiet operation: E-bikes do not make noise like motorcycle. E-bikes with lithium-ion battery of advanced technology are capable of storing electricity and traveling double distances, up to 70-80 miles with a full charge of battery.

4.2 Disadvantages of E-Bike Use

Besides their advantages and benefits, e-bikes, especially e-bikes with lead-acid batteries, also have some disadvantages such as: bulkiness, low life expectancy, short distance move, fire explosion, electric shock, environmental pollution in a certain range due to their use of lead-acid battery.

Bulkiness: E-bike using battery has an average weight of 50kg; the charging time is more than 8 hours. The installation and removal of charger are also quite inconvenient due to the use of large weight battery. On average, an electric bike needs 4 - 6 batteries to operate, and the weight of whole battery set is up to 18 - 20kg. This creates difficulties for users.

Low battery lifetime: in fact, most batteries used for e-bikes have a lifetime from 6 to 12 months, equivalent to 300 - 400 chargeable cycles, or about 7,000km of travel distance (see Table 5). In addition, the batteries used for e-bikes are completely non water-resistant, which limits e-bikes to move in inconvenient weather condition such as raining or flooded roads. However, today, the lithium-ion battery technology can overcome this drawback.

Shorter travel distance than motorcycles: due to limited battery capacity, most e-bikes can only run an average of 25 - 40 km per battery charge. If continuously traveling longer distance during a day, e-bike use will be inconvenient without battery chargeable infrastructure in public places.

The risks of traffic safety and traffic accidents: the current traffic safety and accidents of e-bikes are also problems for urban managers and policy makers. The risks of being injured or killed resulted from traffic accidents such as braking suddenly, driving too fast and quickly, or slipping and felling on curve roads often occur among e-bike operations. Also, using the same lanes with other motor vehicles without requirement of a driver's license, moving fast, dangerous zigzagging of younger users create many risks of unsafety and accidents. The smooth and quiet operation of e-bike is also another reason for accidents. According to the World Bank, the cost of traffic accidents accounted for 1- 5% of GDP in developing countries and the average length of hospital stay due to e-bike accidents is about 10 days, at a cost of about 1,321 dollar (Ch. Luan, 2014). E-bike use has been banned in some cities of China such as Beijing, Guangdong, Fuzhou due to its high traffic accident risks (Christopher, 2007).

The risk of environmental pollution: E-bike's battery has low durability, and as it is damaged, volume of lead and acid in the battery easily flows out, causing contamination risks of lead acid batteries for the environment and community health. Each battery contains from 1.8 to 2.8 kg of lead (Nguyen Huong, 2014), volume of lead in every set of 4 batteries is average from 7.2 to 11.2 kg. Currently, 95 percent of Chinese electric bike uses lead batteries, so they discharge lead into the air more than many other vehicles (Ch. Luan, 2014). If Vietnam has one hundred thousands of lead battery e-bikes, in every two years, Vietnam will have four hundred thousands of lead batteries or from 720 tons to 1,120 tons of lead discharge into the environment. In areas without strict recycling programs, the risk of environmental pollution is extremely high. In addition, the lead battery and the lithium ion battery must be electric recharged. Electric energy is generated mainly from thermal power plants which use coal to generate electricity. This leads to pollutant emissions into the environment. In case of using electricity from hydropower plants, which often associate with deforestation, e-bike use has much impact on the environment.

Table 5. Comparison of some characteristics between lead battery and lithium-iron battery

No.	Item	Lead acid battery	Lithium-ion battery
1	Durability Life time expectance	300 - 400 discharges 3 - 4 years	900 - 1,000 discharge 6 - 8 years
2	Continuous charging time	5 - 8 hours	4 - 6 hours
3	Energy consumption for per full charge	0.675 kWh (4 lead batteries 12V/12Ah)	0.65 kWh - 0.7 kWh (battery 24V/10Ah)
4	Travel distance per charge	40 - 50 km	80 - 90 km
5	Total travel distance in accordance with battery durability	10,000 - 14,000 km	45,000 - 50,000 km
6	Average weight	4.5 - 5 kg /battery 18 - 20 kg /4 batteries	6 kg /battery
7	Dimension	Bigger because of having 4 batteries	15 x 10 x 40 cm
8	Market price	400,000 VND /battery 1,600,000 VND /4 batteries	4,000,000 VND /battery
9	Water resistance	None water resistance	Water resistance
10	Anti-fire explosion ability	No guarantees, short-circuit, easy ignition and fire, dangerous to user	Absolute explosion protection in all weather conditions
11	Environment impact	Environmental pollutant due to lead and acid waste	Friendly environment because of no elements of toxic metals
12	Warranty period	6 - 12 months	2 years

Source: http://xedapdienbridgestone.com (2014); http://hkbike.com.vn (2014); author's data collection

With the high technology development in recent years, lead battery e-bikes have been replaced by lithium-ion e-bikes. Lithium-ion battery has overcome the disadvantages of lead battery. With a closed design, lithium e-bikes can be used even in rainy weather, resist to fire explosion, and do not pollute the environment. With the moving ability up to 70 - 85 km per full battery charge, lithium e-bikes are able to meet the user's needs for longer distances to travel. However, lithium batteries have a number of drawbacks: quality deterioration over time regardless of use or no use; need to use the charger with automatic shut-off function as the battery is fully charged; damage caused when the charging voltage exceeds the permitted level; flammability; difficulty of repairing and replacing because they are not commonly used; need to charge at least one time per week.

Using electric bicycle is a popular trend in Vietnam, especially in big cities such as Ha Noi, Ho Chi Minh City, Da Nang, Hai Phong, etc. The use of e-bikes brings significant benefits for users but also has certain limitations. In addition to some restrictions on the environment pollution, e-bike's advantages such as lower initial purchase cost, lower operational cost per km in comparison with motorcycle, friendly environment energy consumption, equivalent durability to gasoline vehicles (8 to 10 years) and if petrol price continues to increase, along with increasingly stringent requirements of the environmental management agencies for traffic vehicles, the purchasing power of e-bikes is expected to continue to rise in the coming time.

6. SOME RECOMMENDATIONS TO MANAGE EFFECTIVELY E-BIKE USE IN VIETNAM

To promote the advantages and minimize the constraints of electric bicycles, some supportive policies should be developed to encourage the use and production of e-bikes in Vietnam. Beside, the effective management policies for e-bike in order to use e-bike as an effective, safe and environmentally friendly vehicle are also needed.

6.1 Recommendations to encourage the use of e-bike

In Taiwan, electric two-wheelers were promoted and subsidized for the use during 1996 and 2003 as a means of improving urban air quality, but this policy failed. The main problem was that their scooters were too expensive due to their high power and energy requirements (Jonathan, 2007). E-bikes have increased in China due to the extensive e-bike infrastructure, public transit congestion and restriction of gasoline motorcycles (ADB, 2009).

The government in Malaysia and Singapore focus on the installation of charging stations and infrastructure development to encourage people to use electric vehicle (Almec, 2012). In USA, Germany and England, the charging infrastructure is developed at national and local level. Sharing system enables many people to experience on electric vehicles with low cost and people can share parking lots in the cities of France; therefore, they do not need to worry about the parking place (Almec, 2012).

Based on this experience and the economic and environmental benefits of using e-bike, there are some recommendations given to promote using e-bike in Vietnam as follows:

- Encouraging people to use e-bikes for short distances of less than 15 km to limit the number of motorcycles used in order to reduce energy demand and emissions pollution;
- Building rechargeable battery stations in public areas such as railway stations, bus stations, parks and commercial centers to create convenience for e-bike users.
- Constructing parking places for e-bike's keeping and rental at public transport locations or transport hubs to encourage people to use public transport such as metro in the near future and buses for longer distance of more than 10 km.
- Developing supportive policies for rental services of e-bikes with cheap price.
- Encouraging private sectors to participate into e-bike rental services and to invest in battery charge infrastructures and keeping places.

6.2 Recommendations to limit the environmental pollution by encouraging the use of e-bike with lithium iron battery

In developed countries, batteries are a key technology for the commercial viability of electric vehicles. Li-ion batteries are now the mainstream for electric vehicles. Compared to other batteries, the advantages of Li-ion batteries are their high power density, long lifetime and low self-discharge (refer to Appendix 4). In Japan, electric bicycles with Li-on become gradually popular in the city. Battery strategy is one of the six strategies in the "Strategies for New Generation Vehicles 2010" of government. Targets for battery development were set in 2006 and the development of batteries for EV/PHEV is key technology for EV diffusion (Almec, 2012). In Taiwan, China and Korea, the government focuses on battery development as a key for electric vehicles technology and their cost. Furthermore, Korea focuses on other batteries related technologies such as battery exchange system instead of charging, wireless charging system, and others. They have tried to apply those technologies to daily lives. Various attempts for public bus transportation are also notable (Almec, 2012).

In order to limit the environmental pollution caused by the use of e-bike, it is necessary to consider restrictions on the use of lead acid battery. This will help to reduce the amount of lead-acid waste. Besides, presenting and encouraging supportive policies for lithium-ion high technology industries through applying the preferential tax policies or environmental costs imposed specifically on each vehicle type should be applied in Vietnam.

With the aim of raising the awareness of using lithium iron battery e-bike, it is necessary to develop action plans to make people understand the benefits and utility of electric bikes, especially in the field of energy saving and environmental protection. Additionally, practical actions, initiating programs to save energy, protect the environment and promote sustainable urban development should be implemented as soon as possible.

6.3 Recommendations to manage the safely and effectively e-bike use

In terms of macro level, it is necessary to have a regulation that lets people use e-bike more safely and effective. Researching possibilities to register and issue license plate for e-bikes to manage systematically and clearly defining management authorities who issue registration and license plate are the important tasks which should be done by the governmental authorities such as Department of Transport, Ministry of Transport and National Traffic Safety Committee, etc. The registration and use of license plate for e-bikes could be a secure solution to protect consumers from smuggled vehicles, unqualified vehicles and fakes.

It is necessary to have dedicated lanes for electric bicycles to avoid conflict with other motor vehicles. This issue should be considered in the long term due to crowded and narrow lanes, weak infrastructure and many intersections in Vietnam. Experience from other countries has shown that, some countries have already had a separate lane for e-bike and bicycle. In Japan, electric bikes and bike are ridden on sidewalks. However, many Canadian cities, including Toronto, have considered banning electric bikes ride in bicycle lanes. Also in New York City in USA and some countries in Europe, the use of same lanes between e-bike and conventional bike has created conflicts for users (National Traffic Safety Committee, 2013). In order to have an appropriate lane for e-bike in Vietnam, it is necessary to conduct a comprehensive research on lanes using in Vietnam depended motorcycled country.

To support the management of effective and safe e-bike use, it is also necessary to have a legislation adjustment to encourage e-bike's use safely wearing helmet, which has been applied successfully in China. Experience from China has shown that, traffic safety is one of the most important issues of e-bike. Some Chinese cities such as Beijing, Guangdong and Fuzhou have banned the use of electric bikes because of safety and pollution. In contrast, in Kunming and Shanghai provinces, electric bicycles still predominate bike (Chris and Robert, 2006).

6.4 Recommendations to support for electric bicycle manufacturing industry

Singapore, Thailand and Malaysia are more aggressive for their promoting wider adoption of electric vehicles. The basic incentive is reduced taxes for both electric vehicle manufacturers and electric purchasers. In Malaysia, tax reduction on electric vehicles can encourage auto manufacturers to join the field demonstrations. In Thailand, the government uses tax reduction as an incentive for fuel-efficiency vehicles: import tax reduction for hybrid vehicles and 10% tax reduction system for purchasing low-emission vehicles (Almec, 2012).

The government of Vietnam is interested in the electric vehicle development. National policy of Vietnam states to develop hybrid electric vehicles and low-emission transport (Almec, 2012). At the moment, the government focuses on public transportation system rather than private vehicles. For private vehicles, the government issues only technical barrier.

With the great advantage of less environmental pollution when using e-bike, the government should promote the planning orientation of electric bicycle industry towards green industry based on the actual needs of the market. This development orientation should be aligned with the government oriented development in order to overcome the spontaneous market development and management loose.

The government should also have consistent tax preference policies for green industries to encourage the development of domestic production and e-bike industry. Projects related to the production of bicycles, electric bicycles, especially lithium high technology industries should be priority investment.

Monitoring, closely examining the market for anti-counterfeit, smuggled and fake vehicles; controlling strictly vehicle quality and stamps for vehicle sales on the market; implementing specific penalties, higher fines for illegally imported vehicles and tax evasion should be the major solutions to support the electric bike manufacturing industry in Vietnam.

7. CONCLUSION

Using e-bikes today is a common trend in Vietnam and other countries around the world such as China, Taiwan, Myanmar and India etc., as well as in developed countries such as the Netherlands, Switzerland, Germany, and Japan etc. Promotion of using e-bikes will bring many benefits to the economic and social environment such as saving travel costs, reducing pollution, saving energy, improving human health and probably proceeding to replace completely and effectively the gasoline motorcycles. Therefore, minimizing and limiting the use of lead-acid battery e-bikes, encouraging the use of lithium-ion battery e-bikes, building public infrastructures for e-bike's services in association with effective measures to manage and control effectively the vehicle quality should be implemented. In addition, the supportive polices for e-bike industry are also a very important to promote the use of e-bike in Vietnam.

Data relevant to e-bike use, e-bike consumers and producers in Vietnam is still very limited. Therefore, to fully understand the impact of e-bike use on environment as well as the important characteristics of e-bike consumer and producer and factors influencing on e-bike user's choice, another comprehensive research should be implemented in Vietnam market for further study in this field. The experience on e-bike management and relevant policies from other countries should be learnt and adopted for the successful application in Vietnam in the future.

REFERENCES

Almec (2012), “Basic data collection study on low – emission public transport system in Lao PDR”, Final Report, JICA, October 2012.
Asian Development Bank (ADB) and Sida (2009), Electric bikes in the People’s Republic of China: impact on the environment and prospects for growth”, Report, Mandaluyong City, Philippines: Asian Development Bank, 2009.
Asian Development Bank, 2009, Electric Two-Wheelers in India and Viet Nam Market Analysis and Environmental Impacts, ISBN 978-971-561-873-1.
Ch. Luan (2014) “The danger of China’s E-bike”, http://www.tuoitreonline/hiem-hoa-xe-dap-dien-trung-quoc, 19 May 2014.
CETD (2013), Research on electrical bus use in Hochiminh, Department of Science and Technology, Hochiminh city.
Christopher Cherry, Jonathan Weinert, Davis Chaktan Ma (2007) “The Environmental Impacts of E-bikes in Chinese Cities”, Working Paper UCB-ITS-VWP-2007-2 April, UC Berkeley Institute of Transportation Studies.
Duong Nhi (2013) “Potential dangers behind electrical bike trend” http://baophapluat.vn/xa-hoi/an-hoa-sau-con-sot-xe-dap-dien, 21 September 2013.
Jonathan Weiner, Chaktan Ma, Chris Cherry (2007), “The Transition To Electric Bikes In China: History And Key Reasons For Rapid Growth”, Working Paper, Transportation, 2007.
John MacArthur, Nicholas Kobel (2014), Regulations of E-Bikes in North America, Report NITC-RR-564, National Institute for Transportation and Communities (NITC).
National Traffic Safety Committee (2014), http://www.mt.gov.vn/PrintView.aspx ?ArticleID=14754, 04/01/2014.
National Traffic Safety Committee (2013), “Hidden dangers from electric bike”, http://antoangiaothong.gov.vn /hiem-hoa-tiem-an-tu-xe-dap-dien, 1/11/ 2013.
Nguyen Huong (2014), “Need to re-order the collection and recycling of lead batteries” dated 29 April 2014, http://tapchicongthuong.vn/can-lap-lai-trat-tu-trong-viec-thu-gom-tai-che-ac-quy-chi-20140429024057635p33c403.htm
Nguyen Son (2013), “Vietnamese enterprises localize electric bikes”, http://tienphong.vn/Kinh-Te/657141/doanh-nghiep-viet-noi-dia-hoa-xe-dap-dien, 17/11/2013.
Nguyen Son (2013), “Lack of development strategy for electric bikes, domestic e-bikes are afflicted”, http://thoibaokinhdoanh.vn/441/news-detail/thieu-chien-luoc-phat-trien-nganh-xe-dap-dien-hang-noi-dieu-dung/798386, 19/9/2013.
Nguyen Tong (2013), “More than 80% of traffic accidents caused by motorcycle”, http://www.congan.com.vn/tren-80%-tai-nan-giao-thong-d0-xe-may-gay-ra”, 16/4/2013.
Nguyen Van Nhan (2009), “Efficient use and energy saving policies in Vietnam”, AFD 2009, *International Conference on Energy Efficient Policy*, page 76.
Phan Duy Toan (2012) “Losses and harm due to urban traffic congestion” http://tuanvietnam.vietnamnet.vn/2012-01-31-that-thoat-va-lang-phi-do-un-tac-giao-thong-do-thi.
Tran Thuy (2013), “Smuggled electric bicycle: People likes so hard to manage”, http://www. vietnamnet.vn/vn/kinh-te/xe-dap-dien-nhap-lau-dan-thich-nen-kho-quan, 12/2013.
Viet Hung (2013), “Electric bicycle: Unsolvable problem of quality and management”, http://thuvienphapluat.vn/xe-dap-dien-nan-giai-bai-toan-chat-luong-va-quan-ly, 13/9/2013
www.nguoi-viet.com (2013), “Electric bicycles in Vietnam accused of environmental damage” dated 25 September 2013, http://www.nguoiviet.com/absolutenm2/templates/ viewarticles NVO. aspx? Articleid =174037& zoneid=2#.VYxNBxvtmko
www.xedapdien.com; http://xedapdienbridgestone.com; http://hkbike.com.vn

Appendix 1

Some Circulars, Decrees on the management of electric bicycle's use in Vietnam are as follows:

- Circular No.39/2013/TT-BGTVT of the Ministry of Transport dated 11 January 2013: Promulgate national technical regulations on electric bicycles QCVN number 68: 2013/BGTVT, effective from 01 January 2014.
- Circular No.41/2013/TT-BGTVT of the Ministry of Transport dated 11 May 2013: Regulations on technical safe quality control of electrical bicycle applied for domestic production, domestic assembly and import, effective from 01 January 2014.
- Decree No.171/2013/ND-CP of the Government dated 13 November 2013: Regulation on sanction of administrative violations in the field of road and railway, effective 1 January 2014 (alternative Decree No.34/2010/ND-CP of Government, Decree No.44/2006/ND-CP of Government). The next sitting person on electric scooters, electric bikes will also be fined if not wearing a helmet.
- Circular No.19/2014/TT-BGTVT of the Ministry of Transport dated 28 May, 2014: Amending and supplementing a number of articles of Circular No. 41/2013/TT-BGTVT dated 11 May 2013 of the Ministry of Transport of regulations on technical safe quality control of electrical bicycle, effective 15 July 2014.
- Decision No.69/2014/QD-UBND of People's Committee of Hanoi dated 20 August 2014: Payment fee for keeping/parking bicycle (including electric bikes, electric scooters), motorcycles, cars in Hanoi city, effective 31 August 2014. E-bikes are along with bicycle groups.
- Circular No.132/2014/TT-BTC of the Ministry of Finance dated 10 September 2014: Stipulating for collection level, collection and payment mechanism, management and use of payment fee of technical safety quality control for electric bicycle; fee of technical safety inspection and environmental protection for three-wheeler motorcycles and similar vehicles, effective 25 September 2014.

Appendix 2.

Table 1. Energy cost of electric bicycle for per kilometer

#	Item	E-bike with lead-acid battery	E-bike with lithium-ion battery
1	Number of batteries per set (battery)	4	1
2	Battery price (VND/battery)	400,000	4,000,000
3	Power consumption of a rechargeable set per charge /hour (W/hour)	135 (12V/12Ah, 4 batteries/set)	130 (24V/10Ah, one battery/set)
4	Average actual time for continuously recharging full battery set (hour)	5	5
5	The total power consumption for a full charge (kWh)	0.675 (135W x 5 hours)	0.65 (130W x 5 hours)
6	Unit price of electricity (includes 10% VAT)	2,000 VND/kWh	2,000 VND/kWh
7	Total money of electricity for a full charge	1,350 VND	1,300 VND
8	Average actual moving distance per charge (km)	45	85
9	Average cost per kilometer	30 VND	15.30 VND

Source: http://xedapdienbridgestone.com (2014); http://hkbike.com.vn (2014); author's data collection and calculation; Exchange rate on 5 February, 2015 of 21,365VND/US$ or 0.00004681USD/VND

Appendix 3.

Table 2. Emissions from E-scooter in comparison to a 4-stroke motorbike

Pollutant	Class 1	Class II	Class III	4-stroke

	Low Power E-scooter	Mid Power E-scooter	High Power E-scooter	motorbike
CO_2 (g/km)	16.1	20.5	27.7	55
BC (mg/100)	0.8	1.0	1.4	-
CO (mg/100 km)	31.5	40.2	54.2	1,250,000
NO_X (g/100 km)	1.3	1.7	2.3	15
OC (g/100 km)	0.4	0.5	0.6	-
PM_{10} (g/100 km)	0.3	0.4	0.6	10
$PM_{2.5}$ (g/100 km)	0.2	0.3	0.4	-
SO_2 (g/100 km)	1.9	2.4	3.3	-
VOC (g/100 km)	0.0	0.1	0.1	225

− = no data available, BC = black carbon, CO = carbon monoxide, CO2 = carbon dioxide, e-scooter = electric scooter, g/100 km = gram per 100 kilometers, g/km = gram per kilometer, mg/100 km = milligram per 100 kilometers, NOx = nitrogen oxide, OC = organic compound, PM10 = particulate matter 10, PM2.5 = particulate matter 2.5, SO2 = sulfur dioxide, VOC = volatile organic compound.
Source: Asian Development Bank, 2009, "Electric Two-Wheelers in India and Viet Nam Market Analysis and Environmental Impacts", ISBN 978-971-561-873-1.

The data shows on a per-kilometer basis, e-scooters can reduce CO_2 emissions by one-third to one half of a motorcycle's emissions. CO is practically undetectable compared to a motorcycle's emissions. The only pollutant that has a potentially higher emission rate during the use phase is SO_2, whereas SO_2 emission rates of vehicles using unleaded gasoline are often undetectable. (ADB, 2009).

The same study indicates that in 2005, 12 billion passenger-kilometers were traveled in Hanoi, or 8,000 km per motorbike. This clearly shows the immense emission reduction that is possible when an uptake in the use of electric bicycles takes place (ADB, 2009).

Appendix 4.

Table 3. Electric vehicle action on battery development in developed countries

Country	Battery development situation
USA	Advanced battery development project: United States Advanced Battery Consortium (USABC) (1991-) Freedom Cooperate Automotive Research (Freedom CAR) (2001-) Li-ion battery development for PHEV: Vehicle Technology Program (2009-)
EU	Standardizing the EV on charging process.
Germany	Innovation of Lithium Ion Batteries 2015
France	STEEV: research on next generation Li-ion battery development

Source: Almec, 2012; compiled by JICA Study Team based on various sources