

Business Models of a Solar Powered Charging Station for Electric Two-Wheelers in Hanoi-Vietnam

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Abstract: Nowadays, the market of electric vehicles (EVs) has grown increasingly powerful. This has affected strongly demand on the charging infrastructure that still is so scanty, for them. In addition to the increasing of charging stations from the grid, the solar power charging stations (SPCS) also should be considered because of the benefits that they could get back, such as no noise, chemical pollutants or radioactive substances, etc. Through the finding out on business models of SPCS for EVs on the world, the studied team will give the basic information on them and the potentials to apply them in the conditions of Vietnam (like in Hanoi).

Keywords: Electric vehicles (EVs), Solar power charging stations (SPCS), Business models of SPCS

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I. INTRODUCTION

Up to the end of 2012, the public charging stations for EVs have been presented on the world with about 50,000 units in some developed countries, such as United State, Europe, Japan and China [1]. At that moment, the goal of these stations is to support EV owners and encourage the development of EV industry, but the electric supplying to EVs in here has mainly taken from the grid using fossil fuels, and therefore, in fact, reducing the dependence on the fossil fuel is not really significant. In order to address the dependence on the fossil fuel and the reduction of greenhouse gases, the business models for solar powered charging stations have been considered to increase charging infrastructure for electric transportation. The combination of solar power and charging stations is one of the ways of the sustainable development for the EV industry of the nations on the world with 96% less mass of pollutants than all-electric vehicles using the grid [2]. The purpose of this paper is to provide some basic information about the business models of SPCS for EVs on the world and to propose business models of SPCS for electric two-wheelers in Hanoi (Vietnam).

1.1. Technologies of SPCS

The technologies of SPCS include two major ways: the supply sources from solar energy and grid (figure 1) or the supply sources from solar energy only (figure 2). Implementing the charging processes in Fig.1 is based on the condition of the EV battery, PV power and the grid electricity by the central controller with one of five modes: charging by PV only; charging by grid only occurs; charging by both PV and grid; no charging; and vehicle to grid (V2G).

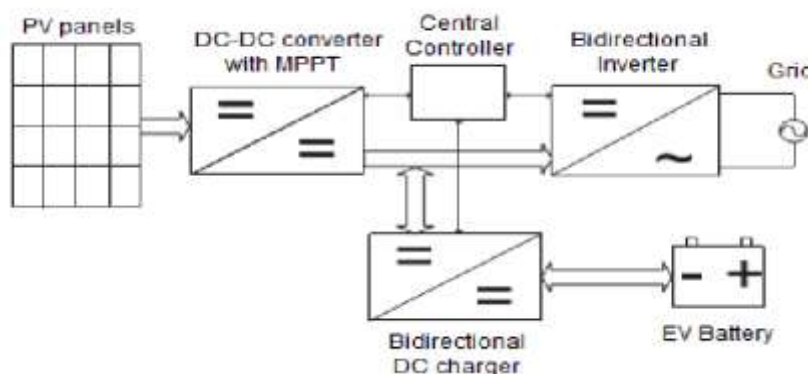


Fig. 1. The diagram of a solar and grid charging station for EVs [3]

And the charging in Fig.2 is done by using the power from PV panels to supply to EV through storage battery banks. Using intermediate storage equipment also enables to store the excess energy to serve in cases that the electric from PV panels is unavailable to supply for EVs. Of course, a direct connection between PV panels and EV without storage is possible, but the charging has to be impacted negatively if the power from PV is insufficient. Besides that, using battery banks also keep the output power of system away from the abrupt changes due to the intermittency of the solar irradiance.

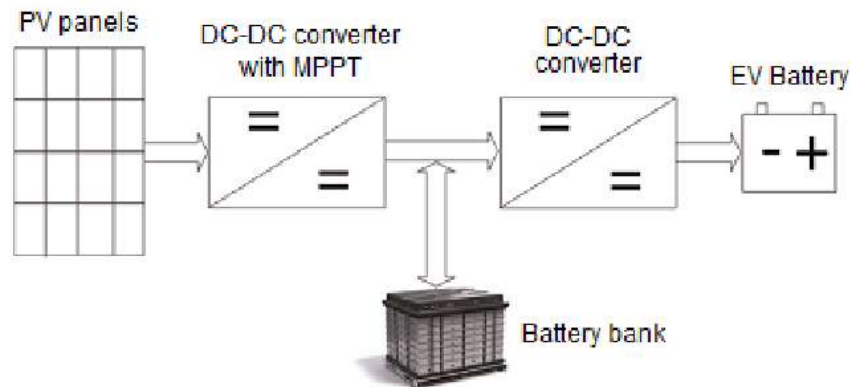


Fig. 2. The diagram of a charging station with solar energy only [3]

The performance of the SPCS technologies has three charge levels (level 1–3) at the electric charging stations: level 1 charging technology is the slowest one of three charge levels with charging rate of 3 to 5 miles/hour using a standard 120 VAC/15 A single-phase outlet and a standard J1772 connector for EVs [4,5]; level 2 charging technology has many capacities to apply than level 1 with charging rate of 12 to 75 miles/hour using a single-phase outlet standard with 240 VAC/up to 80 A and SAE J1772 standard to supply power [4,5]; level 3 charging technology is the fastest charging of three charge levels with charging rate of 100 to 300 miles/hour using a 480 V or higher voltage circuit of three phases and it required an off board charger to supply regulated AC–DC adapter and the standards for DC plugs [4,5].

1.2. Market of SPCS and EVs in Vietnam

It is easy to see that in Vietnam, the number of electric two-wheelers is more popular than of electric cars. They are divided two types, one with pedals (an electric bicycle) and one without pedals (an electric scooter). And the price for an electric scooter (720\$) and for an electric bike (even cheaper) in Vietnam are lower than in USA (800\$ for an electric bike) and EU (1,500\$ for an electric bike), but this cost is over the monthly minimum wage in Vietnam about 5 to 6 times [7].

However, in Vietnam, almost EVs are imported from the other countries, such as Japan, USA, EU, China, etc. In 2013, the number of electric two-wheelers is imported up to 117,000 units, increasing by nearly 49% in comparison with in 2012, with 53,000 electric bikes, and so by 2013, the number of electric two-wheelers in use reaches to 370,000 units with 150,000 electric bikes sold. In 2014, the quantity of electric two-wheelers increased to 500,000 units, and by September 2015, Vietnam’s EVs market for two-wheeler vehicles has grown to about 2.5 million units [6].

The form of electric two-wheelers is very variety, but basically, they have a battery bank to store the power and a motor on the rear wheel to transmit the motion. A customer uses a handle bar to control the speed and the stop of them. The voltage at batteries usually is in range of 36 V to 48 V and the capacity oscillates from 180 W to 4kW depending on electric two-wheelers used. Electric bikes usually have a maximum speed of 25 km/hour and the speed of electric scooters is higher than them, up to 50 km/hour [6]. The customers for these electric types in Vietnam often are pupils, students (about 70% in the ages of 14 and older), and middle-aged people because of its convenience, such as no license, low O&M cost, and less space parking. These customers also focus on in some big cities of Vietnam, like Hanoi, Ho Chi Minh City, Hai Phong, Da Nang, Thanh Hoa, Ha Long (Quang Ninh).

By the end of 2015, there are over 1086 electric cars in Vietnam to serve the need of personal and tourism in some big cities like Hanoi, Ho Chi Minh City, Da Nang and some tourism cities like Hai Phong, Ha Long (Quang Ninh), Sam Son (Thanh Hoa), Dong Hoi (Quang Binh), Hue, and Cua Lo (Nghe An) [6]. Almost of them are imported from China (Condi Panda), Japan (Mitsubishi, Nissan), USA (Tesla, Chevrolet) and EU (Renault). For example, in Hanoi, by the end of 2014, there are 50 units to serve the foreign tourists in here; in Ho Chi Minh City, by 2015, a pilot scheme on using electric cars have been deployed to serve tourists including some famous sites like Ben Thanh market, the Municipal Theater, the People’s Court Mansion, Saigon Notre-

Dame Cathedral, etc.; in Hai Phong, by 2015, there were 30 electric cars deployed for tourism in Do Son and Cat Ba with capable of transporting from 8 to 14 passengers each time [6].

It is easy to see that almost of electric cars are used in tourism service in Vietnam. The market for the personal electric cars seems not to be cared fully, and one of the causes is due to the authorities have not yet allowed the persons owned electric cars to get off the road because of the concerns about safety in traffic conditions of Vietnam. It means that similar to the electric two-wheelers, these vehicles are not officially regulated in the Law of Road Traffic, and that there are not any agencies that are responsible for license registration, safety control, traffic monitoring system, etc. By now, there is only an official *dispatch No.4638/BGTVT on April 14th 2015* submitted to the Prime Minister from Ministry of Transport about propose the regulation of automobiles (with electric or fuel engine) and that the Public Security Ministry oversee the registration of all electric cars. These issues have been being the major challenges for the development of electric cars industry in Vietnam.

II. BUSINESS MODELS OF SPCS IN HANOI – VIETNAM

2.1. Development trends

2.1.1 Model for universities, high schools

As above mention, by now, in big cities of Vietnam, most people used electric two-wheelers are pupils, students, and middle-aged people. And so, the parking lots at universities and high schools with SPCS should be built together to serve pupils, students, teachers, staffs, in which both level 1 and level 2 charging stations are available for this infrastructure. In addition to supply the power to charge EVs, SPCS will provide the other benefits, such as shade, protection from weather, improved image, and education here. Selling annual/monthly parking permits for pupils, students, teachers, and staffs to park on campus also will be an income source for host organization.

Investing on SPCS at universities and high schools will be inherited tax incentives following the policies for renewable energy (RE), such as *Prime Minister's Decision No.53/2004/QĐ-TTg on 17th August 2004* about Strategic direction for sustainable development in Vietnam, *Prime Minister's Decision No. 130/2007/QĐ-TTg on 2nd August 2007* about Financial policy for investment projects in clean development program (CDM), *Government's Decree No. 24/2007/ND-CP on 14th February 2007* about detailing the implementation of the Law on Enterprise Income Tax.

2.1.2 Model for state agencies

Basically, SPSC in these agencies is similar to SPSC in universities and high schools, but these charging stations should be free. This charging infrastructure will be level 1 and level 2 charging station.

Free charging is to improve the image of the state agency, to encourage purchases of electric vehicles, and to reduce emissions and to get targets on RE following country's plan, e.g. *Prime Minister's Decision 1775/QĐ-TTg on November 2012* about Management of GHG emissions; management of carbon credit trading activities to the world market, *Government's Resolution No. 24-NQ/TW on June 2013* about Pro-actively responding to climate change, enhancing natural resource management and environmental protection, and *Law on Environment on June 2014*, support to INDC (*Intended Nationally Determined Contribution*) implementation in Viet Nam, *Prime Minister's Decision 2068/QĐ-TTg, 25 November 2015* on the Approval of the Viet Nam Renewable Energy Development Strategy (REDS) up to 2030 with an outlook to 2050, and the revised *Power Development Plan VII (PDP VII-revised)*.

2.1.3 Amusement Center

In Hanoi, there are many the amusement centers like theaters, cinemas, play stations, bars, clubs, coffee shops, etc., and at these centers, the customers ready spends many time and money to relax and relieve stress from the life and work. The combination between the amusement centers and SPCS owners will get benefits from the business partnership, such as improved image, greater customer base, and shaded parking for amusement centers, and SPCS owners is able to market their name, improve their own image, and increase their profits from customers' charging.

In this case, the pricing structure for the stations could be set up following the parking price structure at the amusement centers before. Both level 1 and level 2 charging options should be provided: level 1 should be provided since some electric vehicles can only handle this level charging and some customers spend the majority of their day in here; and level 2 should also be provided since some customers only stay for an hour or two and thus need a faster charging rate.

Besides that, in Vietnam, the power purchase agreements (PPAs) could help reduce the initial investment and maintenance cost of SPCS for host businesses since the partnering business owns the stations.

2.1.4 Shopping Center

Like the amusement centers, nowadays, in Hanoi, there are many shopping centers with 10 or more businesses in a plaza, such as Vincom plaza, Trang Tien plaza, Aeon mall, etc. And of course, the customers ready spends many time and money to shop the goods in here.

Basically, the business model of SPCS at shopping centers similar to amusement centers. The combination between the shopping centers and SPCS owners will get benefits for involved partners. However, because these businesses share together parking spaces, they also share the cost of the SPCS. For example, the businesses could use the same pricing structure (hourly rate or flat fee) for the SPCS fees, or use the different pricing structures for the other objects as staffs, loyal customers and normal customers; the customers who do not have EVs can benefit from shaded parking provided by the SPCS and only pay fees the same as before. And in order to attract the customers, the businesses could partial support fees by using store income to pay for the SPCS installation and maintenance, and the electricity consumed that is not already offset by the generated solar power. Using sales tax also allows customers to indirectly pay for the SPCS as they purchase food or items at the shopping center stores.

2.1.5 Public parking stations

Now, in Hanoi, almost EVs are electric two-wheelers owned by residents here and stored in their houses, and the electric cars are used in serving tourism and owned by travel agencies. And so, in near future, the investment in public parking of SPCS is not yet really necessary. The travel agencies could link to SPCS owners to provide SPCS services for their EVs. The combination between SPCS owners and the travel agencies will share together benefits similar to the combination with amusement centers and shopping centers, such as improved image, greater customer base, shaded parking, charging, etc.

When the electric cars become much more and more popular, the city could install SPCS for public parking along streets and in lots, where there is free or metered parking, and in parking garages, where there is often an hourly rate to encourage economic activity from tourists, electric vehicle owners and environmentalists. In less convenient or less frequented places, free charging for SPCS should be provided to encourage EV owners to travel and entice them to shop at local businesses. For parking spots with metered parking, SPCS should be provided with hourly rate charging to encourage more vehicle turnover, allowing more drivers to use the well-located SPCS spaces. The city can use a portion of sales tax and tax incentives to help pay for the installation, maintenance, and electricity usage.

2.1.6 Public charging stations

Currently, in Hanoi, there are some the free public charging stations for electric two-wheelers with electric getting only from the grid (without using solar energy) by EV trading companies in order to support and encourage EV owners. With the solar potential up to 3,5kWh/m²/day in Hanoi [8], it is possible for the city to exploit and invest the public SPCS for commercial purposes. These public charging stations will be hourly priced charging with level 2 and level 3 SPCS, in which the charging electric will be from both grid and solar energy, and the SPCS level will depend on the partner and customer needs. The public charging stations have the ability to charge a certain price per kWh of electricity approved by authority agencies. The charge rate can be slightly high for the consumer to get a profit, but, these higher priced SPCS will have to be available in convenient locations so customers can use easier.

Besides that, the partnerships between the city and the involved agencies, such as EV suppliers, PV suppliers, or electric charging station companies, and advertised companies, will get back for the city with benefits from improved image, advertising, tax incentives, etc.

2.2. The business model of SPCS for the university in Hanoi

The chosen university is University of Science and Technology of Hanoi (USTH) which is established in 2009 under the Intergovernmental Agreement between Vietnam and France. Now, using the parking lot in USTH often cost money. Therefore, if installing SPCS station, users also have to pay money for using this station, but the cost for parking permits should be same with the previous cost. In other words, charging for EVs at SPCS parking is free, and that this incentive is necessary to encourage students, teachers, staffs in using EVs and response the call of the government on RE development plans in Vietnam.

For operation and development the SPCSs here, they should be inherited tax incentives abreast of the income generated from station use, such as shade, shelter and improve image, etc. USTH also could link to some involved partners to get back the benefits to pay for operation and maintenance SPCS. USTH needs the partners: installers, certification authorities, government, EVN, research labs, PV suppliers, electric equipment companies (electric equipment including electrical cabinets, switchboards, wiring, breaker, inverter, charger, battery, etc...), advertising companies, retailers, and EV owners. The combination with the installers will help reduce the overhead for installing the charging station; with the certification authorities is to receive the

certification of CERs, LEED; with the government is to get tax incentives and PPA; with EVN is to trade the power generated; with research labs is to test the conformity of facilities; with PV suppliers and electric equipment companies is to get solar PVs and electric equipment for the charging station with preferential prices; with advertising companies is to help advertise the image of USTH and other partners to community; with other retailers is to receive the finance support in advertising their image; and of course, in addition to loyal customers as students, teachers, staffs of USTH, the charging station will have more other customers from surrounding communities.

Besides the key purpose is the charging and parking, the station has the other activities to get more benefits, like supplying advertising service, selling emission certifications and purchase electric to/from EVN. And therefore, through the partnerships and activities of SPCS, USTH can get back revenues from use of the station, that is the cost from parking permits, improving image, advertising, reducing their electricity bill with generated solar power, selling emission certifications and purchasing electric to EVN (if there).

Business model applied for USTH is illustrated briefly in below table 1.

Table 1. Business model canvas of SPCS at USTH

Key Partners +Suppliers of PV, electrical equipment +Retailers +EV owners + Research labs +Certification authorities +Government +Installers + EVN	Key Activities +O&M SPCS +Supplying charging service +Supplying parking service +Supplying advertising service +Sell emission certifications +Purchase power to/from EVN	Value proposition + Education tool + Get money from parking, advertise + Improving image + Reducing the electricity bill + Reducing GHG emissions + No noise + Clean transport	Customer Relationships + Parking + Charging + Advertise + Power purchase + Emission Certification purchase	Customer Segments + EV owners + Parking user + Suppliers PV and electrical equipment + Advertiser + Retailer + Power purchaser + Emission Certification purchaser
	Key Resources + Solar potential + Support policy + EV owners + Retailers		Distribution Channels + Social media (internet, TV, radio, advertising) + High user rate	
Cost Structure + Installed cost + Equipment costs + Test and certification cost + Electrical cost from the grid		Revenue Stream + From parking permits + From advertising at the station + Improving image + Purchase electric from/to EVN + Selling emission certification		

III. CONCLUSION AND RECOMMENDATION

3.1. Conclusion

In order to develop in stability and environment friendly, EVs must be used and become an important industry in the future. And in order to reduce the dependence on fossil fuels and the pollution of emissions, SPCS infrastructure must be increased more and more, not only in some countries but also on the whole world. Increasing of these charging stations will encourage more EV purchases and distribute to promote the development of EV industry. In addition to the public charging stations, these SPCSs also should be integrated at the convenient locations for user, such as shopping centers, amusement centers, restaurants, bars, clubs, universities, schools and work places; and SPCS charging levels (level 1, 2, or 3) will depend on the selected location. The combination between the involved partners (government, companies, investors, businesses, non-profit organizations, cities, etc.) will generate profits and help shift the balance of power from fossil fuels to alternative fuel sources, e.g. solar energy.

In Vietnam, applying the business models of SPCS existed on the world is very advantageous due to the favors of nature conditions (high solar energy potential) and the need of Vietnamese people in using EVs and SPCS is very big. Basically, the business models in Vietnam and on the world are similar. It means that SPCSs should be installed at convenient locations for user, besides of locations at home, workplace, university, high school, also locations at shopping centers, amusement centers, restaurants, etc. These models also should be implemented under the cooperation of the relevant partners, such as equipment suppliers, traders, investors, businesses, authority organizations, etc. The benefits getting from SPCS also are tax incentives, improved image, increased customers, and reducing the electricity bill.

3.2 Recommendation

The business and use of EVs and SPCS in Vietnam has its own characteristics. For example, currently, almost EVs are two-wheelers vehicles, so the charging level of SPCS only should be up to level 2 and the

capacity of the charging station should not be too high (about 20 kW over a station is enough for 5 – 10 EVs at once); almost EVs owner live in big cities, so developing SPCS in these cities should take precedence first; almost EVs owner are pupils and students, so installing these charging stations in universities and high schools also should be done first. Another noted point is about the policies for EVs and SPCS in Vietnam, they are lacks and not yet strong enough, so investing SPCS should be begun with benefits from tax incentives, improved image, increased customers, and reducing the electricity bill. Within the framework of this mini-project, the studied team has showed the key features of the business models of SPCS on the world and presented the fit business models in conditions of Vietnam, especially in Hanoi and for USTH. Nevertheless, because of the limitation in term of time and the lack of input data of EVs and SPCS (about a quantity, technical parameters, a status of use, a support policy), it is difficult for the studied team to propose the business models in fully and more clear. In near future, we really hope to have an opportunity to study further and deeper in this subject.

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