**This is the Pre-Published Version.**

The following publication I. P. S. Chuen and K. W. E. Cheng, "Charging support in battery electric vehicle (BEV) development," 2017 7th International Conference on Power Electronics Systems and Applications - Smart Mobility, Power Transfer & Security (PESA), Hong Kong, China, 2017 is available at https://doi.org/10.1109/PESA.2017.8277738.

# Charging Support in Battery Electric Vehicle (BEV) Development

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***Abstract*—A recent study shows that the on-road transportation contributes to the major part of oil consumption. By replacing the on-road Car with Electric Car, huge amount of oil consumption can then be cut off. However, fossil fuel consumption by power generation will increase while the number of electric cars is increasing unless the portion of fossil fuel consumption uses renewable energy. Although the electric car technology is ready for practical usage, charging problems appeared to slow down the transformation from traditional car to electric car. This paper is going to investigate charger to electric car ratio and strategy. The charging problem on BEV development by different countries such as the US, the UK and China will be illustrated as examples. From the present data of charger and amount of EV, it is possible to predict the demand of chargers for BEV development in the future. Moreover, charger building strategy can be defined base on the users habit.**

## I. Introduction

The number of Charging Stations determines the convenience of electrical car usage since the range of electrical car is comparatively lower than traditional car. Furthermore, the charging time is incomparable to gas refilling, this reduces the incentive of owing an electrical car. A quick look around the world, Global EV outlook 2017 [1]indicated that the EV stock is around 2 million and the sum of total public charging outlets is around 322 thousand in 2016. This implies that the ratio of Electric cars and public charging outlets is 6 to 1. Although this ratio is reasonable, the ratio across countries varies a lot. Therefore, it should be studied case by case. [2] Additionally, in order to achieve higher efficiency of charger usage, different types of chargers should be allocated to different locations that will satisfy most of users.

## II. BEV stock in different countries

Table 1 EV Market

| EV Market Share | 2014 | 2015 | 2016 |
|---|---|---|---|
| The US | 139.28 | 210.33 | 297.06 |
| The UK | 14.06 | 20.95 | 31.46 |
| Germany | 17.52 | 29.6 | 40.92 |
| France | 27.94 | 45.21 | 66.97 |
| Norway | 41.8 | 72.04 | 98.88 |
| Japan | 60.46 | 70.93 | 86.39 |
| China | 79.48 | 226.19 | 483.19 |

To commence, the report [1] indicated the US and China are the major market of BEV around the world. France, Germany, the UK, Japan, Norway also share relatively larger amount of market share shown in the following Table

Table 3: Fast Charger

| Fast Charger | 2014 | 2015 | 2016 |
|---|---|---|---|
| The US | 2.52 | 3.52 | 5.38 |
| The UK | 0.48 | 1.12 | 1.52 |
| Germany | 0.32 | 0.78 | 1.40 |
| France | 0.13 | 0.54 | 1.23 |
| Norway | 0.25 | 0.7 | 1.05 |
| Japan | 2.88 | 5.99 | 5.99 |
| China | 9.00 | 12.1 | 88.48 |

Table 2: Slow Charger

| Slow Charger | 2014 | 2015 | 2016 |
|---|---|---|---|
| The US | 20.12 | 28.15 | 35.1 |
| The UK | 7.43 | 8.7 | 10.7 |
| Germany | 2.6 | 4.79 | 16.55 |
| France | 1.70 | 10.12 | 14.61 |
| Norway | 5.19 | 5.29 | 7.10 |
| Japan | 8.64 | 16.12 | 17.26 |
| China | 21.00 | 46.66 | 52.78 |

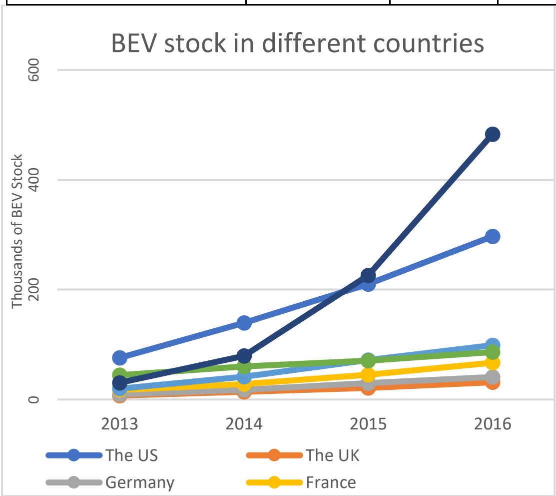

Figure 1 BEV stock

## III. Electric Vehicle Supply Equipment

According to the same report, there were 40 thousand public connectors in the US, 12 thousand in the UK, 18 thousand in Germany, 15 thousand in France, 7 thousand in Norway, 23 thousand in Japan and 141 thousand in China by 2016 shown in Table 2 and Table 3.

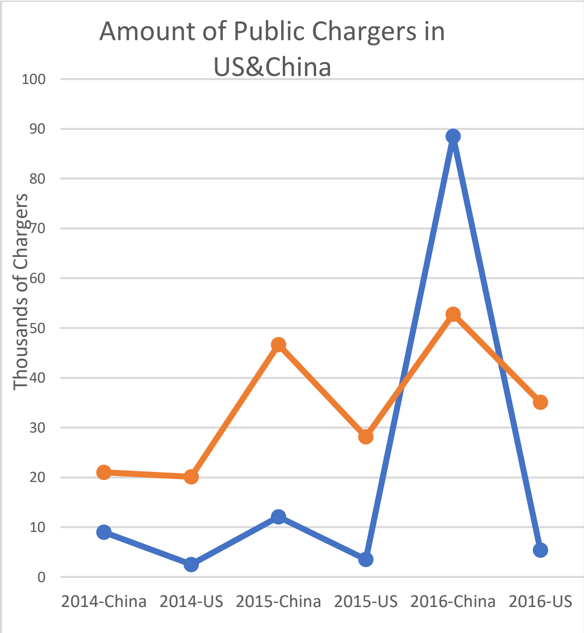


Figure 3 Charger Amount

It is not difficult to see that China owns the greatest amount of fast chargers from the beginning. Since the US and China are the major market of BEV, they are good examples to illustrate the relation between BEV and the amount of charging points.

The data above shows the fact that China keeps building large amounts of chargers either fast charger or slow charger. This serves as a strong support of BEV development. To better illustrate the relation, the BEV to charger ratio is then calculated in order to compare both of them.

## IV. BEV TO CHARGER RATIO

The ratio between BEV and charger is calculated as below in Table 4.

Table 4: Ratio of BEV to Charger

| | BEV:Slow | BEV:Fast | BEV:Total |
|---|---|---|---|
| **China** | | | |
| 2014 | 3.78 | 8.83 | 2.65 |
| 2015 | 4.84 | 18.69 | 3.85 |
| 2016 | 9.16 | 5.46 | 3.42 |
| **US** | | | |
| 2014 | 6.92 | 55.31 | 6.15 |
| 2015 | 7.47 | 59.69 | 6.64 |
| 2016 | 8.47 | 55.17 | 7.34 |

Table 5: New EV Registration

| New EV Registration | 2014 | 2015 | 2016 |
|---|---|---|---|
| The US | 63.42 | 71.04 | 86.73 |
| China | 48.91 | 146.72 | 257 |

The ratio in the US generally higher than that in China while the ratio in fast charging is much higher. This situation will potentially slow down the climbing rate of new BEV sales so that it will take longer time to phase out all traditional cars. In reality, new registration of BEV in these two countries is quite different for the last few years. It implicates the importance of building public charging stations.

## V. NEW BEV REGISTRATION

Obviously, the growing rate in China is much higher than that of the US. It shows that lower BEV to charger ratio is the key stone to drive BEV development.
By assuming that the ratio 3:1 (current ratio in China) provide a better support for BEV, it is easy to predict the future demand of charging points.

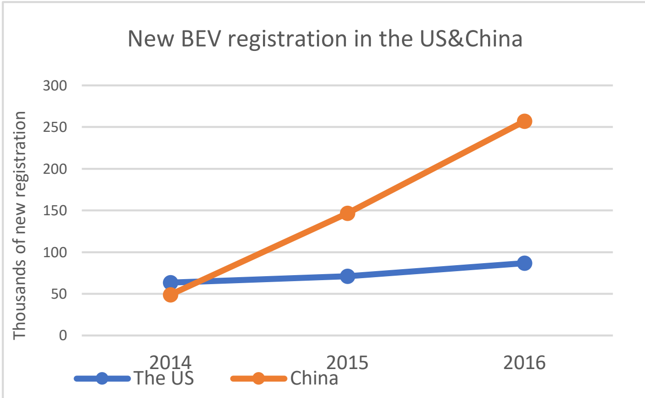


Figure 2 BEV New Registration

## VI. FUTURE DEMAND

Assume the rising rate of BEV follows the same rate of last few years, BEV stock can be estimated as the figure 4.

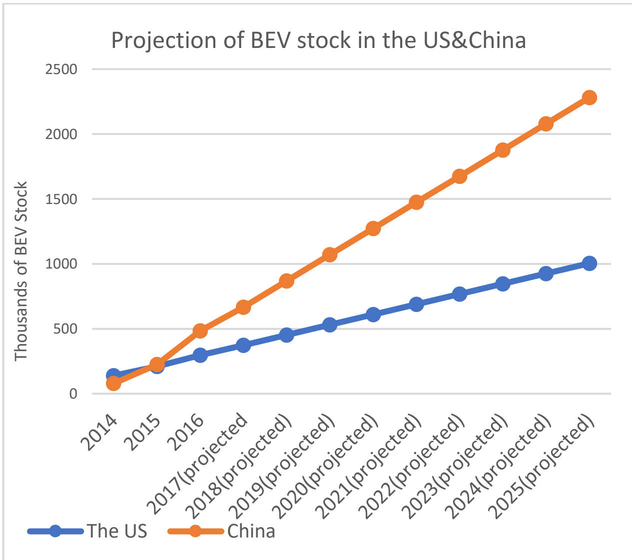


Figure 4 Future BEV Stock Projection

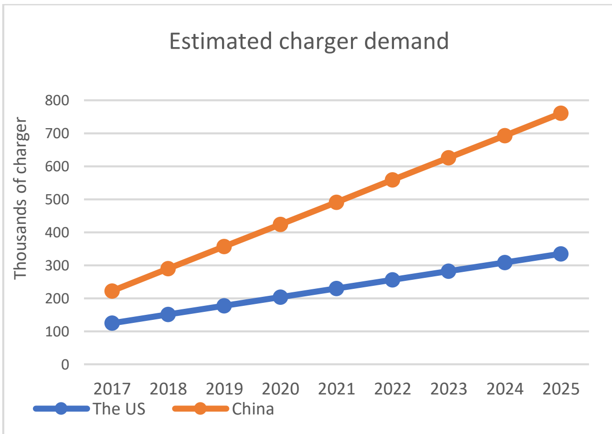


Figure 5 Future Charger Demand

In order to keep the ratio at 3:1, total amount of chargers is estimated in figure 5.

## VII. FAST CHARGING AND SLOW CHARGING

Although the number of chargers provides a rough illustration, the charger type, locating strategy and pricing strategy are the more critical factors. Standard SAE J1772 defines six charging type, but only three are commonly used for electric vehicles. Level 1 operates at 120 VAC that offer 1.4 to 1.9kW, while Level 2 required 208 or 240 V AC that deliver 7.2 to 19.2 kW. On the other hand, fast charging operates at 200 to 450 VDC that provide 50 to 150kW [3]. In a more general saying, slow charging usually means overnight charging which require six to eight-hour (level2) period for 100km range [4]. It should be fine, if every parking space is equipped with a slow charger. But the fact that installing a charger for every parking space is not cost effective since chargers are not going to be used simultaneously. The other option is fast charging which means the electric output is able to deliver 50 kW – 150 kW. In this output rating, chargers can deliver 100km range in 10-30 minutes. Two types of charger go different ways of purpose. Fast charger serve the users with urgent needs. Slow charger target domestic car park or car park at work place which the cars usually stay for over 6 hours. Utilizing these charger with different strategy will deliver a more cost effective planning.

## VIII. DRIVING PATTERN AND CHARGING LOCATION

The location of the charger is important. This is highly related to the drivers' route, pattern and the EV users. The planning is therefore important.

Before the actual planning, driving pattern of users should be evaluated first. For example, the general traveling distance is shorter than 100km for a user in Chicago and Seattle. Travelling distance over 100km users only occupy 6% and 10% respectively in the total users while the mean distance per day is around 40 to 50 km for two cities [5].

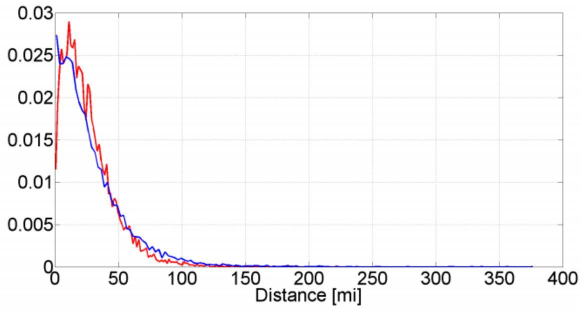


Figure 6 Traveling Distance Probability Density Function

This data is then be transform into probability density function of total number of vehicles on the road vs time graph:

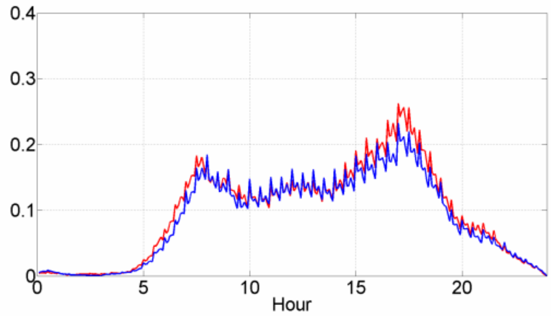


Figure 7 Total Number Of Vehicle On The Road Probability Density Function

The graph shows that the number of vehicles tends to be peak in the morning and the afternoon while they are travelling between work place and home. If this phenomenon can be applied to other main cities around the world. It is not difficult to work out a plan to optimize the charging condition.

## IX. LOCATION STRATEGY

According to the resultant data above, location of chargers should be easy to define. Since electric car often remain stay at least 6 hours at mid-night while the users are sleeping. Assume they are sleeping at home, slow chargers is a cost-effective option to place numerously inside domestic car park. For public area or commercial area such as shopping mall, fast charger should be proposed since the stay is much shorter.

## X. CONCLUSION

As far as the charging problem of BEV is concerned, it is no doubt that charger is the key support for BEV growth. China shows the fact that keeping the EV to charger ratio can provide a better environment for EV. However, chargers can be utilized that based on location strategy, charging type strategy.

The discussion between the ratio of fast charger and the medium power charger is ongoing. The installation of high power chargers need the support of power distribution and most of the existing facility or establishment are not able to support. The ultimate goal is every 5 charger, there is at least one fast charger. Every 10 EVs, there is at least 0.5 charger

## ACKNOWLEDGEMENT

The authors grateful acknowledge the support of Research committee of the Hong Kong Polytechnic University under the reference ZDAN

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