Prediction on the charging demand for electric vehicles in Chengdu

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Abstract. The development of the electric vehicle charging station facilities speed directly affect the development of electric vehicle speed. And the charging demand of electric vehicles is one of the main factors influencing the electric vehicle charging facilities. The paper collected and collated car ownership in recent years, the use of elastic coefficient to predict Chengdu electric vehicle ownership, further modeling to give electric vehicle charging demand.

1. Introduction
Electric vehicle charging and switching facilities are an important facility for electric vehicles and are the main factors influencing the development and promotion of the electric vehicle, however, electric vehicle charging demand is one of the main factors which affect the effect of charging station layout, only by accurately predicting the charging demand, can rational layout of the electric vehicle charging station be achieved. There are many kinds of predicting methods for electric vehicle charging demand. In this paper, a systematic method is used to predict the charging demand of electric vehicles in Chengdu.

2. Prediction Idea
The elastic coefficient method is used to predict the number of cars in Chengdu city by 2020, and then establishes the model and combines the current situation to analyze and predict the annual car ownership and charging demand of the private cars, taxis and buses and electric vehicles.

3. Prediction of the car ownership
3.1 The Introduction of the Methods
The Elastic Coefficient Method is an indirect prediction method which is based on the prediction of the development and change of a factor and predicts the development of another
factor by the elastic coefficient. The Elasticity Coefficient Method is an indirect prediction method for the development of another factor on the basis of the change of one factor. From a mathematical point of view: 

\[ E = X \cdot f'(x) + f(x) \]

\( E \) means elastic coefficient, that is the limit of ratio 

\[ x \cdot f'(x) + f(x) \]

of the relative increment of the function \( f(x) \) and the relative increment of the independent variable \( x \) is the elastic coefficient of the function \( f(x) \). It is seen that the elastic coefficient of the function \( f(x) \) is the ratio of the relative change of function and relative change of independent variable, which correctly reflects sensitivity of the changes between them, elastic coefficient \( |E| = 1 \) shows the relative change between the two and is called a single elasticity, the elastic coefficient \( |E| = 1 \) means that the relative change of \( Y \) is greater than the relative change of \( X \), which is called elasticity, the coefficient of elasticity means that the relative change of \( Y \) is less than the relative change of \( X \), which is called inelasticity.

Based on the definition of the elastic coefficient method here, we take the current GDP data change and predict the growth rate of car ownership, and the formula is as follows:

\[ R = R_{gdp} \cdot E \]

\[ N_n = (1 + R) \cdot N_{n-1} \]

In the formula, R- Annual growth rate of car ownership

\( R_{gdp} \)-GDP Growth rate

\( E \)- Elastic coefficient

\( N_n \) - car ownership in N year

\( N_{n-1} \) - car ownership in N-1 year

3.2 Prediction of the car ownership

Although in the new energy vehicles plan of Sichuan province and put forward our electric car development goal, but because of the charging infrastructure, and the limitation of charging technology, for the development of it will be hard to achieve our goals. Therefore, this paper combines relevant theoretical models and analyses the actual status quo to predict the car ownership of Chengdu in the future.

The number of automobile grew slowly due to the slow development of the national economy a few years earlier ago, however, in recent years, the rapid economy develops rapidly, the growth of car ownership has become rapidly, showing explosive trend. But according to the slow growth of GDP, it will make domestic car ownership tend to saturation in the next few years, the growth rate will gradually decline in the future. According to the GDP growth prediction of the National Statistical Bureau respectively 9%, 8% and 7% during "11th Five-
According to Table 1 and Table 2, the growth rate of the car ownership of China and the annual growth rate of GDP in China can be obtained by combining formula 1-1. The elastic coefficients of the over years are shown in Table 3 below.

### Table 1. Car ownership of our country from 2008 year to 2016 year

| Year | Car ownership /units | Annual increase/ten thousand units | Annual growth rate/% |
|------|----------------------|------------------------------------|---------------------|
| 2008 | 5099.6               | 741.0                              | 17.0                |
| 2009 | 6280.6               | 1181.0                             | 23.1                |
| 2010 | 7801.8               | 1521.5                             | 24.2                |
| 2011 | 9356.3               | 1554.5                             | 19.9                |
| 2012 | 10933.1              | 1576.8                             | 16.8                |
| 2013 | 13700.0              | 2766.9                             | 25.3                |
| 2014 | 15400.0              | 1700.0                             | 12.4                |
| 2015 | 17200.0              | 1800.0                             | 11.6                |
| 2016 | 19400.0              | 2200.0                             | 12.7                |

### Table 2. The situation of GDP from 2008 year to 2016 year

| Year | GDP/Hundred million yuan | Annual growth/hundred million yuan | Annual growth rate/% |
|------|--------------------------|-----------------------------------|---------------------|
| 2008 | 316751.7                 | 27744.7                           | 9.6                 |
| 2009 | 345629.2                 | 28877.5                           | 9.2                 |
| 2010 | 408990.3                 | 63361.1                           | 18.3                |
| 2011 | 484123.5                 | 75133.2                           | 18.3                |
| 2012 | 534123.1                 | 49999.6                           | 10.3                |
| 2013 | 588018.8                 | 53895.7                           | 10.1                |
| 2014 | 640000.0                 | 51981.2                           | 8.8                 |
| 2015 | 689052.0                 | 49100.0                           | 7.6                 |
| 2016 | 744127.0                 | 54900.0                           | 7.9                 |

Combining the formula and principle of the elasticity coefficient, taking into account elastic coefficient in 2009 and 2003 is too large to considered, the average value of the elastic coefficient were 1.4 from 2008 to 2014, So the elasticity coefficient of 2015 is regarded as 1.4. Because this paper considers to predict car ownership in the future, the growth rate of GDP slowly decreases, while car ownership has gradually become saturated value, which there is a transitional phase, elastic coefficient must gradually reduce, so the elasticity coefficient in 2016 is regarded as 1.2, the elastic coefficient should be less than 1 and be regarded as 0.8 from
2017 to 2020, that is the growth rate of the car ownership is 0.8 times the annual growth rate of GDP. According to the resulting elasticity coefficient and GDP growth rate, based on 2014, car ownership of 2015 to 2020 could be predicted table 4.

**Table 4.** Car ownership in Chengdu from 2012 to 2020

| Year | Growth rate of car ownership /% | GDP growth rate /% | Elastic coefficient | Vehicle population /hundred million units |
|------|--------------------------------|--------------------|---------------------|-------------------------------------------|
| 2014 | 16.8                           | 12.0               | 1.4                 | 336.1                                     |
| 2015 | 18.0                           | 12.0               | 1.5                 | 396.5                                     |
| 2016 | 12.32                          | 7.7                | 1.6                 | 445.3                                     |
| 2017 | 9.8                            | 7.0                | 1.4                 | 488.9                                     |
| 2018 | 7.7                            | 7.0                | 1.1                 | 526.5                                     |
| 2019 | 5.6                            | 7.0                | 0.8                 | 555.9                                     |
| 2020 | 5.6                            | 7.0                | 0.8                 | 587.0                                     |

According to predicted national car ownership, combining with the proportion of electric car ownership which is predicted by the Ministry of Industry 0.28% and 2.2% in 2015 and 2020. Here, the paper predicts the number of electric vehicles in Chengdu according to the three high, middle and low ratio schemes. Among high, low and middle ratio schemes, 2012, 2015 and 2020, respectively, 0.6%, 2%, 9%, 0.3%, 1.2%, 6%, 0.1%, 0.3% and 3%. Taking into account the electric vehicle due to national policy and its various aspects will certainly present increasing trend of rapid growth during 2014 to 2020 and fully consider the study and take the proportion of electric vehicles from 2012 to 2020. The prediction is shown in Table 5 below.

**Table 5.** Car ownership of the vehicle car over years

| Year | situation | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------|-----------|------|------|------|------|------|------|------|------|------|
|      | different |      |      |      |      |      |      |      |      |      |
|      | rate      |      |      |      |      |      |      |      |      |      |
|      | high/%    | 0.6  | 0.9  | 1.3  | 2    | 2.5  | 3.5  | 5    | 7    | 9    |
|      | middle/   | 0.3  | 0.6  | 0.9  | 1.2  | 1.8  | 2.6  | 3.4  | 4.6  | 6    |
|      | low/%     | 0.1  | 0.14 | 0.2  | 0.3  | 0.5  | 0.9  | 1.5  | 2.2  | 3    |
|      | number    | 1.44 | 2.77 | 4.36 | 7.90 | 11.13| 17.11| 26.33| 38.91| 52.83|
|      | middle    | 0.72 | 1.84 | 3.02 | 4.76 | 8.01 | 12.71| 17.90| 25.57| 35.22|
|      | low       | 0.24 | 0.43 | 0.67 | 1.19 | 2.23 | 4.40 | 7.90 | 12.22| 17.61|

Taking into account the actual situation, choosing the data of the low scheme to calculate. According to the introduction of the development stage, in the early stage, there is the development of the bus, taxi and other fields, the slow development of private cars; but for the long-term, private cars lies in a stage of rapid development and will show explosive growth, while buses and taxis is steadily developing. Based on this situation, this paper hypothesizes taxi, bus and private cars accounted for the proportion of electric car ownership as in Table 6 shown in 2014 to 2020, taking into account the actual situation, the paper chooses electric vehicle ownership to predict low scheme to calculate the number of private cars and taxis, table 7 can be obtained.

**Table 6.** Proportion of cars in the different market

| Year | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------|------|------|------|------|------|------|------|
| Private car | 20%  | 40%  | 60%  | 78%  | 87%  | 90%  | 92%  |
Table 7. The number of the Private car, taxi and bus

| Year | Vehicle car | Vehicle car | Vehicle car | Vehicle car | Vehicle car | Vehicle car | Vehicle car |
|------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 2014 | 6700        | 11800       | 22000       | 42400       | 75500       | 118400      | 172700      |
| 2015 | 1340        | 4720        | 13200       | 33072       | 58890       | 106560      | 158884      |
| 2016 | 2010        | 2950        | 3960        | 4240        | 5285        | 5328        | 6908        |
| 2017 | 3350        | 4130        | 4840        | 5088        | 6040        | 6512        | 6908        |
| 2018 | 4040        | 4310        | 5200        | 5500        | 6200        | 6600        | 7200        |
| 2019 | 4750        | 4510        | 5600        | 6000        | 6800        | 7200        | 7800        |
| 2020 | 5500        | 5210        | 6000        | 6500        | 7200        | 7700        | 8300        |

4 Prediction of Charging Demand

The charging demand for electric vehicles is to prepare the layout of the electric charging station, so the prediction of its demand should firstly consider the layout and facilities of the charging station.

4.1 Predicting Premise

1) Now, the average mileage of batteries for electric vehicles is 180 kilometers, but as time goes on, the relevant experts predict that in the next 5 years, electric vehicle mileage will reach 300 km or more, but because the mature time of the technology is full of uncertainty, and considering the deep discharge of the automobile, the service life of the battery will be affected.

2) The main charging mode of the private car is regular charging, which is supplemented by charging in the public fast charging station. So supposing that the car is charged at the public quick charging station, once from Monday to Friday and once at the weekend.

3) Taking into account the battery life problems and high depreciation costs, and now the technology and other issues, the construction of the public rapid charging station is based on the principle that the main battery replacement is considered, DC fast charge is supplemented, that is, when the vehicle comes to charge, the battery is replaced under normal conditions, and secondly, the fast charge is selected. This will not only reduce the battery load, but also improve the utilization rate of vehicles.

4.2 Normal Charging Demand

Normal charging is usually aimed at private cars. Now, in order to solve the energy and environmental problems, the government has vigorously promoted the development of electric vehicles as a means of green transportation. So as to introduce a variety of policies to promote the popularization of electric vehicles, so for the private users of electric vehicles, the construction of charging facilities should be funded by the government to build charging facilities. For private electric vehicles, charging facilities should be equipped with charging piles in accordance with the ratio 1:1.

The formula for charging demand is as follows:

\[ Q = N \times \frac{S \text{ mileage}}{S \text{ available mileage}} \]

In the formula, \( Q \) - Actual charging demand of every day

N- the number of the charging cars

S Mileage- average daily mileage

S Available mileage -Battery mileage available

Regular charging mostly aims at the private cars. The average daily mileage is 60 kilometers, and the battery mileage is 150 kilometers. Therefore, a private car charge 0.4 times a day / day.

4.3 Battery replacement charge demand
For buses, environmental sanitation vehicles and vehicles of other groups usually charge by the battery replacement. If the bus is full of electricity, available mileage is 260 kilometers, while the bus in Chengdu run 230 kilometers per day on average. Therefore, the bus is full of electricity, basically it can run one day, that is, the bus charge per day is 1 times / day. Battery replacement mode is more suitable for buses and other special vehicles to charge, the size of the battery replacement station to meet the jurisdiction of the vehicle battery supply of the second day within the station.

4.4 Electricity demand of public fast charging station

The main service object of public fast charging station is the taxi and the private car that needs temporary power supply. According to the survey, the daily mileage of taxis is about 400 kilometers, while the available mileage of the taxi is 150 kilometers, and the number of charging is 2.67 times per day. Since taxis are sometimes required to maintain and attendance rates are unlikely to be 100%, the attendance rate is 90%. The formula for charging demand for taxis can be derived by formula 3-1.

\[ Q = N \times S \text{mileage} / S \text{available} \times C \]

For private cars, the normal charging mode is chose in most cases, and only when the power needs to be temporarily added, the public fast charge can be chose. According to the hypothesis, private cars need temporarily public recharging from Monday to Friday, at least once a week, or 2 times a week at public charging from Monday to Friday. Considering the outside factors such as private car temporary maintenance, the attendance rate of private cars is also 90%. Therefore, the formula for charging electricity demand of private car in public fast charging station is as follows:

\[ Q = N \times q \times C \]

In the formula: Q—charging demand (car/day); q—average daily charging demand of every car(from Monday to Friday 1/5 times every day, weekends 1/2 times every day); N—the number of the charging private car; C—attendance rate;

From the above, you can know that the charging demand on the weekend is significantly greater than Monday to Friday charging demand. In order to avoid too many traveling owners on the weekends and waiting in line too long when charging, when planning the scale of the charging facilities, the requirements of the weekend should be considered to meet the vehicle's electricity demand as a target construction. Due to the driving characteristics of the normal charging service objects, it is possible to build AC charging piles in the special-purpose parking areas and public parking places, and the construction of battery replacement stations in fixed parking areas is suitable for group cars. In view of the location of these two kinds of charging facilities, the existing parking spaces and parking lots can be assured, while the public fast charging stations can not be assured and need to be calculated by prediction. Therefore, this thesis regards the public fast charging station as the main object of the study.

For the taxi, according to the formula 3-2, the formula of the taxi charging demand can be gained: \( Q = N \times 2.67 \times 90\% \); according to the formula 3-3, the formula of the private car charging demand can be gained: \( Q = N \times 0.5 \times 90\% \). Charging demand of the taxi and the private electric cars are given from 2014 to 2020 in table 8.

**Table 8.** The charging demand of the private car and taxi from 2014 to 2020
### Yearly Charging Demand

| Year | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------|------|------|------|------|------|------|------|
| The charging demand of the private car/car/day | 603 | 2124 | 5940 | 14310 | 29558 | 47952 | 72275 |
| The charging demand of the taxi/taxi/day | 4830 | 7088 | 9515 | 11207 | 12699 | 14225 | 16599 |

### Conclusion

This paper combines the development of electric vehicles in Chengdu. In the last few years, the number of car ownership has been collected to predict the number of electric vehicles in Chengdu's 13th five-year plan, and its products are predicted. The model is further established to predict the charging demand of one of the main factors influencing the layout of electric vehicle charging stations. A good setup is provided for the distribution of charging stations for electric vehicles.

### References

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