Comparative Analysis of Energy Consumption Standards Based on Electric Passenger Vehicle Economic Simulation Platform

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Abstract. This paper compares and analyzes the electric vehicles standards of energy consumption, and concludes the main factors that affect the driving range and energy consumption of electric vehicles. Based on a certain vehicle model, through the establishment of pure electric passenger vehicle economic simulation platform. It is calculated that: compared with GB/T18386-2017, the driving range of vehicles tested according to GB/T18386.1 is increased, and the energy consumption is reduced, but for the vehicle with large load, the reverse results may appear; the cycle correction method under GB/T18386.1 is better and more scientific than that of GB/T18386-2017, which helps to reduce the difference of vehicle driving range and energy consumption before and after the test cycle correction, but in general, the driving range of vehicles under the uncorrected test cycle is lower and the energy consumption is higher.

1. Introduction
The standards of electric vehicle’s driving range and energy consumption are very important to access the vehicle economies. At present, the latest energy consumption Chinese standard GB / T 18386.1-2021 "test methods for energy consumption and driving range of electric vehicles - Part 1: light vehicles" has been published, this paper analyzes the differences and similarities between GB/T18386.1-2021 and GB/T 18386-2017.

According to the economic parameters of a pure electric vehicle and its key components, the simulation platform of vehicle driving range and energy consumption is established, and the influence of the two standards on the test results of vehicle driving range and energy consumption rate is compared and analyzed by using the simulation platform. At the same time, the compensation mode method in GB/T18386.1-2021 for the vehicle speed lower than CLTC-P cycle speed is deeply analyzed, which provides research support for new energy enterprises to research and develop, adjust vehicle control strategy, and the energy consumption limit standard being formulated in the next step.

2. The main difference between GB/T 18386.1-2021 and GB/T 18386-2017

2.1 Different test loading weights
According to GB / T 18386.1-2021, On the basis of "curb weight + 100kg", the test mass adds the optional equipment mass and representative mass, which is more in line with the actual road application after modification. Figure 1 compares the loading weights between the two standards. It
can be seen that the test weights in GB / T 18386.1 is larger, and the energy consumption will be increased under other conditions unchanged.

2.2 Different cycle conditions
GB / T 18386.1 adopts CLTC-P, which is more in line with the road driving characteristics of China, with longer cycle time and lower average speed. The new European test cycle NEDC is used in GB / T 18386-2017 [1]. The comparison of two test cycles is shown in Figure 2, and the comparison of main parameters is shown in Table 1.

| Parameter         | NEDC  | CLTC-P |
|-------------------|-------|--------|
| time (s)          | 1180  | 1800   |
| Driving range (km)| 11.03 | 14.48  |
| Average speed (km/h)| 33.6  | 28.9   |
| Maximum speed (km/h)| 120   | 114    |

From the comparison of the two conditions, it can be seen that the average speed and the maximum speed of NEDC are higher than CLTC-P, and the energy consumption of pure electric vehicle is significantly affected by these two parameters. Therefore, considering the difference of cycle conditions alone, the energy consumption level of NEDC is likely to be higher.

2.3 The difference for that the maximum speed of the vehicle is lower than the maximum speed of the cycle
According to the requirements of GB / T 18386-2017, the vehicle whose maximum speed Vmax is lower than the maximum speed Vmax_CYC of the test cycle, the cycle is directly cut off according to the maximum speed Vmax of the vehicle, and the other part is removed in NEDC condition to generate a new cycle. According to the requirements of GB / T 18386.1, the vehicle whose maximum speed Vmax is lower than the maximum cycle speed Vmax_CYC, after the part higher than the maximum cycle speed is removed from CLTC-P, the cycle condition of the vehicle shall be compensated according to the maximum cycle speed, so that the compensated test mileage is the same as that before correction. For specific analysis, please refer to the fourth part of this paper.

2.4 Shortening method for driving-range test
In order to deal with the test of vehicles with long driving range and save test resources, the "shortening method" is introduced in GB / T 18386.1. The test efficiency is improved by taking a limited number of cycles and rapid discharge. The driving range and energy consumption rate of vehicles are gotten by weighted calculation.

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Figure 1. Test mass comparison.

Figure 2. NEDC and CLTC-P comparison.
In order to compare and analyze the influence of GB/T18386.1 and GB/T18386 to the same electric vehicle, this paper built the simulation model to analyze the driving-range according the two different standards.“Shorten method” is only to improve the test efficiency and will not affect the test results. Therefore, this paper focuses on the analysis of the influence of the first three factors on energy consumption and driving range.

3. Relevant parameters for pure electric vehicle’s energy consumption simulation

A light pure electric passenger car is selected to build the simulation platform. The main parameters of the vehicle are showed in Table 2.

Table 2. The relevant parameters of pure electric passenger car.

| Parameter                              | Value   |
|----------------------------------------|---------|
| Kerb weight kg                         | 969     |
| Maximum total mass kg                  | 1268    |
| The highest speed km/h                 | 100     |
| Windward area (m²)                     | 2.34    |
| Drag coefficient Cd                    | 0.32    |
| Coefficient of rolling resistance f    | 0.012   |
| Final drive ratio                      | 6.27    |
| Transmission efficiency                | 0.93    |
| Rated power/maximum power kW           | 20/40   |
| Rated speed/maximum speed rpm          | 3000/9000 |
| Rated torque/maximum torque Nm         | 90/200  |
| Rated voltage V                        | 333     |
| Battery capacity (Ah)                  | 26      |

The blue solid line in the figure represents the external characteristics of the motor with the maximum power of 40kW, the blue dotted line represents the external characteristics of the motor with the rated power of 20kW.
power of 20kW, the contour line represents the efficiency point of the motor, and the pink line represents the maximum braking energy feedback characteristic curve of the vehicle. [2]

The relationship curve between SOC and OCV of cell is showed in figure 4. The ambient temperature is 25°C.

The relationship curve [3] between battery internal resistance and SOC is showed in figure 5. From the figure 5, we can get that if the SOC is lower than 10%, the internal resistance of battery increases in geometric progression.

![Figure 5. The battery R-SOC curve.](image1)

The simulation platform is built by Matlab/Simulink, it contains engine model, battery model, the whole vehicle model. [4]

4. Comparative analysis of energy consumption simulation results

Maximum speed of simulated vehicle is 100km/h, as GB/T 18386-2017 requirement, when it reaches 100km/h in the last high-speed condition, no compensation is made. The new speed condition is showed in figure 7. As GB/T 18386.1-2017 requirement, to the part of CLTC-P condition exceeds 100km/h, it should be added to the new condition according to the mileage generated by the original condition. As this method, after removing the part with speed higher than 100km / h, the constant speed condition of 100km / h should be increased by 5S, and finally the cycle condition becomes 1805s, as shown in Figure 8.

![Figure 6. Vehicle energy consumption simulation platform.](image2)

![Figure 7. NEDC condition (V_{max}=100km/h).](image3)

![Figure 8. CLTC-P condition (V_{max}=100km/h).](image4)

According to the requirements of GB/T 18386 and GB/T 18386.1, bring the loading mass and cycle condition into the simulation platform of driving range and energy consumption of the whole vehicle. The simulation results are showed in figure 9 ~ figure 12, and the red circles in Fig. 10 and Fig. 12 represent the distribution of working points of corresponding working conditions. From the results of unit voltage in the third part of Fig. 9 and Fig. 11, it can be seen that the unit voltage of the vehicle is higher. The unit voltage that has not reached the power limit 3V (red line in the figure), and the SOC is 5% at the end of the simulation. The comparative analysis of simulation results under several conditions is shown in Table 3.
As table 3 showed, we compared the driving range under three test conditions. From the above results, it can be seen that the energy consumption of CLTC-P condition is lower than that of NEDC condition, and the driving range under CLTC-P condition will be increased. In addition, from comparison between test condition 2 and test condition 3, the increased load mass will reduce the corresponding driving range, which has a great impact on the final energy consumption test results.
In order to verify the influence of compensation method in GB/T18386.1 on driving range of vehicles with speed lower than cycle speed, the driving range of vehicles [5] under the following three conditions is compared by using the simulation platform. The calculation results are shown in Table 4.

Table 4. GB/T 18386.1 comparative analysis of simulation results of speed condition compensation.

| Comparison parameters | ① make compensation | ② no compensation | ③ Release the vehicle speed to meet the working conditions |
|-----------------------|----------------------|-------------------|--------------------------------------------------------|
| Load mass kg          | 969+100+45           | 969+100+45        | 969+100+45                                             |
| Cycle condition       | Complete 11 CLTC-P (Vmax=100) | Complete 11 CLTC-P (remove more than 100km/h) | Complete 11 CLTC-P                                      |
| Total energy consumption kwh | 16.68              | 16.68             | 16.68                                                  |
| The driving range km  | 164.8                | 167.0             | 161.9                                                  |
| Energy efficiency Wh/km | 101.2             | 99.9              | 103                                                    |

As the table 4 showed, compare the condition ① with the condition ②, the driving range is reduced 2.2km, the compensation method of GB/T 18386.1 is more rigorous to the assessment of vehicle energy consumption. Using compensation method is more scientific. It avoids the situation that once the vehicle passes the high-speed section to the low-speed section under the original simple treatment mode, this phenomenon will increase the driving range. Compare the condition ① with the condition ③, the driving range to make compensation is 2.9km more than the driving range to meet the working conditions. The reason is that although compensation is made for this part, the average speed of the compensation based on 100km/h constant speed condition is lower than that of the original condition, so the energy consumption of this part is lower than that of the original condition, and the driving range is also increased correspondingly.

5. Conclusion
This paper analyzes the main differences between GB/T 18386.1-2021 and GB/T 18386-2017. With one vehicle parameters, the economic simulation platform of pure electric passenger vehicles is built to compare and analyze the differences between GB/T 18386.1-2021 and GB/T 18386-2017, and the following conclusions are drawn:
1) Compared with NEDC condition, CLTC-P condition is more conductive to increase driving range and reduce energy consumption. However, according to the requirements of GB / T 18386.1, the test mass of the vehicle is increased, which has a certain impact on the energy consumption. The more the test mass increases, the greater the energy consume, and the shorter the driving range. Therefore, due to the less loading mass of the light passenger vehicle (such as the simulation vehicle in this paper), the driving range is increased. While the loading mass of the larger passenger vehicle is large. The driving range may be shorter.
2) When the maximum vehicle speed is lower than the maximum test cycle speed, according to GB / T 18386.1, the cycle condition is revised by compensation. Through the analysis of pure electric passenger vehicle simulation platform, the increase of compensation condition improves test requirements. Compared with GB/T 18386-2017, the method of compensation condition increase the vehicle energy consumption and reduces the driving range. It’s more scientific. The development of pure electric passenger vehicle economy simulation platform, the above conclusions can guide automobile manufacturers to adjust control strategies according to the latest
energy consumption standard GB / T 18386.1, guide vehicle economy development, and play a technical support role for the energy consumption limit standard based on GB / T 18386.1.

6. References
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