Impact of New Energy Vehicles on Average Fuel Consumption of BYD Auto’s Passenger Vehicles

Jia C. Li

ABSTRACT

The impact of new energy vehicles (NEV) on average fuel consumption of automakers’ passenger vehicles in China is a question that has not been clearly addressed. In this paper, average accounting fuel consumptions and average real fuel consumptions of BYD Auto (hereinafter referred to as "BYD")'s passenger vehicles, as well as average fuel consumptions of BYD’s NEV and average fuel consumptions of BYD’s conventional energy vehicles (CEV) from 2016 to 2021, were calculated. Then the impact of production multiplier of NEV and low average fuel consumption of NEV were distinguished to reveal the path and extent of NEV’s impact on average fuel consumption of BYD’s passenger vehicles. The results showed that, Production multiplier of NEV and low average fuel consumption of NEV are key factors by which NEV promoted the decline of average fuel consumption of BYD’s passenger vehicles. Production multiplier of NEV caused the difference between average accounting fuel consumption and average real fuel consumption of BYD’s passenger vehicles. Low average fuel consumption of NEV caused the difference between average real fuel consumption of BYD’s passenger vehicles and average fuel consumption of BYD’s CEV, and the total impact of NEV on the average accounting fuel consumption of BYD’s passenger vehicles was equal to the sum of the above two differences, which is equal to average accounting fuel consumption of BYD’s passenger vehicles minus average fuel consumption of BYD’s CEV.

Keywords: Average accounting fuel consumption, average real fuel consumption, BYD, new energy vehicle (NEV), passenger vehicle.

I. INTRODUCTION

In China, new energy vehicles (NEV) include battery electric vehicle (BEV), plug-in hybrid electric vehicle (PHEV) and fuel cell vehicles (FCV). According to the corporate average fuel consumption (CAFC) standard of China's passenger vehicle makers [1], [2], NEV have been put into CAFC accounting since 2016. At this time, one new energy vehicle can be counted as a multiplier greater than 1 (Table I), and its consumption of electricity and hydrogen is excluded. The above privileges enjoyed by NEV in CAFC accounting can lower CAFC and facilitate automakers to reach average fuel consumption standard [3]. However, the above privileges enjoyed by NEV mean that, average fuel consumption of passenger vehicle maker is actually average accounting fuel consumption, rather than average real fuel consumption of passenger vehicle maker, which is the average fuel consumption of all passenger vehicles produced by passenger vehicle maker (excluding export) by test under legal operating condition.

Su and Ge compared average accounting fuel consumptions of passenger vehicle fleet and average fuel consumptions of CEV fleet from 2013 to 2017 in China, and pointed out that the average annual declines of the two were 4.7% and slightly less than 2% respectively [4]. Kang, Qin and A compared average accounting fuel consumptions of passenger fleet and average fuel consumptions of CEV fleet from 2013 to 2018, as well as average accounting fuel consumptions of passenger vehicles and average fuel consumption of CEV of some automakers in 2017 and pointed out the significant impact of NEV on the average accounting fuel consumptions of passenger vehicle fleet and automakers [5]. The above studies tried to reveal the impact of NEV on the average accounting fuel consumption of passenger vehicle fleet or automakers, but did not reveal the impact of NEV on the average real fuel consumptions of passenger vehicle makers, did not display basic data and calculation methods, and even mistakenly calculated the fuel consumption of PHEV as 0. Li clearly proposed for the first time the calculation formulas with CEV’s average fuel consumptions of passenger vehicle makers and used them to calculate CEV’s average fuel consumptions of four typical passenger vehicle makers in 2019 model year [6].
Wang, Zhao, and Liu believed that although production multiplier of NEV promoted NEV expansion, it diluted average fuel consumptions of automakers [7].

The role of NEV in the decline of average fuel consumption of passenger vehicle maker is a question worth deeply discussing but has not been fully investigated so far. In this paper, the average accounting fuel consumptions of BYD's passenger vehicles in 2016-2021 were firstly expounded, and the average real fuel consumptions of passenger vehicles, average fuel consumptions of NEV and average fuel consumptions of CEV with BYD in 2016-2021, were calculated by using deduced calculation formulas. Then, the paths and degrees of NEV’s impact on the average fuel consumptions of BYD’s passenger vehicles were further revealed.

II. AVERAGE FUEL CONSUMPTIONS OF BYD’S PASSENGER VEHICLES

BYD is the largest NEV manufacturer in China and a world-renowned NEV manufacturer. Its NEV production in 2021 was second only to Tesla, and it became the world’s largest NEV producer in 2022.

A. Average Accounting Fuel Consumptions of BYD’s Passenger Vehicles

If \( \text{CTFC}, \text{CTFC} \) and \( \text{CTFC} \) represent total fuel consumption of BYD's passenger vehicles, total fuel consumption of BYD's NEV and total fuel consumption of BYD’s CEV; if \( y, y_1 \) and \( y_2 \) represent total output of BYD's passenger vehicles, NEV and CEV respectively; and if \( m \) and \( \text{CAFC}^A \) represent production multiplier of NEV and average accounting fuel consumption of BYD's passenger vehicles respectively, then the following formulas for calculating fuel consumption of BYD's passenger vehicles can be established.

\[
\text{CAFC}^A = \frac{\text{CTFC}_1 + \text{CTFC}_2}{my_1 + y_2} = \frac{\text{CTFC}_1}{my_1 + y_2}
\]  
\[
\text{CTFC} = \text{CAFC}^A (my_1 + y_2)
\]  

The data about BYD passenger vehicles in Table II come from bulletins of China’s Ministry of Industry and Information Technology about the average fuel consumption credits and the new energy vehicle credits of passenger vehicle makers during 2016-2021 [8]-[13].

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>42249</td>
<td>32011</td>
<td>45685</td>
<td>39955</td>
<td>39026</td>
<td>70974</td>
</tr>
<tr>
<td>( y_1 )</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>( y_2 )</td>
<td>86047</td>
<td>92633</td>
<td>21259</td>
<td>18142</td>
<td>16405</td>
<td>56597</td>
</tr>
<tr>
<td>( \text{CAFC}^A ) (L/100 km)</td>
<td>3.13</td>
<td>2.30</td>
<td>2.22</td>
<td>2.13</td>
<td>3.22</td>
<td>1.33</td>
</tr>
</tbody>
</table>

B. Average Real Fuel Consumptions of BYD’s Passenger Vehicles

If \( \text{CAFC}^R \) represents average real fuel consumption of BYD's passenger vehicles, then:

\[
\text{CAFC}^R = \frac{\text{CTFC}}{y} = \frac{my_1 + y_2}{y} \text{CAFC}^A
\]  

According to (2) and (3) and the data in Table I and II, average real fuel consumptions of BYD’s passenger vehicles can be calculated (Table III).

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CTFC} (L/100 km) )</td>
<td>23997</td>
<td>15884</td>
<td>19581</td>
<td>16239</td>
<td>17849</td>
<td>16223</td>
</tr>
<tr>
<td>( y )</td>
<td>42249</td>
<td>32011</td>
<td>45685</td>
<td>39955</td>
<td>39026</td>
<td>70974</td>
</tr>
<tr>
<td>( \text{CAFC}^R ) (L/100 km)</td>
<td>5.68</td>
<td>4.96</td>
<td>4.29</td>
<td>4.06</td>
<td>4.57</td>
<td>2.29</td>
</tr>
</tbody>
</table>

C. BYD’s Total Fuel Consumptions and Average Fuel Consumptions of NEV

BYD’s total fuel consumption from NEV (\( \text{CTFC}_2 \)) is equal to the total fuel consumption of BYD’s PHEV (\( \text{CTFC}_p \)). The fuel consumption and output of BYD's PHEV model i are represented by \( f_{ci} \) and \( y_{pi} \) respectively. BYD’s total fuel consumption of NEV can be calculated by (4).

\[
\text{CTFC}_1 = \text{CTFC}_p = \sum f_{ci} y_{pi}
\]  

BYD’s average fuel consumption of NEV is represented by \( \text{CTFC}_1 \), and its calculation method is shown in (5).

\[
\text{CTFC}_1 = \frac{\text{CTFC}_2}{y_1}
\]  

Table IV shows the estimation method about BYD’s total
fuel consumption of NEV in 2021, and the estimation methods about BYD’s total fuel consumptions from NEV in other years are the same. For brevity, they will not be listed one by one.

Table V shows total and average fuel consumptions of BYD’s NEV from 2016 to 2021.

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTFC1 (L /100 km)</td>
<td>7315</td>
<td>8088</td>
<td>17405</td>
<td>89418</td>
<td>63102</td>
<td>38212</td>
</tr>
<tr>
<td>CAFC1 (L /100 km)</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

D. Average Fuel Consumptions of BYD’s CEV

If \( CAFC_2 \) represents average fuel consumption of BYD’s CEV, then:

\[
CAFC_2 = \frac{CTFC_2}{\gamma} = \frac{CTFC - CTFC_1}{\gamma} \quad (6)
\]

According to (6) and the data in Table II, III and V, average fuel consumptions of BYD’s CEV can be calculated (Table VI).

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTFC (L /100 km)</td>
<td>23997</td>
<td>15884</td>
<td>19581</td>
<td>16239</td>
<td>17849</td>
<td>16223</td>
</tr>
<tr>
<td>CTFC1 (L /100 km)</td>
<td>7315</td>
<td>8088</td>
<td>17405</td>
<td>89418</td>
<td>63102</td>
<td>38212</td>
</tr>
<tr>
<td>CAFC2 (L /100 km)</td>
<td>6.92</td>
<td>6.63</td>
<td>7.30</td>
<td>7.03</td>
<td>7.61</td>
<td>8.63</td>
</tr>
</tbody>
</table>

III. Decline in Average Fuel Consumption of BYD’s Passenger Vehicles Caused by Production Multiplier of NEV

By comparing (1) and (3), it can be found that the difference between the average accounting fuel consumption and average real fuel consumption of BYD’s passenger vehicles is caused by production multiplier of NEV. Therefore, \( CAFC_4 - CAFC_8 \) represents decline in average accounting fuel consumption of BYD’s passenger vehicles caused by production multiplier of NEV, which is shown in Table VII. It should be pointed out that the decline in average fuel consumption of BYD’s passenger vehicles caused by production multiplier of NEV, is not real average fuel consumption decline, but average accounting fuel consumption decline, or the result of statistical adjustment.

In addition, (7) not only reveals the decisive role of NEV’s production multiplier greater than 1 (if \( m=1 \), there is no difference between average accounting fuel consumption and average real fuel consumption of BYD passenger vehicles), but also reveals NEV production ratio \( (\gamma/\gamma) \) and average accounting fuel consumption of BYD’s passenger vehicles \( (CAFC_4) \). They also affect the reduction degree of average fuel consumption of BYD’s passenger vehicles caused by NEV’s production multiplier.

\[
CAFC_4 - CAFC_8 = -\frac{\gamma}{\gamma} CAFC_4 (m - 1) \quad (7)
\]

Table VIII shows what factors drove the decline in average fuel consumption of BYD’s passenger vehicles caused by NEV’s production multiplier.
IV. DECLINE IN AVERAGE FUEL CONSUMPTION OF BYD’S PASSENGER VEHICLES CAUSED BY NEV’S LOW AVERAGE FUEL CONSUMPTION

By comparing (3) and (6) or judging intuitively, the difference between average real fuel consumption of BYD’s passenger vehicles and average fuel consumption of BYD’s CEV comes from the impact of NEV’s average fuel consumption being lower than CEV’s average fuel consumption, that is, NEV’s low average fuel consumption. Therefore, \( CAFC^A - CAFC^2 \) represents decrease in average fuel consumption of BYD’s passenger vehicles caused by low average fuel consumption of NEV, as shown in Table IX. It should be pointed out that decrease of average fuel consumption of BYD’s passenger vehicles caused by low average fuel consumption of NEV is not only the decrease of average accounting fuel consumption, but also the decrease of average real fuel consumption.

TABLE IX: CALCULATING DECREASE OF AVERAGE FUEL CONSUMPTION OF BYD’S PASSENGER VEHICLES CAUSED BY LOW AVERAGE FUEL CONSUMPTION OF NEV

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m - 1 )</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>( \gamma/y )</td>
<td>0.203</td>
<td>0.289</td>
<td>0.465</td>
<td>0.454</td>
<td>0.420</td>
<td>0.797</td>
</tr>
<tr>
<td>( CAFC^A ) (L/100 km)</td>
<td>3.13</td>
<td>2.30</td>
<td>2.22</td>
<td>2.13</td>
<td>2.22</td>
<td>1.33</td>
</tr>
<tr>
<td>( CAFC^2 ) (L/100 km)</td>
<td>-2.55</td>
<td>-2.66</td>
<td>-2.07</td>
<td>-1.93</td>
<td>-1.35</td>
<td>-0.96</td>
</tr>
</tbody>
</table>

In addition, (8) not only reveals the decisive role of low average fuel consumption of NEV (if \( CAFC_2 = CAFC_1 \), the average real fuel consumption of BYD’s passenger vehicles will not be different from that of CEV), Moreover, it is revealed that BYD’s NEV production ratio (\( \gamma/y \)) also affects decreasing degree of BYD’s average fuel consumption of passenger vehicles caused by low average fuel consumption of NEV.

\[
CAF_C^R - CAF_C^2 = -\frac{\gamma_1}{\gamma} (CAFC_2 - CAFC_1) \quad (8)
\]

Table X shows what drive decrease in average fuel consumption of BYD’s passenger vehicles caused by low average fuel consumption of NEV.

V. TOTAL DECLINE IN AVERAGE FUEL CONSUMPTION OF BYD’S PASSENGER VEHICLES CAUSED BY NEV

Total impact of NEV on average accounting fuel consumption of BYD’s passenger vehicles is equal to the sum of the above two impacts, namely, \( CAFC^A - CAFC_1 \) (Table XI). (9) is the calculation formula of decrease in average accounting fuel consumption of BYD’s passenger vehicles caused by NEV.

\[
CAF_C^A - CAF_C^2 = -\frac{\gamma_1}{\gamma} [CAF_C^A(m - 1) + (CAF_C^2 - CAFC_1)] \quad (9)
\]

TABLE X: FACTORS THAT DRIVE DECREASE IN AVERAGE FUEL CONSUMPTION OF BYD’S PASSENGER VEHICLES CAUSED BY LOW AVERAGE FUEL CONSUMPTION OF NEV

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>( CAFC^A ) (L/100 km)</td>
<td>6.07</td>
<td>5.76</td>
<td>6.48</td>
<td>6.54</td>
<td>7.23</td>
<td>7.95</td>
</tr>
<tr>
<td>( CAFC_1 ) (L/100 km)</td>
<td>0.203</td>
<td>0.289</td>
<td>0.465</td>
<td>0.454</td>
<td>0.420</td>
<td>0.797</td>
</tr>
</tbody>
</table>

Fig. 2 shows the impact of NEV on decline in average fuel consumption of BYD’s passenger vehicles from 2016 to 2021. As can be seen in Fig. 2, from 2016 to 2021, the decline in average fuel consumption of BYD’s passenger vehicles caused by NEV’s production multiplier has continued to narrow since 2018 and is smaller than that caused by NEV’s low average fuel consumption. However, the decrease of
average fuel consumption of BYD’s passenger vehicles caused by low average fuel consumption of NEV continued to increase and showed a sharp decline in 2021. Due to the above changes, the decline in average fuel consumption of BYD’s passenger vehicles caused by NEV increased in fluctuation.

VI. IMPACT OF NEV ON AVERAGE FUEL CONSUMPTION AFTER BYD STOPPED CEV PRODUCTION

As of March 2022, BYD officially discontinued CEV production, thus becoming a pure NEV producer. Due to CEV’s average fuel consumption does not exist, NEV’s low average fuel consumption no longer exists, and so does decline in average fuel consumption of CEV caused by NEV’s low average fuel consumption. However, at least until 2024, decline in average fuel consumption caused by NEV’s production multiplier for BYD passenger vehicles still exists (10). By comparing (7) and (10), it can be found that after BYD stopped CEV production, $\frac{1}{\gamma} = 1 - \frac{\text{CAFC}^A}{\text{CAFC}^S}(m - 1)$. Of course, from 2025 onwards, all NEV-induced average fuel consumption reduction for BYD passenger vehicles will no longer exist due to $m = 1$, although as a pure NEV producer, BYD’s passenger vehicles will maintain low average fuel consumption.

\[
\text{CAFC}^A - \text{CAFC}^S = -\frac{\text{CAFC}^S}{m}(m - 1) \quad (10)
\]

REFERENCES


