The application of green score method in total amount control of Shenzhen diesel vehicles

Bao Liu 1 and Wenwei Huang

School of Automotive and Transportation Engineering, Shenzhen Polytechnic, Shenzhen518055, China.

1 Email: liubao@szpt.edu.cn

Abstract. Shenzhen is highly developed in logistics and transportation industry. Motor vehicle transportation played an important role in the city and depended heavily on diesel vehicles. The effect of diesel vehicle emissions control could improve the air quality. Measures to control the total emissions of diesel vehicles became the first priority for Shenzhen government. The paper used AHP (Analytic Hierarchy Process) to construct Green Score system for diesel vehicles. The calculated carbon emission scores were related to the degree of environmental pollution. The higher emission scores showed the greater pollution to the environment. The detailed calculation method was introduced by calculating the emission score of enterprise diesel vehicles.

1. Introduction

Diesel vehicle is a mixed gas combustion, which has high thermal efficiency and fuel economy. The emissions of NOx and PM of diesel vehicles are higher than those of gasoline vehicles. 343000 diesel vehicles in Shenzhen contribute as much as 85% to air pollution (Human Settlements and Environment Commission of Shenzhen Municipality).

In this paper, the emission characteristics and the main influencing factors of diesel vehicles are analyzed. We select the index system for evaluating the emission of diesel vehicles and score the diesel vehicles scientifically. The enterprises of the diesel vehicles upgrade the diesel vehicles by the force of the policy. Green Score method has important significance for improving the quality of the air environment in Shenzhen.

2. Background of domestic and foreign research

Reducing greenhouse gas emissions, building a reasonable emission reduction mechanism and establishing a sustainable low carbon economic development model are the major challenges for all the countries in the world [1]. More and more countries and regions have set up the total amount of carbon emissions and rationally allocate emission rights. They carry out emissions trading and lead the related subjects to reduce emissions through market means.

The key problem of this study is to introduce effective policies to increase the emission cost and force the enterprises to reduce emissions by themselves. At present, the emission reduction policies of domestic generally only involve the elimination of old standard vehicles. The government adopts financial subsidies to promote the use of new energy vehicles, which may be ineffective for many car companies and some individuals. As long as most diesel vehicle enterprises meet the environmental protection standard. They lack the power of motorization and zero emission of diesel vehicles of self-
interest. The policy will enter into a period of failure. The Green Score system can force enterprises to upgrade their diesel vehicles and accumulate sufficient scores within a specified period (three years). Otherwise, there will be a high cost.

3. Main research methods and content framework
This paper analyzes the emission characteristics of diesel vehicles and constructs a comprehensive evaluation index of diesel vehicle emissions. The weight of the evaluation index is determined by AHP (the analytic hierarchy process). The emission factors of diesel vehicle emission index are evaluated according to the five grades of excellent, good, medium, poor and extreme difference. The calculated carbon emission score is positively related to the degree of environmental pollution. The higher the emission fraction indicates the greater the pollution to the environment. Under the pressure of policy, enterprises reduce carbon emission scores through electric diesel vehicles, renewal of vehicles and other measures. Reducing carbon emissions is defined as Green Score. The carbon emission score of vehicle has been checked and tested by the Shenzhen Vehicle Management Institute. The carbon emissions calculated through the model are uploaded to the data platform of the HSES (Human Settlements and Environment Commission of Shenzhen Municipality) and the CCES (China Emissions Exchange Shenzhen Management). Enterprises must assess the reduction of carbon emissions by no less than 10% a year (2017-2020) and achieve a total reduction rate of 30% in three years. Reduced the emission score can convert into the corresponding Green Score. Green Score of Enterprises obtained by reduced emissions must increase by no less than 10% a year or achieve 30% growth rate within three years (2017-2020). Substandard enterprises must buy Green Score through trading platform to compensate for environmental pollution.

The basic steps and procedures for comprehensive assessment of diesel vehicle emissions are as follows

3.1. Analytic hierarchy process (AHP) using to calculate
The analytic hierarchy process (AHP) decomposes the problem into different components according to the nature of the problem and the total goal to be reached [2]. According to the interrelated influence of the factors and the relation to assemble the factors, it forms a multi-level analysis structure model. In this paper, we use Yaahp10.3 software to provide model construction and analysis.

3.2. Construction Model
It is a key step to select scientific and accurate indicators to describe diesel emissions and to build an evaluation system. The emission of diesel vehicle belongs to the dynamic moving source. The actual pollutant emission is very complicated and changes at all times. There are different types and distribution of diesel vehicles, road traffic conditions, temperature and humidity and the emission status of vehicles are also different. In order to determine the main influencing factors of diesel vehicle exhaust emissions, it is necessary to determine the emission inventory of different pollutants. Vehicle emission inventory reflects vehicle type, time and spatial distribution characteristics of vehicle pollutant emissions. Domestic and foreign research institutes use various models to estimate urban pollutant emission inventory according to emission factor method. Some emission models used abroad, such as MOBILE COPERT MOVES, etc. On the basis of various models abroad, we build the model to evaluate diesel vehicle emissions, which select diesel vehicle fuel, diesel vehicle emission standard and diesel vehicle operating condition as three main evaluation index [3]. The model lists the relevant policies adopted by the government to reduce emissions from diesel vehicles and sets the framework in table 1 for building the model.
Table 1. AHP for Total Emission Control of Diesel vehicles in Shenzhen

| Target layer                                      | Guideline layer                                      | Policy layer                                      |
|--------------------------------------------------|------------------------------------------------------|--------------------------------------------------|
| O (Total Emission Control of Diesel vehicles in Shenzhen) | A1 (Vehicle fuel)                                   | B1 (power)                                       |
|                                                  |                                                      | B2 (Hybrid power)                                |
|                                                  |                                                      | B3 (Clean energy such as natural gas)             |
|                                                  |                                                      | B4 (diesel oil)                                  |
|                                                  | A2 (Emission standard)                               | B5 (Chinese emission standard at phase III)       |
|                                                  |                                                      | B6 (Chinese emission standard at phase IV)        |
|                                                  |                                                      | B7 (Chinese emission standard at phase V)         |
|                                                  |                                                      | B8 (Chinese emission standard at phase VI)        |
|                                                  | A3 (Diesel vehicle operating condition)              | B9 (vehicle power - ton/power)                    |
|                                                  |                                                      | B10 (vehicle type)                               |
|                                                  |                                                      | B11 (Vehicle service life)                        |

Figure 1. AHP for total emission control of diesel vehicles in Shenzhen.

Note: Using yaahp10.3 Software to construct the Model of “Total quantity Control of Diesel vehicles in Shenzhen
According to the calculation results Figure 1, the weight of A1 (vehicle fuel), A2 (emission standard) and A3 (diesel vehicle operating condition) in diesel vehicle emission fraction is \( \omega_1 = 0.8142 \), \( \omega_2 = 0.114 \), \( \omega_3 = 0.0718 \) respectively.

### 3.3. Evaluation factor assignment of diesel vehicle emission

In order to quantify the emission of diesel vehicle, the model scores different emission evaluation factors according to the five grade score, excellence (100), good (200), middle (300), poor (400), extreme (500). The lower score represents the higher pollution in table 2.

1. The emission of diesel vehicles is closely related to fuel. The diesel vehicles can use clean energy, such as electricity to reduce emission.

#### Table 2. Scoring table of fuel for diesel vehicles.

| index | Evaluation factor(Bi) | Grade   | Score(Si) |
|-------|------------------------|---------|-----------|
| A1    | B1 (power)             | Excellence | S1 =100  |
|       | B2 (Hybrid power)      | Good    | S2 =200   |
|       | B3 (Clean energy)      | middle  | S3 =300   |
|       | B4 (diesel oil)        | poor    | S4 =400   |

2. The higher the emission standard for diesel vehicles represents the lower emission in table 3.

#### Table 3. Scoring table of emission standards for diesel vehicles.

| index | Evaluation factor(Bi) | Grade   | Score(Si) |
|-------|------------------------|---------|-----------|
| A2    | B7 (Chinese emission standard at phase V) | Good    | S7 =200   |
|       | B8 (Chinese emission standard at phase VI) | Excellence | S8 =100  |
|       | B6 (Chinese emission standard at phase IV) | Middle  | S6 =300   |
|       | B5 (Chinese emission standard at phase III) | Poor    | S5 =400   |

3. The actual operation of vehicle emission is related to diesel engine working condition, driving condition, driving road and load. Low vehicle power (low energy consumption), small vehicle type, short service life represents low emission in table 4.

#### Table 4. Scoring table of operating condition for diesel vehicles.

| index | Evaluation factor(Bi) | Grade   | Score(Si) |
|-------|------------------------|---------|-----------|
| A3    | B9 (ton/power)         | 1-10    | Excellence | S9=100   |
|       |                        | 10-12   | Good      | S9=200   |
|       |                        | 12-14   | Middle    | S9=300   |
|       |                        | >14     | Poor      | S9=400   |
|       | B10 (vehicle type)     | Micro   | Excellence | S10=100  |
|       |                        | Light   | Good      | S10=200  |
|       |                        | Medium  | Middle    | S10=300  |
|       |                        | Heavy   | Poor      | S10=400  |
|       | B11 (service life)     | <1 year | Excellence | S11=100  |
|       |                        | <2 years| Good      | S11=200  |
|       |                        | <3 years| Middle    | S11=300  |
|       |                        | <4 years| Poor      | S11=400  |
|       |                        | ≥5 years| Extreme   | S11=500  |
The Scores of diesel vehicle emission $O$ is as follows (N- number of vehicles, i- weight of emissions)

$$O = \left( \sum_{i=1}^{3} A_{i} n_{i} \right) / N = \left( \sum_{i=1}^{4} B_{i} S_{i} \omega_{i} + \sum_{i=5}^{8} B_{i} S_{i} \omega_{i} + \sum_{i=9}^{11} B_{i} S_{i} \omega_{i} \right) / N \quad (1)$$

4. Calculation and analysis of emission scores of diesel vehicles in enterprises

4.1. Calculation of emission scores of diesel vehicles in enterprises

Take Shenzhen Zhongtong Company, for example, which owns 100 trucks. The company's vehicle fuel, emission standards and actual vehicle conditions are as follows in table 5.

**Table 5. 2016 Diesel vehicle average emission scores table (Data from 1 division of the Shenzhen Zhongtong company).**

| index | Evaluation factor(Bi) | Evaluation sub-factor | Number of vehicles | Score (Si) | Total Score |
|-------|----------------------|-----------------------|--------------------|------------|-------------|
| A1 (fuel) | B4 (diesel oil) | | 100 | S4 =400 | 40000 |
| A2 (emission standard) | B7( Chinese emission standard at phase V) | | 100 | S7 =200 | 20000 |
| A3 (operating condition) | B9 (ton /power) | | 10-12 | S9 =200 | 8000 |
| | | | 12-14 | S9 =300 | 12000 |
| | | Medium | 3 | S10 =300 | 15000 |
| | | Heavy | 5 | S10 =400 | 20000 |
| | B10 (vehicle type) | | 40 | S11 =400 | 20000 |
| | B11 (service life) | | 20 | S11 =200 | 4000 |

The Scores $O_{2016}$

$$\frac{40000\times 0.8142+20000\times 0.114+92000\times 0.0718}{100}=415$$

In 2017, the company phased out some old diesel vehicles and bought some small diesel vehicles. The remaining 70 diesel vehicles are listed in table 6.

**Table 6. 2017 Diesel vehicle average Emission Scores Table (Data from 1 division of the Shenzhen Zhongtong company).**

| index | Evaluation factor(Bi) | Evaluation sub-factor | Number of vehicles | Score (Si) | Total Score |
|-------|----------------------|-----------------------|--------------------|------------|-------------|
| A1 (fuel) | B1 (power) | | 40 | S1 =100 | 4000 |
| | B4 (diesel oil) | | 30 | S4 =400 | 12000 |
| A2 (emission standard) | B8( Chinese emission standard at phase VI) | | 40 | S8 =100 | 4000 |
| | B7( Chinese emission standard at phase V) | | 30 | S7 =200 | 6000 |
| A3 (operating condition) | B9 (ton /power) | | 10-12 | S9 =300 | 3000 |
| | | 12-14 | S9 =300 | 3000 |
| | | Micro | 40 | S10 =100 | 4000 |
| | | Heavy | 30 | S10 =400 | 12000 |
| | B10 (vehicle type) | | <1 year | S11 =100 | 4000 |
| | | <2 years | 10 | S11 =200 | 2000 |
| | | <3 years | 20 | S11 =300 | 6000 |

The Scores $O_{2017}$

$$\frac{16000\times 0.8142+10000\times 0.114+39000\times 0.0718}{70}=242$$
As listed in Table 6, the company’s emissions score declined significantly in 2016-2017. Reduced emission scores are defined as GS (Green Score) for the enterprise in the past year, which means contribution to the environment.

\[
GS = O_{2016} - O_{2017} = 415 - 242 = 173
\]  
(2)

\[
\Delta GS = (O_{2016} - O_{2017}) / O_{2016} \times 100\% = 42\%
\]  
(3)

According to the results, the enterprise has reduced the emission by electronization, improved emission standards and improved vehicle conditions. The enterprise contributed to the environment and obtained the Green Score [4]. The 173 scores reduction of emissions are defined as the GS (Green Score) of Shenzhen Zhongtong Company, growth rate of 42%.

5. The implementation of the Green Score Trading system

5.1. Green Score account registration
The Green Score system of Diesel vehicles in Shenzhen are the mandatory trading system. All diesel vehicle enterprises must register their accounts through the Shenzhen carbon emissions trading system before September 30, 2018 and fill in the information of diesel vehicles truthfully. The system will automatically calculate the score based on the information.

5.2. Term and standard of Green Score assessment
The Green Score system conducts two examination standard including annual examination and periodic examination. The government implements three years (2017-2019) an assessment cycle and the annual assessment node is September 30. According to the "13th Five-Year Plan" of the State Council, the total amount of NOx emissions and SO2 are controlled within 15.8 million tons and 15.74 million tons respectively [5]. The Shenzhen government requires diesel enterprises to increase their annual Green Scores by 30% by September 30, 2020 [6].

5.3. Green Score trading mechanism
Green Score Trading system introduces offset and selling mechanism. If the Green Score of diesel enterprises is not enough, the enterprises can buy through the carbon exchange. The unit price of the Green Score is given under the guidance of the Shenzhen carbon Exchange or by the trading auction. The surplus Green Scores from current year balances can be transferred to the next year, but all the Green Scores are automatically cleared at the end of a 3 years cycle.

5.4. Reward and punishment
Diesel vehicle enterprises that meet the standard of Green Score assessment can obtain the five-star green certification issued by the government and enjoy the green channel service in terms of loans and financial subsidies. Enterprises that are not up to standard must buy the corresponding Green Scores at the Shenzhen carbon Emission Exchange. Otherwise, enterprises will be restricted and other penalties.

6. Conclusions
In this paper, we discuss the scientific evaluation and calculation of emission of diesel vehicle using AHP and introduce the calculation and assessment of Green Score of diesel vehicle enterprise.

In the 1990s, California established and implemented a program (Zero Emission Vehicle Program). The program promoted the coordinated development of environment. The core idea of the study combines the two forces of government and market, forcing diesel enterprises to eliminate old diesel vehicles and reduce the pollution to the environment. The Green Score system, as a market-oriented mechanism innovation, will play an important role in reducing urban vehicle emissions.
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