Air transport carbon reduction optimization based on low carbon emissions

Wei Lin*
Tianjin University of Technology, Tianjin, China

*Corresponding author e-mail:linwei0726@qq.com

Abstract. Nowadays, with the deepening of environmental protection concept, low-carbon transportation has gradually become the mainstream trend, the environmental cost of airport emissions research will gradually arouse social concern. Real low-carbon transport has become a country to achieve low-carbon energy saving, win the low-carbon war, sustainable development of the only way. Through the analysis of transportation costs and carbon emission costs related to aviation networks, reference to domestic and foreign calculation methods for carbon emissions environmental costs, the establishment of airport environmental cost model, through the analysis of pollutant components to reduce the cost of emission control, so as to reduce operating costs and achieve carbon emission reduction.

1. Introduction
Aviation is one of the top ten greenhouse gas emissions industries in the world. The global aviation industry accounts for 2.1% of global greenhouse gas emissions, while the global aviation industry, including non-carbon dioxide, accounts for 4.9% of global greenhouse gas emissions. [1] According to the International Civil Aviation Organization (ICAO) 2016 Environmental Report, global aviation emissions will increase significantly by the middle of the 21st century, with annual international aviation CO₂ emissions likely to increase from about 700 million tons today to about 2.6 billion tons by 2050[2]. The global aviation industry emits about 56 billion tons of carbon dioxide between 2016 and 2050. To achieve the zero growth target for international aviation greenhouse gas emissions after 2020, the total amount of greenhouse gas emissions from the international aviation industry between 2020 and 2040 is expected to be approximately 14.4 billion tons of carbon dioxide, with a reduction in emissions requirements of about 7.8 billion tons [3]. This paper integrates the international situation and the current situation of China's aviation industry, on the basis of which considering the total cost of aviation operation including operating costs and low-carbon costs, so as to achieve the lowest comprehensive transportation costs [4].

Civil aviation aircraft in the course of operation will produce CO₂, HC, SO₂, NOₓ, CO and so on. According to Pareto's optimal theory, air transport is considered efficient only when the external costs of the emission environment are taken into account [5, 6]. At present, there are two main methods to measure the cost of air transport in the ring and the overseas department. First, the sum of the cost of pollution damage and the cost of avoiding pollution damage, that is, the external cost of air transport. Second, the marginal pollution reduction cost of air transport is measured as the external cost of the marginal environment of air transport. The first method is more applicable to the actual situation in
China. Emissions from aircraft engines are usually used to characterize emissions from aircraft engines. The emission index is the number of grams of the substance produced after fuel combustion, i.e.:

\[ \varepsilon = \frac{G_g}{G_f} \]  

(1)

Wherein, the \( G_g \) represents the quality of each gaseous pollutant discharged, and \( G_f \) is the quality of combustion [7]. Through the study of the literature, the use of expert scoring cloud calculated the cost of pollutant emissions can be found in Table 1.

| pollutants | Average unit environmental external cost/(yuan/kg) |
|------------|--------------------------------------------------|
| HC         | 47.5                                             |
| CO         | 1.05                                             |
| NO\textsubscript{X} | 105.23                                         |
| SO\textsubscript{2} | 71.11                                          |
| CO\textsubscript{2} | 0.31                                          |

Table 1. Pollutant emission costs

2. Data introduction and description

In order to measure the amount of pollutants (HC, SO\textsubscript{2}, NO\textsubscript{X}, CO) emitted by aircraft in civil aviation airports, combined with the data of China's civil aviation fleet, civil aviation flight data and the concept of the take-off landing (LTO) cycle in the International Civil Aviation Organization (ICAO) standards, the aircraft L is calculated by using its aircraft emission database The emission severity of gas pollutants in the TO cycle, the annual LTO cycle emissions of aircraft from civil aviation airports[8], the results of the study are detailed in Table 2.

| Year | HC/t      | CO/t      | NO\textsubscript{X}/t | SO\textsubscript{2}/t |
|------|-----------|-----------|-----------------------|-----------------------|
| 2014 | 819.62    | 8609.19   | 13923.68              | 929.05                |
| 2015 | 820.39    | 8615.51   | 13935.48              | 929.92                |
| 2016 | 1058.23   | 10967.73  | 15662.52              | 1385.75               |
| 2017 | 1227.74   | 11572.87  | 19147.48              | 1385.75               |
| 2018 | 1314.48   | 13341.16  | 21095.19              | 1584.71               |

Table 2. Emission of gas pollutants

When calculating CO\textsubscript{2} emissions, consider carbon emission factors and energy consumption. The calculation formula for the carbon emissions (M) derived from the study can be expressed as:

\[ M = A \times F \]  

(2)

Of these, M represents the amount of CO\textsubscript{2} released into the atmosphere per kilometre of the transport of a ton of cargo; A indicates the amount of energy consumed per kilometre required to transport a ton of goods; F indicates the amount of CO\textsubscript{2} emitted per unit of energy consumed, i.e[9]. carbon emission factors when analyzing the cost benefits of aviation low carbon under the corresponding indicators developed by the state, the general model of the quantitative calculation of the basic cost-benefit criteria needs to be further adjusted[10]. The quantity of CO\textsubscript{2} emissions is calculated by the corresponding data in Table 3. The cost of each component is calculated as shown in Table 4.

| year | Quantity of fuel/million tons | Carbon dioxide per ton |
|------|-------------------------------|------------------------|
| 2014 | 5.0                           | 1700                   |
| 2015 | 3.4                           | 1170                   |
| 2016 | 3.3                           | 1130                   |
| 2017 | 4.2                           | 1440                   |
| 2018 | 5.6                           | 1920                   |

Table 3. CO\textsubscript{2} emissions
### Table 4. Cost

|        | HC   | CO   | NOX  | SO2  | CO2  | Pollutant cost |
|--------|------|------|------|------|------|----------------|
| 2014   | 4268.2 | 90.4 | 147721.2 | 7217.5 | 427000 | 636211.4 |
| 2015   | 4512.2 | 90.5 | 147421.4 | 7311.3 | 357000 | 512352.2 |
| 2016   | 5201.4 | 113.9 | 182920.4 | 9421.4 | 324000 | 540883.4 |
| 2017   | 6207.8 | 123.4 | 200345.7 | 10463.3 | 442300 | 664281.3 |
| 2018   | 7093.8 | 153.4 | 234013.9 | 11204.2 | 595200 | 847626.2 |

### 3. Data processing analysis

Using the entropy method to build a model, using matlab to deal with the data accordingly, the weights can be found in Table 5. Weighted weighting scored comprehensive scores for each year see table 6

### Table 5. Weight table

|       | HC  | CO  | NOX | SO2  | CO2  |
|-------|-----|-----|-----|------|------|
| weight| 0.0589 | 0.0056 | 0.1592 | 0.3021 | 0.4742 |

### Table 6. Comprehensive scores

| Year | scores |
|------|--------|
| 2014 | 0.2057 |
| 2015 | 0.2055 |
| 2016 | 0.2057 |
| 2017 | 0.2058 |
| 2018 | 0.1773 |

According to the matlab weight analysis table, the weight of CO2 is 0.4742, the SO2 weight is 0.3021 second after CO2, and CO2 and SO2 are the key objects when optimizing airlines' consideration of external environmental cost optimization. According to the analysis of the comprehensive score table, the comprehensive score was relatively stable between 2014 and 2017, and there was a downward trend in 2018.

Comprehensive analysis of the previous data, research and put forward the optimization of the design plan, which can be explained as follows. (1) To promote the development of aviation biofuels and the introduction of fuel-efficient aircraft, CO2 and SO2 occupy the weight of 0.4742 and 0.3021, respectively, occupy the total weight of 0.7763. Therefore, the development of aviation biofuels need to pay attention to the S and C elements of the proportion balance and treatment. (2) Civil aviation aircraft can reduce pollution emissions through the use of bio-fuels, to achieve the goal of energy conservation and emission reduction. With the progress of science and technology, waste animal and plant oil (geo-oil), agricultural and forestry waste, oil algae, etc. have been successfully converted into bio-gas raw materials, on this basis, researchers by reducing the viscosity of oil, boiling point, etc. to regenerate it into bio-fuel. Refined bio-fuels, such as oil, are not significantly different from conventional aviation fuels in terms of power supply, but at the same time reduce the overall carbon intensity of the fuel used.

### 4. Conclusion

The aviation industry can reduce CO2 emissions by reducing the flight distance, reducing aircraft load (e.g. optimizing the amount of fuel, water, food used to fly) and improving fuel efficiency. In addition, the development of new fuel-efficient aircraft (e.g. engine and wing performance improvements), the development and application of aviation biofuels, and energy-saving measures in ground and landing at the airport will reduce CO2 emissions in the aviation industry. Studies have assumed that the increase in fuel efficiency resulting from technological advances is generally 1% to 1.5% per annum. The above emission reduction effects can be achieved at both the technical and regulatory levels, not through policy and economic incentives. The implementation of the EU aviation carbon trading policy will be achieved through economic leverage to reduce CO2 emissions and mitigate the impact on climate change within a certain range. Mendes and others from the aviation demand analysis, the size of emission reduction spree and carbon price is proportional to the cost, and decided on the actual increase in the cost of air...
operators; From the analysis of aviation supply, it is believed that the emission reduction is related to the economic feasibility of specific emission reduction measures. In addition, some studies have shown that CO₂ emissions from the aviation industry will increase year by year and will shift to other industries to purchase carbon emissions. Vespermann et al. have found that the initial emission reduction effect of EU aviation carbon trading is not obvious, with a 0.9% reduction in emissions in 2013 compared to the non-implementation of the policy, and a greater late-stage emission reduction effect, with a 7.7% reduction after the implementation of the policy in 2020. Frontier Economics argues that the aviation industry's inclusion of EUETS is of little value, that carbon trading emissions reductions are not effective, and that significant emission reductions can only be achieved through stricter measures, such as individual trades within the aviation industry. The differences in the findings are related to its assumed conditions, such as route differences, aviation growth rates, carbon prices, price transfers, demand elasticity, etc. In addition, the specific emission reduction effect sits still to be determined by the disclosure of basic data such as CO₂ emissions from each airline, as well as the evaluation criteria established and agreed upon by the relevant countries.

References

[1] Yang bei, wang fangjun, huang kan. Carbon emission cost model for enterprises adapting to low-carbon economy [J]. Journal of xi 'an jiaotong university (social science edition), 2 011, 31 (1) : 44-47.

[2] W. Strunk Jr., E.B. White, The Elements of Style, third ed., Macmillan, New York, 1979.

[3] Yang hengshu. Optimization of multistage water transport network for bulk dry bulk cargo considering carbon cost [D]. Dalian maritime university, 2013

[4] Zhu yanling. Air cargo network space model analysis and layout optimization [D]. Dalian: dalian maritime university, 2013

[5] Zou Ming. Research on low-cost operation mode of Chinese airlines [D]. Harbin: Harbin university of engineering, 2009

[6] Luo yuelei. Research on optimization of inland collection and distribution network of container ports from the perspective of low carbon [D]. Dalian: dalian maritime university, 2014

[7] Wang miaomiao. Study on airline network optimization in alliance environment [D]. Nanjing: nanjing university of aeronautics and astronautics, 2016

[8] Lin J. Network analysis of China’s aviation system, statistical and spatial structure[J]. Journal of Transport Geography, 2012, 22:none:109-117.

[9] Brouer B D, Desaulniers G, Karsten C V, et al. A Matheuristic for the Liner Shipping Network Design Problem with Transit Time Restrictions[J]. Transportation Research Part E, 2014, 72(C):42-59.

[10] Ratnatunga J, Balachandran K R. Carbon Emissions Management and the Financial Implications of Sustainability[M]/ Corporate Sustainability. 2013.

[11] Zhuang guiyang, pan jiahua, zhu shouxian. Connotation of low-carbon economy and construction of comprehensive evaluation index system [D]. Economics dynamics, 2011 (1) : 132-136.