

# Carbon emission prediction of hub airport under dual carbon background-Take a hub airport in southwest China as an example

Yaoguo Fu<sup>1,2</sup>, Shuzhi Xiong<sup>4</sup>, Dengyu Qiu<sup>3</sup>, Lin Sun<sup>3</sup>, Yu Lei<sup>3</sup>

<sup>1</sup> Postdoctoral Programme, Chongqing Airport Group Co., Ltd., Chongqing 401120, China;

<sup>2</sup> School of Civil Engineering, Chongqing Jiaotong University, Chongqing 400074, China;

<sup>3</sup> Expansion Headquarters, Chongqing Airport Group Co., Ltd., Chongqing 401120;

<sup>4</sup> Chongqing Airport Group Co., Ltd., Chongqing 401120,

**Abstract.** In order to predict the carbon emissions of civil airports and the possibility of carbon peaking, the influence of key factors of carbon reduction on carbon emissions was studied. This paper takes a large hub airport in southwest China as the research object, sets the terminal energy demand module on the LEAP model of the airport to calculate the energy demand of the airport, and sets the carbon emission of the airport into three different scenarios: baseline scenario, low carbon scenario and zero carbon scenario, so as to predict the carbon emission trend of the airport and the possibility of carbon peaking in the next year. The analysis data in this paper can provide reference for civil airports to make "dual carbon" implementation plan.

**Keywords:** Civil airports; Scenario analysis; LEAP model; Energy consumption forecast; Carbon emissions.

## 1. Introduction

As an industry with high energy consumption and high emissions, air transport occupies a large share in the total carbon emissions of the national economy. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), the aviation industry accounts for 2.5% of the global carbon dioxide emissions that contribute to climate change. Among this 2.5% figure, the carbon emissions generated by the airport's own operations account for 5%, and the carbon emission reduction of airports is of great significance to global climate change. Among them, the prediction of total energy consumption and intensity control targets are the focus of energy development planning. As the basic energy data sources of large hub airports are not uniform, the statistics are difficult, and the energy consumption characteristics of various units in airports are different, how to scientifically and reasonably sort out the energy consumption types of each energy-consuming unit and make accurate statistics is an important problem at present [1]. On the basis of accurate statistics of energy consumption, predicting the future energy demand of airports is a key issue to guide the formulation of the "double carbon" goal of airports. This paper takes a large hub airport in southwest China as the research object, analyzes its energy supply and consumption status, scientifically and reasonably predicts the change trend of airport energy consumption and carbon emissions, analyzes the impact of taxi time reduction, clean energy use, energy consumption optimization and other low-carbon technology application on carbon emissions, and further analyzes the key driving factors affecting the airport carbon peak.

## 2. LEAP-Aircraft model and predictive scenario setting

### 2.1 LEAP-Aircraft model

Based on the structure and characteristics of LEAP model and the availability of data, a large hub airport in Southwest China was taken as the research object to establish an airport LEAP model [2-4] to predict the long-term energy consumption and carbon emissions of the airport. The total

energy consumption covers the entire airport energy consumption terminal. In this paper, terminal energy demand module is set on the airport LEAP model to calculate the airport energy demand. The terminal energy consumption segment is divided into airport and airline segments, and airport energy consumption is further subdivided into fixed fossil fuels, net purchased electricity, on-site vehicles and auxiliary power units (APU). In the established airport LEAP model, 2019 is taken as the baseline year, the forecast period is 2020-2060, and three scenarios are set. Namely, the baseline scenario, low carbon scenario and zero carbon scenario, the airport energy demand and carbon emissions are respectively predicted under the three scenarios. The airport LEAP model structure constructed in this paper is shown in the following table.

Table 1 LEAP model structure of airport

Energy consumption sector	subdepartment	Energy type	Energy consumption	CO <sub>2</sub> emission	formula
airport	Fixed facilities fossil fuels	Converted to standard coal	Activity level× Energy intensity	Energy consumption × Emission coefficient	$CO_2 = \sum \sum \sum AC_j \times EC_j \times C_k$
	Net purchase of electricity				
	Yard vehicle				
	Auxiliary power unit (APU)				
Airline company	Aircraft emission				

With 2019 as the initial year, CO<sub>2</sub> emissions from energy consumption at the airport are about 870,400 tonnes. Carbon dioxide emissions from energy consumption activities in each branch are aircraft emissions, net purchased electricity, fossil fuels for fixed facilities, vehicles and auxiliary power units (APU), accounting for 89.66%, 7.29%, 1.49%, 1.24% and 0.32%, respectively. The corresponding carbon emissions are 780400 tons, 63400 tons, 13300 tons, 10800 tons and 2800 tons.

## 2.2 Forecast scenario setting

The baseline scenario refers to the scenario that continues the current economic and social development trend of the airport and the policies and measures of energy conservation and emission reduction. This scenario is based on the baseline year of 2019, in accordance with the "14th Five-Year Plan for Civil Aviation Development" and the "14th Five-Year Plan for Green Development of Civil Aviation", while referring to the medium and long-term development goals of airports, energy consumption and emission intensity control targets. The development trends of airport economic growth, population size, urban and rural structure, industrial structure and other parameters from 2022 to 2035 are predicted [5-6]. On this basis, this paper sets two additional scenarios, namely low carbon scenario and zero carbon scenario. A low-carbon scenario is defined as a scenario in which carbon reduction technologies are introduced under the baseline scenario. Zero-carbon scenarios are defined as scenarios where carbon emission reduction technologies are introduced and new energy technologies are used.

## 3. Airport energy consumption and carbon emissions under different scenarios

According to the parameters set in the previous section and some relevant assumptions, the LEAP model is used to obtain the airport energy consumption and carbon emission under the three scenarios set. The results of the three scenarios are analyzed below.

### 3.1 Forecasting and analysis of long-term terminal energy consumption of airports

LEAP model was used to forecast the airport energy demand under the baseline scenario, and the results were shown in Figure 3.1. We can see that the total energy consumption in each scenario presents a trend of first increasing and then decreasing. In the baseline scenario, the total energy consumption will peak in 2035 at about 396,200 tons of standard coal, and then show a downward trend year by year. In the low-carbon scenario, the total energy consumption will peak in 2032, consuming about 372,700 tons of standard coal, and has shown a downward trend year by year since then. In the zero-carbon scenario, the total energy consumption will peak in 2032, consuming about 372,600 tons of standard coal, and then show a downward trend year by year. In the overall scenario, airport energy demand will peak before 2035.

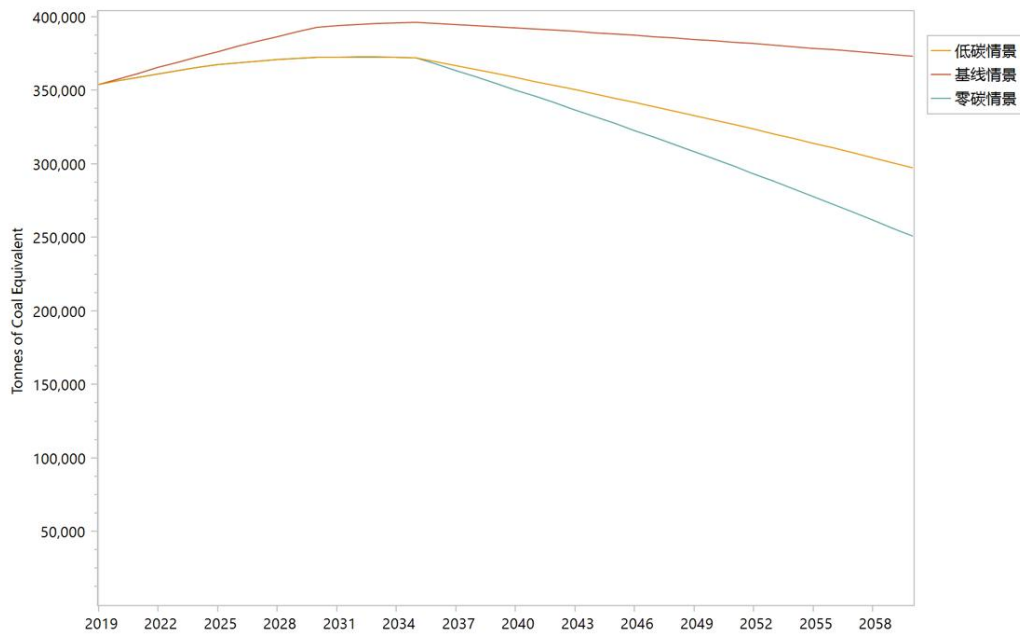


Figure 1 Total energy consumption of airports in 2019-2060 under three scenarios

### 3.2 Long-term carbon emission forecast analysis of airports

#### (1) Carbon emission trend

According to the product of the predicted results of total energy consumption under the above three scenarios and the corresponding carbon emission reference coefficients of various energy sources, the total carbon emission of the airport under the three scenarios is obtained, as shown in Figure 2. In the baseline scenario, it is expected to peak at 974,700 tonnes in 2035. In the low-carbon scenario, total airport carbon emissions are expected to peak at 904,700 tons in 2030. In the zero-carbon scenario, each further increases the proportion of clean energy use, and its peak of 892,200 tons will be reached in 2028.

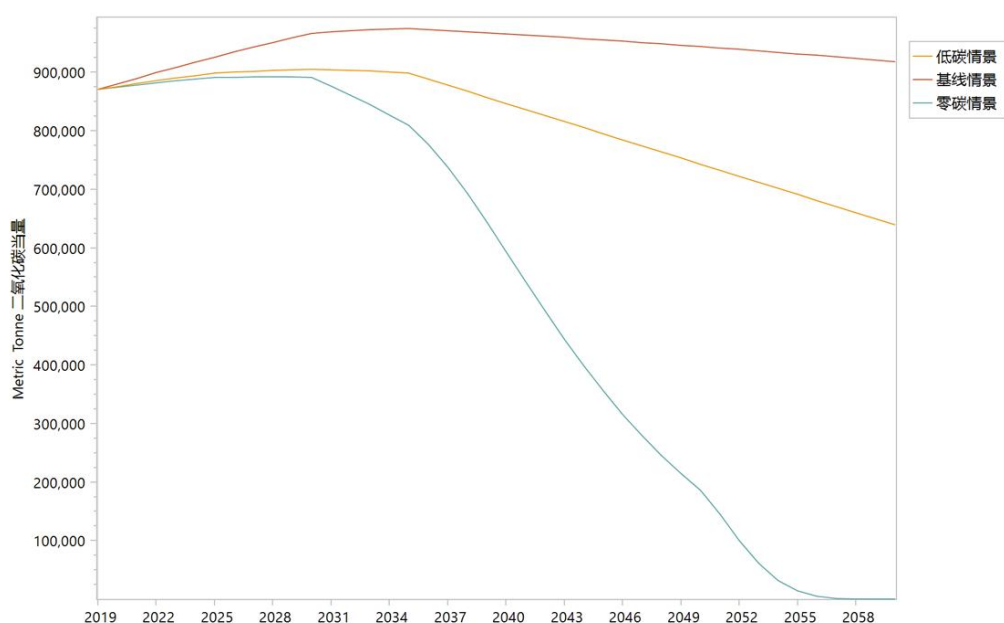
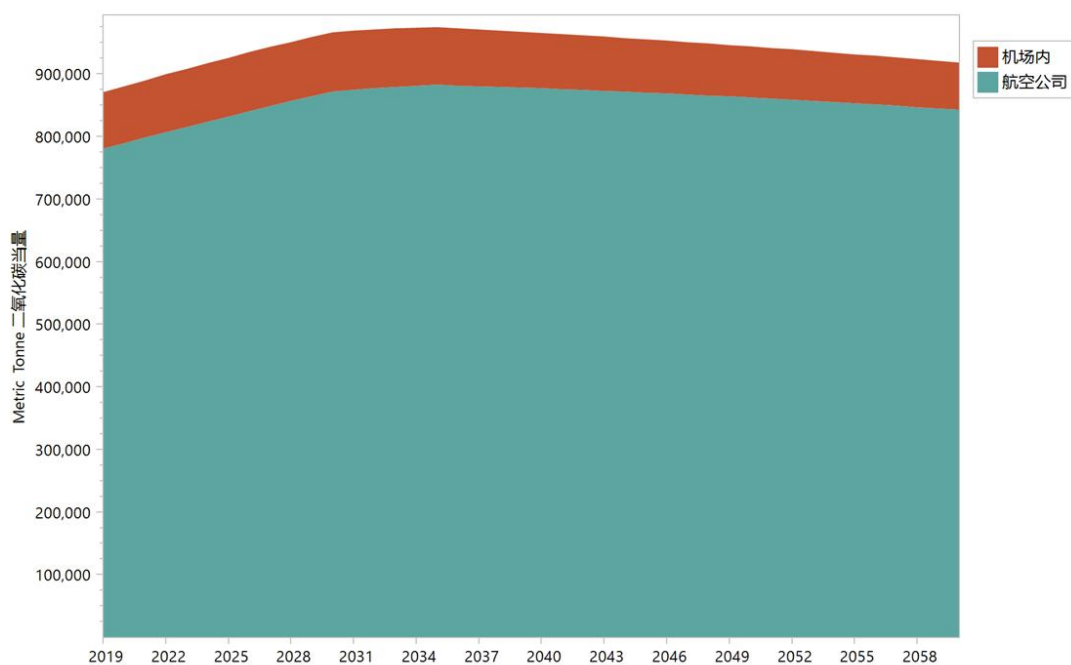


Figure 2 Carbon emissions of airports in 2019-2060 under three scenarios

## (2) Baseline scenario

In the baseline scenario, emissions would peak at 974,700 tonnes in 2035. From the perspective of carbon emission distribution, carbon emissions from aircraft accounted for the highest proportion, followed by carbon emissions from net purchased electricity, carbon emissions from fossil fuels in fixed facilities and carbon emissions from vehicles in the site were less, and carbon emissions from auxiliary power units (APUs) accounted for the least.



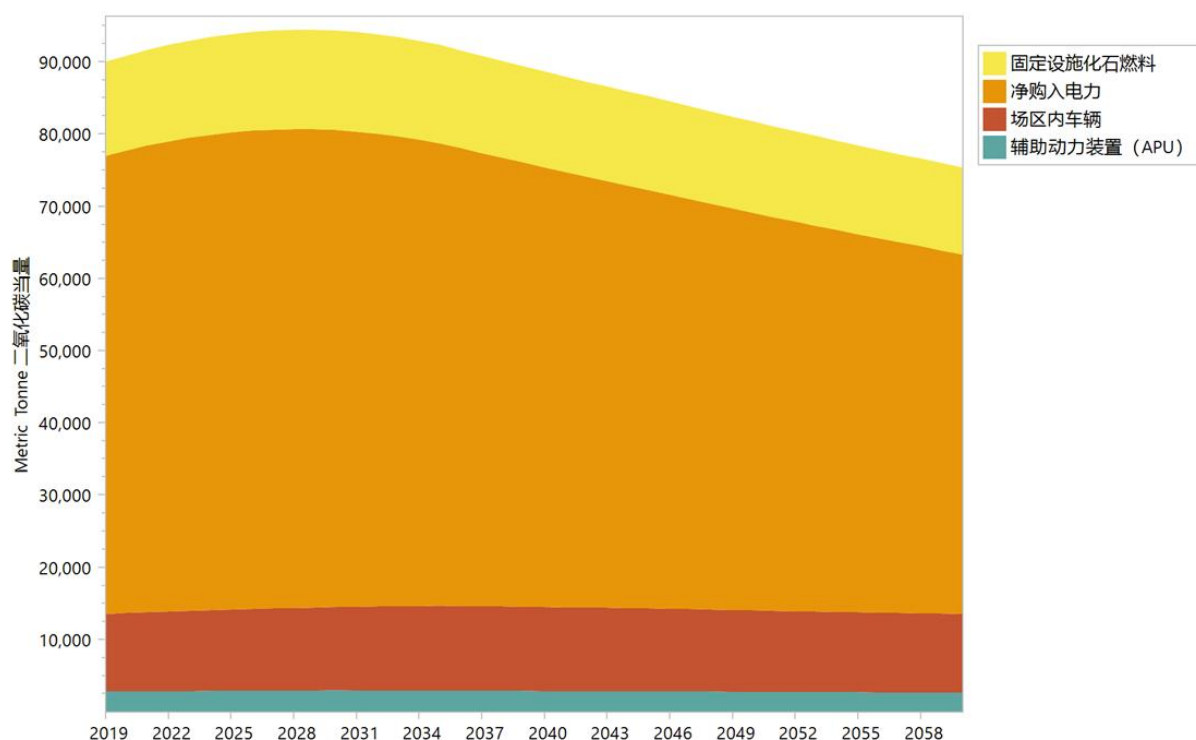
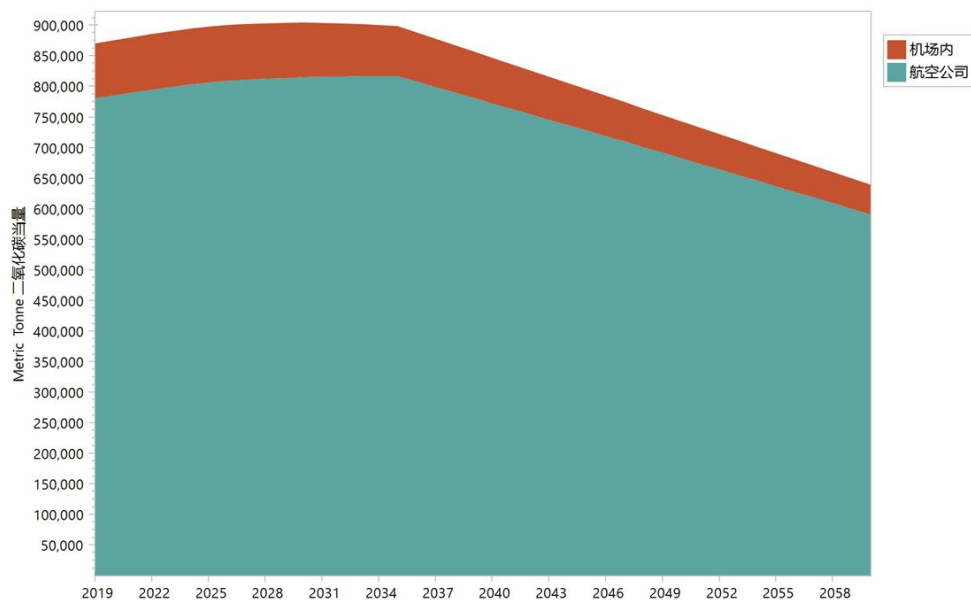


Figure 3 Airport carbon emissions from 2019 to 2060 under the baseline scenario

### (3) Low carbon scenario

In the low-carbon scenario, carbon emissions will peak at 904,700 tons in 2030. Compared with the baseline scenario, the peak year of carbon emissions has been significantly advanced, and carbon emissions have been significantly reduced. However, from the perspective of carbon emission distribution, aircraft carbon emissions still account for the highest proportion.



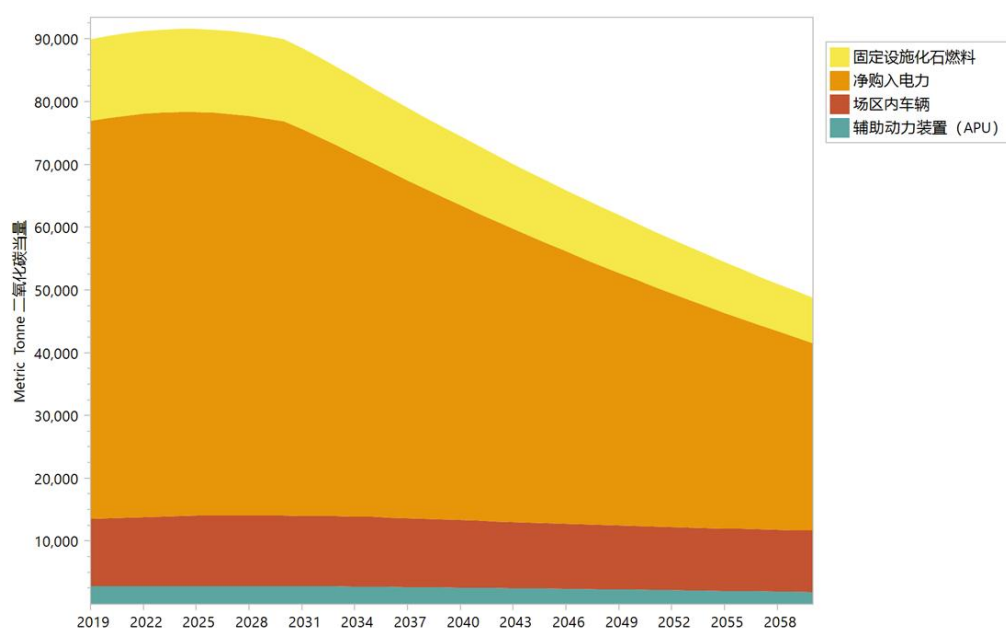
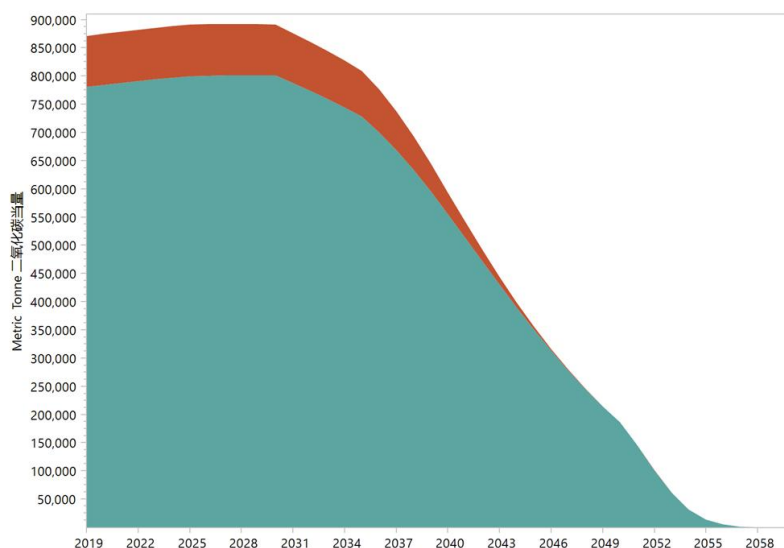


Figure 4 Carbon emissions of airports from 2019 to 2060 under the low-carbon scenario  
(4) Zero carbon scenario

In the zero-carbon scenario, the peak of carbon emissions will reach 89.20 million tons in 2028. Compared with the baseline scenario and low-carbon scenario, the peak year of carbon emissions will be further advanced, and carbon emissions will obviously decrease further. From the perspective of carbon emission distribution, aircraft carbon emissions account for the highest proportion, but with the passage of time, carbon emissions have shown a sharp decline.



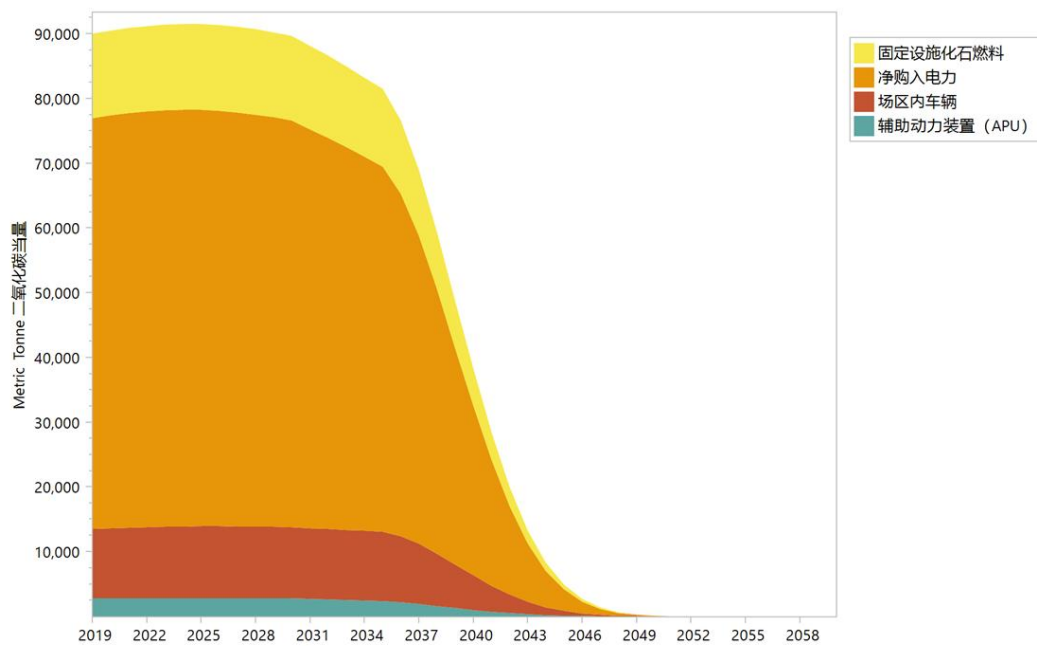


Figure 5 Carbon emissions of airports from 2019 to 2060 under zero carbon scenario

#### 4. Conclusion

On the basis of sorting out the types of airport energy consumption, this paper divides the types of airport carbon emissions from six aspects: aircraft carbon emissions, auxiliary power unit (APU), airport fossil energy consumption, airport operation power consumption, vehicle energy consumption within the airport yard, and ground transportation (GAV), and statistics the energy consumption and carbon emissions data of each type in the base year. Among them, the carbon emission of aircraft during LTO cycle accounted for 89.66% of the total carbon emission of the airport, and the electricity consumption accounted for the largest proportion in the operation process of the airport. The LEAP-Aircraft model is built based on the classified statistics of airport energy consumption. Based on this model, the basic scenario, low-carbon scenario and zero-carbon scenario are divided, and the long-term terminal energy consumption and carbon emission of the airport are predicted and analyzed. The analysis data in this paper can provide reference for the airport to make the "dual-carbon" implementation plan.

#### Reference

- [1] Ding Jianfeng, Xu Haiyan. Design process planning and decoupling analysis in uncertain environment based on grey DSM[J]. Chinese management science, 2014, 22(S1):15-21.
- [2] Sun Feng, Yan Zehua, Zhang Haoling. Analysis of input-spillover effect in social sector: calculation based on input-output method[J]. Xue Hai, 2018, (02):140-146.
- [3] Wei Binxian, Ning Zijun. Structural change, efficiency improvement and energy demand forecast in Zhejiang Province[J]. Science and technology bulletin, 2012, 28(11):130-134.
- [4] Du Hanbei, Zhao Lijun, Liu Chengwei. Prediction and uncertainty analysis of carbon peak in main urban area based on LEAP model and KAYA model[J]. Journal of Ecology and Rural Environment, 2022, 38(08):983-991.
- [5] Sun Zhifeng, Qu Shiling, Jin Xi. Carbon emission status and implementation path analysis of typical airport terminals in China[J]. Building science, 2023, 39(12):28-35.
- [6] Jiang Yu, Wang Yasha, Xue Qingwen. Research on space-time taxi optimization of aircraft based on carbon emission[J]. Journal of South China University of Technology (Natural Science Edition), 2023, 51(10):152-159.