Research on Low-Carbon Campus Based on Carbon Footprint Model

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Abstract. This paper uses the carbon footprint model to study the carbon emissions of low-carbon campuses. Based on the actual campus conditions, the campus carbon cycle is investigated through field surveys and interviews to discuss the school’s carbon balance and obtain the water, electricity and domestic waste of Tianjin University of Technology. The conclusion that the carbon emissions are large and the emissions of people and cars are small, carbon emissions governance needs to be greatly improved based on the carbon footprint model of low-carbon campus research.

Keywords: Carbon footprint model, low carbon.

1. Introduction
Nowadays, the international community is facing increasingly severe natural disasters and environmental degradation. The low-carbon economy, which focuses on energy conservation and emission reduction and new energy development, is gaining more and more attention at home and abroad. In the 13th Five-Year Plan of China, it is necessary to achieve a 15% reduction in per capita energy consumption and water consumption of colleges and universities across the country, and promote the construction of 300 green campus demonstration units. [1] Therefore, colleges and universities, as key energy consumption units, should bear the responsibility of leading ecological civilization, raise the awareness of building low-carbon campuses, actively explore the methods of building low-carbon campuses, and let teachers and students participate in the construction of low-carbon, ecological and sustainable development Campus environment. This article fully understands the construction level of low-carbon campuses under basic units from the perspective of campus communities, and provides theoretical suggestions and support for the sustainable development of domestic campuses in the future.

2. Models and methods
2.1. Research objects and methods
Tianjin University of Technology was founded in 1979. It is a multi-disciplinary university with multi-disciplinary and coordinated development based on engineering. The school is located in Xiqing District of Tianjin. The water area is 400,000 square meters, with more than 27,000 full-time undergraduates and more than 1,800 faculty members. The topographic map of Tianjin University of Technology is shown in Figure 1. In the figure, the circle marked area is specifically lake water area, and the rectangle marked area is land-land area. This article uses the carbon footprint theory. The "carbon footprint" theory
refers to the collection of greenhouse gas emissions caused by corporate organizations, activities, products or individuals through transportation, food production and consumption, and various production processes. It is based on carbon dioxide. For calculations, [2] Starting from two aspects of carbon emissions and carbon sequestration, from the campus green space vegetation, energy consumption (including tap water, electricity), campus traffic conditions (private cars, official cars, trucks, etc.), students and teachers daily carbon emissions, etc. Five angles are used to analyze the carbon flow in the campus in depth, and the carbon emissions of various processes throughout the year are further calculated and collected through the above data collection. [3]

Figure 1. Tianjin University of Technology resource distribution map

2.2. Carbon footprint model framework

Through data collection and processing, the article combines scholars’ research to make a framework for carbon emissions in a specific environment. Among them, the carbon pool is defined as CP (carbon pool), the school’s population carbon emission is R, the transportation carbon emission is J, the school’s energy carbon emission is NN, the school’s domestic waste carbon emission is NC, and the school’s green land carbon sequestration is LC. See Figure 2 for details.

Figure 2. Carbon footprint model of low-carbon campus

2.3. Model calculation and method

2.3.1. Carbon emissions of the entire school population. There are many sources of carbon dioxide in the air in daily life. In order to simplify the calculation of campus carbon emissions, now only the carbon emissions of teachers’ birthdays are considered. By querying the school’s official website and related data, the school’s teachers and students, logistics management personnel, school catering staff, etc. A total of more than 30,000 people, the number of school days except for the 60 days of winter and summer vacation is 300 days and the order is D. The carbon emission coefficient of adults in daily life is C1, where the value of C1 is 14kgCO2/d, [3] makes the carbon emissions of the entire school population R,
the total number of students in the school is NR, and the calculation formula of the total school carbon emissions is as follows (1).

\[ R = NR \cdot C_1 \cdot D \]  

(1)

Among them:
- \( R \) —— carbon emissions of the entire school population
- \( NR \) —— the total number of the whole school
- \( C_1 \) —— Adult carbon emission coefficient
- \( D \) —— days in school

2.3.2. Transportation carbon emissions. The car model of the teacher is different from the model of the car. The carbon emission coefficient of the medium-fuel-consuming car is 0.3kgCO2/km (according to the data of the Daohe Environment and Development Institute). The field mileage of the car is roughly estimated by the field survey. 4km, The average number of times of entering and leaving the campus is 3000 per day, and the number of days in school is 300 days except for 60 days in winter and summer vacations, and there are 620 (interval) buses that enter and leave the campus for 22 flights per day and the round-trip mileage is 0.5km, and the number of days on campus is 365 days. As above, the carbon emission coefficient is \( C_2 \), and the value of \( C_2 \) is 0.01kgCO2/km, so that the school’s traffic carbon emission is \( J \), the number of daily vehicles is \( S \), the average driving distance is \( L \), and the number of driving days is \( D \). The calculation formula is (2).

\[ J = \Sigma S \cdot L \cdot D \]  

(2)

Among them:
- \( J \) —— Carbon carbon emissions of the whole school
- \( S \) —— number of vehicles per day
- \( L \) —— average driving distance
- \( D \) —— days in school

2.3.3. Energy carbon emissions. Many factors are involved in the calculation of energy carbon emissions on campus. Now the main calculations are the usage of water and electricity on campus. The calculation formula is (3), and the carbon emission coefficients of each energy are shown in Table 1.

![Table 1](image)

Table 1. Carbon emission coefficients of various energy sources

| Energy type          | symbol | Corresponds to the symbol for carbon emission factor | value of number             |
|----------------------|--------|-----------------------------------------------------|-----------------------------|
| Water                | W      | \( C_3 \)                                            | 0.91kgCO2/m³                |
| Electric power       | E      | \( C_4 \)                                            | 1kgCO2/kwh                  |

Note: The data comes from Daohe Environment and Development Institute

\[ NN = \Sigma NL \cdot CP \]  

(3)

Among them:
- \( NN \) —— the school’s energy carbon emissions
- \( NL \) —— Energy type
- \( CP \) —— Corresponding carbon emission factor symbol

2.3.4. Carbon emissions of domestic waste. Domestic waste on campus is mainly derived from daily catering waste and other waste of teachers and students. According to the 2018 report of the World Bank Organization, the per capita waste generation in China in 2016 was 0.43kg/d, [4], and the school days were 300 days. The carbon emission coefficient is 2.97kgCO2/kg. The calculation formula is as (4).
Among them:
NC——carbon emissions of household garbage
DC——Total daily garbage
C5——China’s per capita garbage production
D——days in school

### 2.3.5. Carbon fixation in green space.

The greening plants on the campus are mainly trees, shrubs and herbs. From the map, it is estimated to be about 265700m². The green area of trees and shrubs is about 66400m². The green area of trees and herbs is about 66400m². The green area of shrubs and herbs is about 132900m², because Tianjin is located in northern China, some trees and shrubs will fall in autumn, so in order to more accurately calculate the annual carbon sequestration of the green space, the time will be reduced by two months. According to the literature, the average carbon fixation coefficient and the different green space area are obtained in the case of different vegetation coverage of green land as shown in Table 2 [3] below. The annual carbon absorption formula of green land is shown in (5).

| Green space type (LL) | area | Carbon emission coefficient symbol | Carbon sequestration per unit area (kgCO2/d·m³) |
|----------------------|------|-----------------------------------|-----------------------------------------------|
| Arbor + shrub (LL₁)  | S₁   | C₆                                | 0.27                                          |
| Arbor + Herb (LL₂)   | S₂   | C₇                                | 0.11                                          |
| Shrub + herbs (LL₃)  | S₃   | C₈                                | 0.12                                          |

\[
\text{LC} = \sum \text{LL} \cdot \text{S} \cdot \text{D} 
\] (5)

Among them:
LC——the amount of carbon sequestered in the whole school
LL——green space type
S——Green area
D——days of carbon emissions

### 3. Results and discussion

#### 3.1. Campus carbon emissions

The total population of the whole school is 30,000, ignoring the number of school leavers and the number of days on holiday, the average school time is 300 days, the daily carbon emissions of the whole school population is 34.2t, and the annual carbon emissions calculated by formula (1) is 10260t. In terms of transportation, the daily carbon emission of school transportation is 3.6t, and the annual carbon emission calculated by formula (2) is about 1080t. In terms of energy, the annual average water consumption of Tianjin University of Technology is 1.6×10⁴ t, the carbon emission is 14560t, the average annual electricity consumption is 3000×10⁴ KW·h, and the carbon emission is 30,000t. In terms of carbon emissions from domestic waste, the amount of domestic waste generated by the school per day is 12.9t, and the carbon emissions generated throughout the year are 11293.9t. Specifically shown in Figure 3.
It can be clearly seen from the above figure that the amount of electricity used is very large, resulting in 45% of carbon emissions, followed by 22% of the carbon emissions generated by water consumption. Due to the large population of the school, food residues and waste clothing The increase has resulted in a carbon emission of 17%, and the carbon emission of the population is 15%. The minimum carbon emissions from motor vehicles are 1%.

3.2. Campus carbon fixation
From the field investigation and check with the campus logistics department, the green area of the campus is estimated to be about 265700m², the green area of trees and shrubs is about 66400m², the green area of trees and herbs is about 66400m², the green area of shrubs and herbs is about 132900m², Therefore, calculated by formula (5), the carbon sequestration of campus green space is 41.18t per day, and the annual carbon sequestration is 12354t.

3.3. Campus carbon balance
The total annual carbon emissions of the campus are 6,7193.9t, and the annual carbon sequestration is 12,354t. The annual school carbon gap is 5,489.9, and the carbon overflow ratio is 82%. From Figure 4, it is more vivid to see that the gap is large, indicating that carbon absorption lags far behind carbon emissions.

Based on the survey of carbon emissions on campus, there is a problem of excessive water and electricity consumption, and the amount of waste generated is also a very prominent problem. It is imperative to do a good job of waste classification to reduce the generation of waste, but from the
canteen and According to investigations in places such as dormitory areas, there are many wastes of water and electricity. After consulting the views of some classmates, it is more comfortable to waste collective resources than to waste one's own resources, and the awareness of environmental protection and low carbon is weak. Judging from the above survey indicators, the school has a lot of room for improvement in terms of hydropower and domestic waste. Establishing and improving a low-carbon evaluation system is the most urgent task to promote the construction of low-carbon campuses, followed by deep-level infrastructure and garden planning.

4. Conclusion
In the course of building low-carbon campuses, colleges and universities should fully learn from the successful experience of domestic and foreign universities, and build communities with their own characteristics—a low-carbon model of harmonious environmental symbiosis, actively advocate the concept of sustainable development, and establish a low-carbon campus evaluation system is not only clear Colleges and universities are implementing the main obligations and responsibilities of energy conservation and emission reduction in the state, provinces and cities, and also pointed out the direction for green, low-carbon and sustainable development of colleges and universities. [5] In addition, it is necessary to use resources reasonably to reduce carbon emissions. In promoting the construction of energy-saving carpet campuses, statistics show that less than 10 floors of elevators can reduce carbon emissions of 2.18kg. 10% of the country’s printing or copying can achieve double-sided printing energy saving Reduce carbon emissions by 164000t. [6] Strengthen the master spirit of promoting the construction of teachers and students' low-carbon campuses, establish a low-carbon reward and punishment mechanism, and implement the campus low-carbon goals through two hands. Finally, we must improve energy-saving infrastructure, green planning and scientific carbon fixation. Universities should incorporate the concepts of energy saving, low carbon and environmental protection into the reconstruction, maintenance and expansion of campus infrastructure. In the indoor and outdoor decoration, heat insulation in winter and heat dissipation in summer The goal is to promote the use of solar power in a planned manner in terms of electricity, photovoltaic heating to replace central heating in winter, solar water heaters to reduce coal gas, and so on. In addition, the school's logistics and green plant maintenance department should scientifically plan the coverage of idle open space green plants, on the one hand beautify the landscape, on the other hand the scale of plant carbon sequestration, in addition, fully develop the school's scientific research force to promote the implementation of low-carbon campus goals and provide technical support.

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