

# Analysis of Influencing Factors of Electric Bus Energy Consumption

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**ABSTRACT:** With the continuous improvement of environmental awareness and the rapid development of new energy technology, electric buses are playing a more and more important role in urban transportation. In this paper, the influence factors of electric bus energy consumption are deeply studied, including vehicle characteristics, driving conditions, driving behavior and environmental factors. Through the analysis of the actual running data and the experimental research, the specific influence mechanism of these factors on the energy consumption of electric buses is revealed. On this basis, the effective measures and suggestions to reduce the energy consumption of electric buses are put forward, which provides theoretical basis and practical guidance for improving the energy utilization efficiency of electric buses and promoting the sustainable development of urban public transportation.

**KEY WORDS:** Electric bus; Energy consumption; Vehicle characteristics; Driving condition; Driving behavior; Environmental factors

## 1. INTRODUCTION

In the context of global energy crisis and increasingly serious environmental pollution, electric buses, as a green and environmentally friendly means of public transport, have been widely concerned and promoted. However, the energy consumption of electric buses is still one of the key factors restricting its further development. In-depth study of the factors affecting the energy consumption of electric buses has important practical significance for improving the energy efficiency of electric buses, reducing operating costs and reducing environmental pollution.

## 2. THE INFLUENCING FACTORS OF ELECTRIC BUS ENERGY CONSUMPTION

### 2.1. Vehicle characteristics

#### 2.1.1. Vehicle quality

The greater the mass of the electric bus, the greater the rolling resistance and air resistance it needs to overcome during the driving process, resulting in increased energy consumption. Therefore, reducing the vehicle mass is one of the important ways to reduce the energy consumption of electric buses.

#### 2.1.2. Battery performance

The battery is the power source of electric buses, and its performance directly affects the energy consumption of the vehicle. Battery energy density, charging and discharging efficiency, cycle life and other factors will have an impact on the energy consumption of electric buses. For example, a battery with a high energy density can be lighter in weight for the same

amount of power, thus reducing the energy consumption of the vehicle and improving the driving range.

#### 2.1.3. Motor efficiency

The motor is a key component that converts electrical energy into mechanical energy, and its efficiency directly affects the energy consumption of electric buses. Efficient motors can output more mechanical energy for the same input power, thus reducing the vehicle's energy consumption. At the same time, the higher the energy recovery rate of the motor, the more energy efficient the vehicle.

#### Seal insulation

The sealing heat insulation performance of the vehicle affects the heat exchange between the inside and outside of the vehicle, and the sealing heat insulation is good, the heat loss of the vehicle is less, and the energy consumption of the air conditioner can be reduced.

#### Gas path to maintain pressure

Gas road pressure protection is a full-time work, directly affect the working frequency and time of the air pump, good pressure protection, vehicle energy saving.

### 2.2. Driving conditions

#### 2.2.1. Road conditions

Different road conditions have a great impact on the energy consumption of electric buses. When driving on a flat road, the vehicle needs to overcome less resistance, and the energy consumption is relatively low; When driving on a bumpy road,

the vehicle needs to overcome the resistance is larger, and the energy consumption is relatively high.

#### 2.2.2. Traffic flow

When the traffic volume is high, the speed of the electric bus will be limited, and frequent starts and stops will increase the energy consumption of the vehicle. In the case of small traffic flow, the vehicle can maintain a relatively stable speed, and the energy consumption is relatively low.

### 2.3. Driving behavior

#### 2.3.1. Acceleration and deceleration

Frequent acceleration and deceleration will increase the energy consumption of an electric bus. Because the acceleration needs to consume a lot of electric energy to improve the speed of the vehicle, while the deceleration of the energy recovery, but still part of the kinetic energy through the vehicle braking system into thermal energy to be emitted, resulting in waste of energy.

#### 2.3.2. Drive at a constant speed

Maintaining a constant speed will reduce the electric bus's energy consumption. When the vehicle is driving at a constant speed, the resistance that needs to be overcome is relatively stable, and the output power of the motor is also relatively stable, which can improve energy efficiency.

#### 2.3.3. Air conditioning use

During the hot summer months and the cold winter months, the air conditioning system of an electric bus will consume a lot of electricity. Reasonable use of the air conditioning system, such as setting the appropriate temperature and avoiding turning on the air conditioning for a long time, can reduce the energy consumption of the vehicle.

### 2.4. Environmental factors

#### 2.4.1. Environmental temperature

The ambient temperature has a certain impact on the energy consumption of electric buses. In low temperature environment and high temperature environment, when the vehicle is running, the car needs to open the air conditioning, adjust the appropriate temperature, improve passenger comfort, air conditioning will consume more energy, vehicle energy consumption increases.

## 3. MEASURES TO REDUCE ENERGY CONSUMPTION OF ELECTRIC BUSES

### 3.1. Optimize vehicle design

#### 3.1.1. Reduce vehicle mass

The use of lightweight materials, such as high strength steel, aluminum alloy, carbon fiber, etc., to optimize the body, chassis and other components of electric buses, reduce vehicle mass and reduce energy consumption.

#### 3.1.2. Improve battery performance

The battery with high energy density, high charge and discharge efficiency, good temperature resistance and long cycle life can improve the performance of the battery, increase the driving range of the vehicle and reduce energy consumption.

#### 3.1.3. Optimize motor design

Adopt efficient motor design technology to improve the efficiency and energy recovery rate of the motor and reduce the energy consumption of the vehicle.

#### 3.1.4. Optimize air conditioning design

The use of heat pump air conditioning, power and vehicle required cooling capacity matching, refrigerant using efficient refrigerant, improve the efficiency of air conditioning, reduce the energy consumption of vehicles.

#### 3.1.5. Optimize thermal insulation design

The vehicle adopts thermal insulation measures to reduce the heat exchange between the car and the outside, reduce the loss of hot and cold energy, and reduce the energy consumption of the vehicle.

#### 3.1.6. Optimize the design of pressure preservation

The vehicle gas road adopts the pipeline with good sealing effect and verifies the pressure holding, reduces the air leakage, reduces the working frequency and time of the air pump, and then reduces the energy consumption of the vehicle.

#### 3.1.7. Regular battery maintenance

During the use of the vehicle, there will be differences in the consistency of the single battery, leading to a decline in battery performance and mileage. In view of the consistency difference, active balance and passive balance are taken to maintain the battery, improve the consistency of the battery, which can improve the overall battery performance, extend the driving range, and reduce the comprehensive energy consumption.

### 3.2. Reasonable planning of driving routes

#### 3.2.1. Choose flat road conditions

When planning your route, try to choose a flat road to reduce the time the vehicle spends on rugged roads and reduce energy consumption.

#### 3.3.2. Avoid traffic jams

Arrange the driving time reasonably, try to avoid the traffic jam period, the vehicle in the case of heavy traffic, energy consumption will increase.

### **3.3. Standardize driving behavior**

#### **3.3.1. Smooth acceleration and deceleration**

The driver should develop the habit of smooth acceleration and deceleration, avoid frequent rapid acceleration and deceleration, and reduce the energy consumption of the vehicle.

#### **3.3.2. Drive at a constant speed**

During the driving process, try to keep a constant speed, adjust the speed reasonably according to the road conditions and traffic flow, and improve energy efficiency.

#### **3.3.3. Use air conditioning reasonably**

According to the season and the temperature in the car, set the air conditioning temperature reasonably, avoid turning on the air conditioning for a long time, and reduce the energy consumption of the vehicle.

### **3.4. Improve environmental conditions**

#### **3.4.1. Temperature control**

In winter, measures such as preheating the battery and installing thermal insulation devices can be used to improve the performance of the battery; In summer, you can use shading, ventilation and other measures to reduce the temperature in the car, reduce the use of air conditioning time, reduce energy consumption.

## **4. EXPERIMENTAL RESEARCH AND TEST ANALYSIS**

In order to verify the influence of the above factors on the energy consumption of electric buses, relevant experimental studies were carried out. Aiming at the 10-meter electric bus, the actual operation test was carried out under different working conditions, driving behavior and environmental conditions, and the energy consumption of the vehicle was analyzed.

### **4.1. Experiment on the impact of vehicle characteristics on energy consumption**

Electric buses with different loads are tested under the same driving conditions. The results show that the energy consumption of the vehicle with light mass is significantly lower than that of the vehicle with heavy mass.

### **4.2. Experiment on the influence of driving conditions on energy consumption**

The electric bus is tested under different road conditions (flat road, rugged road) and traffic flow (large flow and small flow). The results showed that the energy consumption of the vehicle was lower on a flat road with low traffic flow; And on rough roads with large traffic flow, the vehicle energy consumption is higher.

### **4.3. Experiment on the influence of driving behavior on energy consumption**

Different drivers were asked to drive electric buses in different driving ways (frequent acceleration and deceleration, constant speed, reasonable use of air conditioning). The results showed that drivers who accelerated and decelerated smoothly, kept a constant speed and used air conditioning properly drove vehicles with lower energy consumption.

Smooth driving and avoiding sharp acceleration and braking can significantly reduce energy consumption. Rapid acceleration will cause excessive torque of the motor and increase power consumption; Sharp braking consumes a lot of power.

Rational Use of energy recovery, pure electric vehicles have the function of energy recovery in the process of slowing down or braking. As far as possible to implement predictive electric braking, reduce air braking, can effectively improve the efficiency of energy recovery.

air conditioning use, air conditioning is the vehicle electric equipment after the drive motor the largest energy consuming equipment. Reasonable setting of air conditioner temperature and use of air exchange function can reduce energy consumption.

### **4.4. The impact of environmental factors on energy consumption experiment**

The electric bus is tested at different temperatures (low temperature, normal temperature, high temperature). The results showed that the energy consumption of the vehicle was lower at normal temperature; In both low and high temperature environments, the energy consumption of the vehicle will increase.

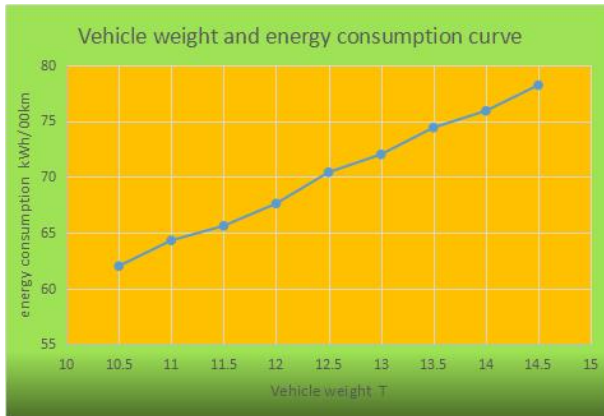
### **4.5. Test of the effect of regular battery maintenance on energy consumption**

Through the active balancing function and passive balancing function of the battery management system, the consistency of the battery is repaired, and the energy efficiency of the battery is

improved, which can reduce the energy consumption of the vehicle.

Based on the analysis of experimental data, the following chart is drawn:

#### 4.5.1. Relationship curve between vehicle mass and energy consumption



The 10-meter bus, under the same driving conditions, increases by 0.5 tons per drive, gradually increasing from 10.5 tons to 14.5 tons.

With the increase of vehicle mass, energy consumption is on the rise, about every 1 ton of vehicles, 100 kilometers of energy consumption increased by about 5kWh, lightweight vehicles can reduce the overall vehicle energy consumption. Optimize the body structure, the use of lightweight materials, etc.

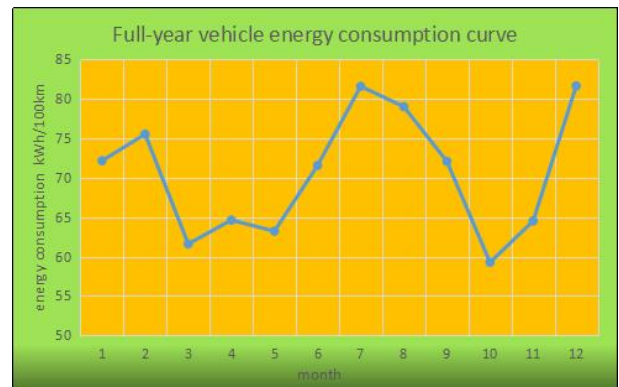
#### 4.5.2. Driving speed and energy consumption relationship curve



The 10-metre bus, under the same conditions, respectively at 5 km / 10 km per hour / 20 km / 30 km / 40 km / 50 km, 60 km.

Within a certain speed range, energy consumption decreases with the increase of speed, but when the speed exceeds a certain value, energy consumption will increase with the increase of speed. The vehicle runs at a speed of 30~40km/h, and the energy consumption is low.

#### 4.5.3. Relationship curve between ambient temperature and energy consumption



The monthly energy consumption of a 10-meter bus that has been running on a bus line for one year was measured.

In the four seasons, winter low temperature and summer high temperature environment, energy consumption is significantly higher than the spring and autumn environment, the maximum difference in energy consumption is about 30% higher, mainly winter and summer air conditioning energy consumption. Improving vehicle insulation, selecting high-efficiency energy-saving air conditioners, rational use of air conditioners, etc., will reduce vehicle energy consumption.

#### 4.5.4. Batteries are regularly maintained to improve performance



Balance before and after maintenance

During the use of the battery, there will be a certain difference in battery voltage, generally in 3 to 6 months to do a balanced maintenance.

The battery system is maintained through active balance and passive balance, the battery consistency is improved, the "bucket

effect" of the battery system is eliminated, the overall performance of the battery is given full play, the battery performance is improved, the battery life is extended, and the energy consumption is reduced.

## 5. CONCLUSION

Through the in-depth study of the factors affecting the energy consumption of electric buses, this paper draws the following conclusions:

1. Vehicle characteristics, driving conditions, driving behavior and environmental factors will have an impact on the energy consumption of electric buses. Among them, vehicle quality, battery performance, motor efficiency, road conditions, traffic flow, driving habits and ambient temperature are the main influencing factors.

2. By optimizing vehicle design (lightweight body, high energy density battery), reasonable planning of driving routes, standardized driving behavior (driver smooth driving training), improving environmental conditions, optimization and rational use of air conditioning and regular battery maintenance and other measures, the energy consumption of electric buses can be effectively reduced and energy efficiency can be improved.

3. Experimental research and test analysis results verify the authenticity and effectiveness of the above influencing factors, and provide scientific basis and practical guidance for reducing the energy consumption of electric buses.

In the future, with the continuous development and application of new energy technology, the problem of energy consumption of electric buses will be further solved. At the same time, we also need to constantly explore new technologies and methods to improve the energy efficiency of electric buses, and make greater contributions to promoting the sustainable development of urban public transport.

## ACKNOWLEDGMENT

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