**Analysis of Electric Power Substitution Development in Transportation Field and Research on Energy Conservation Efficiency Measurement Method**

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**Keywords:** Electric power substitution, Electric vehicle, Port and coastal power, Energy efficiency decline, Measurement.

**Abstract.** With the development of electric energy substitution in the field of transportation, related research has been deepened. In this paper, the current situation of electric energy substitution in the field of transportation is analyzed, and the calculation model of charging energy-saving effect of electric vehicles and the calculation model of charging energy-saving effect of ports and shores are constructed. Finally, some suggestions for the future development of electric energy substitution in the field of transportation are put forward. This study can provide theoretical support for further promoting the work of power substitution.

**Introduction**

In recent years, China's environmental damage has become more and more serious, and the pressure of ecological environment protection has been increasing. The large-scale and long-term severe fog and haze weather at the beginning of this year truly reflects the current severity of air pollution. Coal is the main energy structure in China, and coal-fired emission is the main source of atmospheric pollution. According to the relevant agencies, coal and fuel are important sources of PM2.5 in China, of which 50% - 60% come from coal-fired emissions and about 20% from motor vehicle fuel emissions.

From the energy efficiency point of view, the energy efficiency of electrical equipment is far higher than that of coal-fired, oil-fired and other energy-using equipment. Increasing the promotion of electric energy and realizing the substitution of electric energy for coal, oil and other terminal energy consumption can not only reduce the emission of pollutants, but also improve energy efficiency.

There are many articles on the research of electric energy substitution, mainly focusing on the potential calculation, such as literature 1 and literature 2, mainly focusing on the potential calculation methods. Documents 3, 4 and 5 specifically calculate the potential of Shanghai, Shandong and Shaanxi provinces. The calculation in the field of transportation is also limited to the potential, but the research on the calculation method of energy efficiency decline is less.

Transportation consumes a third of the energy used globally, and that number continues to grow. In China, as car ownership continues to rise, energy consumption will continue to increase [6]. In the field of transportation, there is a great potential for energy saving and power substitution. This paper mainly focuses on the analysis of the substitution of electric energy for vehicle and ship, which is the main body of energy consumption in the field of transportation, and studies the calculation method of energy-saving effect.

**Development of Electric Power Substitution in Transportation**

In recent years, many policies have been issued at the national and local levels to encourage and support electricity substitution in the field of transportation. This paper combs the typical policy documents.

(a) Electric vehicles
In 2012, the tax on vehicles and vessels exempted from new energy sources was introduced; in April 2012, the State Council discussed and adopted the "Energy Conservation and New Energy Vehicle Industry Development Plan (2012-2020)", and proposed that the industrialization of pure electric vehicles and plug-in hybrid vehicles should be promoted, popularization of non-plug-in hybrid vehicles and energy-saving internal combustion motor vehicles should be promoted, and technology should be implemented. Technical Innovation Project; The Announcement on Tax Exemption for the Purchase of New Energy Vehicles, launched in 2017, clearly exempts the purchase tax of new energy vehicles from January 1, 2018 to December 31, 2020. From 2018 to 2020, subsidy recession, integral assessment and market structure were formed. With the further reduction of the subsidy amount, the profit of new energy vehicles continues to decline, the cost advantage brought by scale effect is prominent, and industry barriers are formed. Driven by technological progress, the ease of use and economy of new energy vehicles are highlighted.

(b) urban public transport

The "oil-to-electricity" project of buses has been promoted and implemented in many cities. In 2015, the Ministry of Finance, the Ministry of Industry and Information Technology and the Ministry of Transport jointly issued the Notice on Improving the Policy of Subsidies for Oil Products Prices of Urban Buses and Accelerating the Promotion and Application of New Energy Vehicles. The overall idea is to maintain the relatively stable overall level of subsidies for urban public transport industry. Next, adjust and optimize the expenditure structure of financial subsidies, balance the use cost of traditional fuel buses and new energy buses, and gradually form the comparative advantages of new energy buses. Based on local bus groups, the replacement of new energy buses has been accelerated.

(c) Port shore power

With the continuous growth of port throughput, the impact of port production on urban environment has become more and more significant, and the impact on environmental air quality has become increasingly prominent. In order to speed up the transformation of Shanghai’s port development mode and effectively promote the coordinated development of port production and environmental protection, the relevant policies of developing port shore power have been promulgated in many parts of the country. The Ministry of Transport, the Ministry of Finance, the Development and Reform Commission, the State Energy Administration, the State Grid Corporation and the Southern China Grid Corporation jointly formulated and issued the Notice on Further Promoting the Use of Coastal Electricity by Ships in Ports, which calls for increasing the coordinated promotion of the use of Coastal Electricity by Ships in Ports, resolutely winning the Blue Sky Defense War and building green transportation.

The State Grid regards transportation as one of the four main areas to promote electric energy substitution. In recent years, the field of electric energy substitution technology has been expanding, and the substitution power has been constantly innovating. The following table shows the proportion of each technical field in the implementation of electric energy substitution project by the State Grid Corporation.
Energy-saving Measuring Method for Electric Vehicles

At present, the state is actively promoting the development of electric vehicles. Under the circumstances of subsidies, electric vehicles have certain economy. Experts predict that by 2050, the proportion of energy used by electric vehicles in transportation will increase from only 1% to 33% by 2050, and the annual sales of electric passenger vehicles will increase from 124,000 to 9.65 million by 2050. Therefore, the energy-saving potential of electric steam is huge in the future. Aiming at the energy efficiency calculation method of charging link of electric vehicle, the following model is constructed.

The output of this model is based on the reduction rate of energy consumption of replacing oil by electricity. The input of this model is 100 km fuel consumption of automobiles, fuel conversion standard coal coefficient, 100 km power consumption of electric vehicles, power structure, power consumption of electric vehicles, etc. Among them, the energy consumption is calculated by 100 kilometers. The formula for calculating the rate of energy consumption decline is as follows:

\[ f_i = \frac{\sum n_i \cdot P_i \cdot a - \sum m_i \cdot E_i \cdot b}{\sum n_i \cdot P_i \cdot a} \times 100\% \]  

(1)

\( f_i \) - Energy consumption reduction rate (Electric vehicles)
\( P_i \) - 100 km fuel consumption for car type I.
\( a \) - Coefficient for conversion of oil to standard coal
\( n_i \) - Number of car types I
\( m_i \) - Number of electric vehicle types I
\( E_i \) - 100 km electricity consumption for type I electric vehicles
\( b \) - Coefficient of coal for electric scale (Calorimetric coal consumption)

\[ b = \frac{\sum G_i C_i}{\sum G_i} \]  

(2)

\( G_i \) - Power generation for power type I
\( C_i \) - electricity consumption corresponding to power supply type
By rough calculation, about 80% of our electricity comes from thermal power generation (about 15% - 20% of electricity comes from renewable energy generation). From the whole process, the use of electricity will also emit sulfur dioxide and nitrogen oxides into the atmosphere. However, the power industry adopts desulfurization and denitrification methods to centralize the treatment of pollutants, and the desulfurization efficiency of the new superthermal power plant can reach more than 90%, and the denitrification efficiency can reach more than 80%. With the high rate of renewable energy penetration, electricity emissions will gradually decline, and the power emission reduction advantage will further show.

At present, due to the preferential policies of peak and valley electricity prices, the charging time of domestic electric vehicles is mainly concentrated at night for 5-6 hours. At night, it is the time to absorb wind power. Taxis and other categories will also be charged during the day. On the whole, each charge pile will be charged for an average of 8 hours per day. Clean energy represented by wind power and photovoltaic will be used on a large scale in transportation systems. Literature 6 predicts that 58% of energy use in the transportation sector will come from Yuke renewable energy by 2050. The annual sales of electric passenger vehicles will increase from 1.24 million to 9.65 million by 2050. There is more room for energy conservation potential.

Coastal Power Energy Saving Measurement Method

Promoting the replacement of electrical energy in ports and the realization of "electricity for oil" can not only reduce the operating costs of ship transportation companies, but also promote energy conservation and emission reduction in ports and achieve the green development of ports. This is the development direction of the port industry and should be vigorously promoted. In this paper, the measure of energy conservation of shore power is constructed as follows:

The output of the model is the energy consumption reduction rate of the power generation, and the input is the parameters such as the fuel consumption, the fuel conversion coal coefficient, the coal consumption, and the power supply structure. The energy consumption is calculated according to the energy consumption of the power generation.

\[
f_2 = \frac{\sum n_i \cdot Q_i \cdot t \cdot d - \sum m_i \cdot t \cdot b}{\sum n_i \cdot Q_i \cdot t \cdot d} \times 100\%
\]

(3)

\(f_2\) - Energy consumption reduction rate (Port ship charging)

\(Q_i\) - Type I fuel consumption rate for ships using oil (1kwh-fuel consumption for power generation, the unit is kg/kw)

D-oil conversion Standard coal coefficient

T-dock power time

\(n_i\) - Number of ships of type I

\(m_i\) - Number of berths, ships type I

\(b\) - Coefficient of coal for electric scale (Calorimetric coal consumption)

\[
b = \frac{\sum G_i C_i}{\sum G_i}
\]

(4)

\(G_i\) - Power generation for power type I

\(C_i\) - Coal-electricity consumption corresponding to power supply type

Standard coal
Similar to the charging of electric vehicles, the future port power will further increase the use of clean energy, the size of charging ships is not growing, and there is more room for energy conservation.

The measurement of energy efficiency decline due to electrification of other rail transit is similar. Rail transit includes electrified railways and urban rail transit. Electrified railways refer to railways that obtain electricity from external power sources and traction power supply systems and use electric locomotives to pull trains. Urban rail transit refers to the collective name of the ground, elevated and underground rail transit systems used for passenger transport in cities. Urban rail and electrified railway transportation is characterized by large traffic volume, fast speed, safety, punctuality, environmental protection, energy conservation and land use. Urban rail transit can replace buses, and electrified railways can replace diesel locomotives and long-distance buses. In the future, there will be further development of power substitution technology in these fields, and there is also a lot of energy saving space.

**Suggestion**

In order to further promote energy conservation and emission reduction, the following suggestions are put forward in the field of electric vehicles and port power: First, strengthen the construction and improvement of the electric vehicle smart charging and switching service network, so as to lay the foundation for the large-scale promotion of electric vehicles in the future. Second, the government needs to further develop plans to promote the use of electric vehicles and increase support for infrastructure construction such as charging and maintenance. Third, we will push the government to issue policies to limit emissions of fuel vehicles. For example, the government formulated and introduced an environmental tax on motor vehicle pollution emissions. Fourth, we will promote the formulation of guidelines and support policies at the national level to promote the development of electricity technology in ports and ports, with emphasis on the implementation of a unified and mandatory environmental protection policy in coastal and riverine ports. Fifth, we will provide financial and tax relief and financial subsidies to high-voltage ports and ports with higher initial investment in electricity technology. Sixth, jointly promote the construction of electricity technology standards in China's ports and ports and implement unified standards.

**Acknowledgement**

This work was supported by 2018 Science and Technology Project of State Grid Corporation of China (Research and application of energy and power demand forecasting technology in China based on the "two-step" strategy in the new era).

**References**


