Research on the business model of electric vehicle charging facility construction project participating in carbon trading market

Yunfei Chen 1,*, Yuqing Wang 1, Yuwei Cao 1, Ming Zeng 1, Bin Zhu 2 and Xingzhe Hou 2

1 State Key Laboratory for Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Beijing, China
2 Chongqing Electric Power Research Institute, Yubei District, Chongqing, China

*Corresponding author e-mail: 838255136@qq.com

Abstract. In today's society, the economy is gradually transforming to green and low-carbon. As the core link of the low-carbon industry of electric vehicles, charging facilities have great potential to participate in the carbon trading market. In this context, in order to promote healthy and orderly development for electric vehicle charging infrastructure industry and ensure its participation in carbon market economy, based on the analysis of the development trend of China's future carbon trading market, this paper studies the business model of typical electric vehicles charging facility projects participating in the carbon trading market from three aspects of business structure, profit channel and operation mechanism, so as to improve the income level of charging facility operators while improving the carbon trading market.

1. Introduction
At present, China is opening up the field of electric vehicle charging infrastructure construction, vigorously promoting the private capital to enter the charging infrastructure construction, in order to meet the rapidly growing demand for electric vehicle charging[1]. However, electric vehicle charging infrastructure construction and operation costs are extremely high, lack clear business model support[2] and its profit channel is single, a large number of charging facilities operators have long been in a state of loss, and various types of capital investment are insufficient[3]. Therefore, in order to promote the healthy and orderly development of the electric vehicle charging facility industry, it is urgent to broaden the profit channel of charging facilities and explore new profit growth points.

The effectiveness and low cost[4] of the carbon trading market have attracted the attention of governments around the world, which has led countries to establish their own carbon trading markets. As the core link of the low-carbon industry of electric vehicles, charging facilities can theoretically increase revenue by participating in the carbon trading market. China's carbon market is still in the early stage of construction. Pilot carbon trading has been launched in many provinces and cities to explore the establishment of a carbon trading mechanism[5], and preliminary results have been achieved. However, there is no complete development plan for the participation of electric vehicle charging facilities in the carbon trading market, and research on its business model is still blank. Therefore, in combination with the development trend of carbon trading market in the future, this paper proposes the
business model and operation mechanism for electric vehicle charging facility construction projects to participate in the carbon trading market, so as to improve the income level of charging facility operators while improving the carbon trading market, thus promoting the development of electric vehicles and achieving the goal of carbon emission reduction.

2. Development trend of carbon trading market

China's carbon trading market has great potential in the future[6]. In terms of market size, in the long run, if China's carbon market continues to expand and include more enterprises, the total amount of quota issued in the future can reach 6-9 billion tons. Based on the expected turnover rate of 400%, the trading volume of quota will climb to 24-36 billion tons. A large increase in the turnover rate will inevitably drive up the quota price. Based on the consideration of the derivative market, the trading scale of the carbon market will even exceed 100 billion yuan according to the carbon price of 100 yuan per ton. In terms of trading price, the current carbon price is far lower than the average cost of carbon emission reduction. According to the preliminary estimation of the national development and reform commission, the scale of China's carbon trading market still has more than 10 times of development space. In terms of trading mechanism, carbon emission forward trading trial operation, introduced the hedging mechanism. In the future, with the gradual promotion of forward trading, the trading risks of enterprises will be reduced while enriching the trading mechanism of carbon market.

Therefore, as the scale of carbon market increases, the price rises and the trading mechanism becomes more perfect, voluntary emission reduction subjects will be more active in carbon trading[7], further promoting the participation of electric vehicle charging facilities in carbon trading.

3. The business model of electric vehicle charging facilities participating in the carbon trading market

3.1. The business architecture of electric vehicle charging facilities participating in the carbon trading market

In terms of the selection of target users, the participation of electric vehicle charging facilities in the carbon trading market is mainly aimed at all kinds of power-dependent transport users with high promotion degree and great development potential, including public transport, taxi and private users. At the same time, the main business models of electric vehicle charging facilities participating in the carbon trading market are as follows:

3.1.1. Basic business. The basic business of electric vehicle charging facilities participating in carbon trading market includes charging business and power exchange business.

The service mode of charging business is mainly charging pile charging, which can be divided into quick charging and ordinary charging. In the process of service, charging is conducted according to charging amount or charging time, and the difference in electricity price is utilized to make profits. Quick charging is also known as dc quick charging. During charging, 150-400A strong current is used to supplement the battery, and the charging time is 15~30min. Ordinary charging, also known as ac slow charging, uses a normal current of about 15A to charge electric cars for 6-10h.

The service mode of electric changing business is to replace the battery box charged directly, which improves the convenience and rapidity of obtaining energy for electric vehicles. According to different battery ownership, it can be divided into battery leasing mode and battery exchange mode. In the battery leasing mode, the ownership of a car is separated from that of the battery. The user purchases a naked car and rents the battery from a charging station. When the driving power of an electric car is insufficient, the user goes to the charging station to replace the fully charged battery and maintain the battery. Battery exchange mode is a network charging service mode formed based on the battery leasing mode. Users establish a long-term cooperative relationship with battery suppliers, and battery suppliers establish a large number of charging stations to provide users with charging services or battery replacement services. According to different service locations, the electrical changing service can be divided into inbound
service mode and inbound service mode. In the inbound service mode, users need to receive services from the charging station, which is convenient for unified management, but the flexibility of the service is poor. In the point-based service mode, users can choose the fixed demand point or power station for mobile battery replacement service according to their needs.

3.1.2. Core services. The core business of electric vehicle charging facilities participating in carbon trading market is carbon trading business, including directly participating in carbon trading, jointly participating in carbon trading with virtual power plants and providing emission reduction measurement services for users.

With a large number of electric vehicle customers, electric vehicle charging facilities can directly participate in carbon trading. Charging facility operators sign agreements with owners to act as agents for all charging vehicles, and conduct unified accounting and control over carbon emission reduction while charging electric vehicles. Then, they sell these vehicles to relevant institutions or enterprises in the form of voluntary emission reduction transactions for profits.

Electric vehicle charging facilities could also join with virtual power plants to participate in carbon trading. In this mode, both charging facilities and virtual power plants have carbon emission reduction, and thermal power units in the virtual power plant may need corresponding carbon emission reduction deduction. Specifically, electric vehicles and virtual power plants jointly calculate and control the carbon emission reduction of electric vehicles, calculate the carbon emission reduction caused by clean energy in the virtual power plant, and finally offset the carbon emission reduction required by the power plant itself, and then trade in the market to distribute the carbon benefits.

Carbon emission reduction measurement service is to calculate the carbon emission reduction of electric vehicle owners through the statistics of electric quantity when charging. Due to the advantages of electric vehicle charging facilities, charging data of electric vehicle can be collected conveniently and emission reduction data can be obtained more efficiently and accurately through accurate monitoring of emission reduction.

3.1.3. Value-added business. The value-added business of electric vehicle charging facilities participating in the carbon trading market includes contract energy management business, information service and vehicle rental business.

Contract energy management business refers to that electric vehicle charging facility operators and users agree on carbon emission and energy saving targets in the form of contracts, and operators provide necessary charging optimization services to users in order to achieve the targets, so that users can pay operators' investment and reasonable profits with energy saving benefits. Its essence is to reduce the energy cost to pay for the charging facilities operators all costs of energy saving business services.

Information business refers to electronic information business carried out by electric vehicle charging facilities through Internet platform. By designing a mobile APP with strong integration of application functions, it can provide electric vehicle users with real-time positioning of charging stations, real-time control of charging time and quantity, as well as remote monitoring services of charging status such as unexpected interruption of charging, charging appointment reminder and fault alarm. With the goal of improving user experience, mobile APP can provide various conveniences. Users can freely arrange, cancel and change the charging process at any time. At the same time, it provides flexible payment methods to enhance user stickiness. By setting up post advertising space and making use of cloud platform networking to regularly change advertising copy, we can provide various enterprises with product publicity and marketing business, so as to guide and stimulate potential consumers among electric vehicle users.

Vehicle rental business means that operators set up other vehicle rental services, such as bicycles and motorcycles, near the charging facilities. This kind of vehicle can facilitate users' temporary travel during the charging period of electric vehicles.
3.2. The profitable channel of electric vehicle charging facilities to participate in the carbon trading market

The profit channels for electric vehicle charging facilities to participate in carbon trading in the future mainly include the following aspects, as shown in Table 1.

| Service type       | Business name                | Specific benefits                                        | Income category                  |
|-------------------|------------------------------|---------------------------------------------------------|----------------------------------|
| Basic services    | Charging business            | Basic charging charges for electric vehicles            | Sell electricity benefits        |
|                   | Switching service            | Battery replacement fees for electric vehicles         |                                  |
| Core services     | Carbon trading business      | Carbon emission trading income                         | Voluntary emission reduction benefits |
|                   | Measurement of carbon        | Measurement service charge for carbon emission reduction| Information service income       |
|                   | emission reduction Mobile APP| Online service revenue Advertising and marketing revenue|                                  |
| Value-added        | Pile advertising             | Energy saving service income                           | Energy efficiency management benefits |
| services           | Contract energy management   | Rental                                                  | Equipment rental income          |
|                   | Vehicle rental               |                                                         |                                  |

3.2.1. Income from charging and changing services. The income from charging and changing service includes the basic charge fee and battery replacement fee of electric vehicles, and the source is essentially the income from selling electricity. The revenue can be calculated by the following formula:

\[
R_c = p_s \times \sum_{t} E_s - p_b \times \sum_{t} E_b
\]

Where \( R_c \) represents the charge and return service revenue, \( p_s \) represents the sold price per kWh, \( E_s \) represents the amount of electricity sold or supplied at the time \( t \), and \( p_b \) represents the purchase price per kWh.

3.2.2. Carbon trading income. Charging facility operators will calculate and count the carbon emission reduction of electric vehicles while charging them, and then sell them to relevant institutions or enterprises in the form of voluntary emission reduction trade for profits. At the same time, the operator allocates part of the proceeds to the user. The distribution mechanism mainly includes the following three categories:

1. Fixed income model. The charging facility operator and the user agree on the price of the carbon emission reduction, and calculate the carbon emission reduction income of the user according to the monthly actual charging amount. The bidding risk of the carbon trading market is borne by the charging facility operator.

2. Dynamic fixed proportional income model. The charging facility operator and the user agree on the carbon emission reduction income distribution ratio, and calculate the carbon emission reduction income of the user according to the actual price of the carbon transaction and the monthly actual charging amount. The bidding risk of the carbon trading market is shared by the charging facility operator and the user.

3. Guaranteed revenue plus sharing model. The charging facility operator formulates the user's carbon emission reduction price with reference to the historical carbon transaction price, that is, the guaranteed bottom income, and the actual price of the carbon transaction exceeds the guaranteed bottom income portion, and the charging facility operator and the user are divided according to a certain ratio.
3.2.3. Information service income. Information service revenue is mainly obtained through media and public relations channels, including mobile app service, pillar advertising and revenue generated by providing users with emission reduction measurement.

Mobile app services can set up monthly members and annual members, and earn profits by charging service fees through the membership system. In addition, operators can also attract advertisers by using the user flow of the app and earn advertising fees.

Pile advertising business can install LED screen or advertising light box on the charging pile to put commercial advertisements, so as to promote in a certain area. The advertising fee shall be charged to the advertiser in the form of time charge. The advertising fee shall be calculated as follows:

$$R_M = p_a T_a - p_b T_a$$  \hspace{1cm} (2)

Where $R_M$ indicates the pile advertising fee, $p_a$ indicates the advertising unit price, and $T_a$ indicates the advertising time.

The revenue generated by emission reduction metering business can be positioned as additional service revenue, which will be collected in the form of service fee when participating in carbon trading for electric vehicles. If the operator does not participate in carbon trading on behalf of electric vehicles, it can cooperate with the carbon trading agent of electric vehicles as a third party and sell the emission reduction data collected to the agent for profit.

3.2.4. Equipment rental income. The equipment rental income comes from the rental of other means of transportation for electric vehicle charging facilities operators, who can get the income by charging by the hour and by the mileage.

![Figure 1. General operation framework of electric vehicle charging facility operators.](image)

4. Electric vehicle facilities participate in the operation mechanism of carbon trading market

The participation of electric vehicle charging facilities in the carbon trading market requires a complete operating framework and business framework of the operating platform. This paper will analyse the operating framework of electric vehicle charging facilities participating in the carbon trading market and the business framework of electric vehicle charging facilities operating platform.
4.1. The operational framework for electric vehicle charging facilities to participate in the carbon trading market

The overall framework of electric vehicle charging facilities participating in the carbon trading market is shown in Fig. 1. It can be seen that power grid enterprises are responsible for the investment and construction of electric vehicle charging facilities operators, as well as power supply and supervision of operators' operation and management. Operators carry out the daily operation and maintenance of electric vehicle charging facilities operators and provide users with various services, including charging and changing services, carbon trading services and various value-added services. The user shall pay the service fee after enjoying various services provided by the electric vehicle charging facility operator. Among them, according to the different investment and operation subjects, the operation mode of electric vehicle charging facilities participating in the carbon trading market can include third party enterprise investment construction operation, investment and operation of power grid enterprises, electric vehicle manufacturers invest in construction and operation, leasing companies invest in construction and operation and property company investment construction operation.

4.2. Business architecture of ev charging facility operation platform

Electric vehicle charging facility operation platform is an industry platform based on Internet Plus, which is composed of charging support system, monitoring system, network link system, customer terminal system, cloud service platform and other parts. The business structure is shown in Fig. 2.

![Figure 2. Business architecture diagram of electric vehicle charging facility operation platform.](image)

The charging support system should be the main entity of the intelligent charging service system, which is composed of electric vehicles and other components of the charging infrastructure of the power line of the power grid. Charging support system and monitoring system link to provide charging fee settlement service, connect with the network link system to form the charging infrastructure network, sharing charging infrastructure geographical location information through cloud service platform, connect with the terminal system of the customer, and the user can choose the appropriate charging facilities nearby.

Carbon trading system is a system in which electric vehicle charging facility operators package the carbon quota of electric vehicles and conduct carbon trading in the carbon trading center. Carbon trading system needs to aggregate the carbon emission reduction of electric vehicle users, pay attention to the dynamic price of carbon trading market, and adopt certain bidding strategy to conduct carbon trading.

Monitoring system is a series of monitoring and control of energy and safety for the whole charging process, which should include vehicle monitoring system and charging station monitoring system. The main functions of the vehicle monitoring system are monitoring the safety of the battery status,
monitoring the remaining power, and intelligently recommend nearby charging facilities. As the system structure matures, monitoring systems with other functions can be nested. The monitoring system of a charging station includes the control system of a charging machine, the distribution security monitoring system, the billing system, the network link, etc. Its main function is to measure the charging cost, monitor the safe communication link of the electricity consumption of the charging station, etc.

Network link system plays the role of information flow in the whole system. The whole link system can be divided into macro network link and micro network link. Macro network links refer to the link that needs to be linked to the cloud service platform, including charging infrastructure geographical location sharing infrastructure status monitoring power resource allocation cost network settlement, etc. Micro network links refer to local network links, such as the information of battery status, residual power and other internal information of the car, which need not be transmitted to the cloud through the Internet, but can be fed back to the on-board terminal through the internal network of the car.

The main functions of the client terminal system are embodied in the user-friendly display interface and the intelligent digital display of the status of the monitoring subject. The terminal system can monitor the power status of the car in real time, link with the cloud platform through the network, and the car APP should be able to query the charging station nearby in real time.

The cloud service desk plays the role of central control, providing users with real-time information query, charging charge collection, charging facilities, power grid monitoring, carbon trading information query and other services through network links and various macro information exchanges. The cloud service platform is the brain data service center of the whole system and plays an important role in the whole system.

5. Conclusion
This article is based on the future development trend of the carbon trading market in our country, from the business architecture profit channel operating mechanism and so on to study the electric vehicle charging infrastructure construction projects to participate in carbon trading market business model, to broaden the channels of profit of the electric car charging infrastructure construction to promote the development of the carbon trading market in China, to carry out the demonstration application to provide theoretical support for the future.

Acknowledgments
This work was supported by the State Grid Technology Project (52200018000C).

References
[1] Tang Baojun, Wang Xiangyu, Wang bin, Wu Yun, Zou Ying, Xu Huangchen, Ma Ye, Analysis and prospect of the development level of China’s new energy automobile industry, J. Journal of Beijing institute of technology (social science edition). 2019, 21(02):6-11.
[2] Chen Tong, Li Jing, Research on the “Internet Plus” business model of electric vehicle, J. Journal of north China electric power university: social science edition, 2016(4):37-40.
[3] Lan Minbo, Improve supporting standards, promote the healthy development of electric vehicle charging network, J. Forward forum, 2017(8):40-40.
[4] Jiang Baolin, Zhang Wenying, Preliminary understanding and thinking about carbon trading market, J. Inner Mongolia Science and Technology and Economy, 2011(19):11-13.
[5] Liu Mei, The Development of Foreign Carbon Trading Market and Its Enlightenment to China, J. Financial Theory Research, 2012(4):19-24.
[6] Shi Xiaochun, Research on the Development Status and Financial Support Issues of China’s Carbon Trading Market J. Heilongjiang Science, 2014, 5(7):175-175.
[7] Liu Liwei, Develop voluntary emission reduction markets and broaden carbon trading channels, J. Chinese urban economy, 2010(11X):289-289.