Carbon Emission Monitoring System and Measurement Needs of Industrial Enterprises

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Abstract. In terms of carbon emission monitoring, China started late and has not yet formed a perfect standard system, but in the power industry, it has begun to promote continuous monitoring of greenhouse gas emissions based on stationary source flue gas. In terms of carbon measurement, the State Council has successively issued the Action Plan for Carbon Peaking Before 2030 and the Measurement Development Plan (2021-2035), emphasizing the improvement of the measurement and monitoring system to provide support for greenhouse gas emissions. In this study, the current situation and challenges of carbon emission monitoring system and measurement needs of industrial enterprises in China are deeply analyzed. In addition, the advantages and disadvantages of common automatic greenhouse gas monitoring techniques, including gas chromatography, non-dispersive infrared and Fourier transform infrared spectroscopy, were introduced in detail. Finally, suggestions are put forward for development needs, emphasizing measures such as unifying industry standards, formulating incentive policies, improving data accuracy, and improving the management platform. This paper provides an in-depth and professional research foundation for the carbon emission monitoring system of industrial enterprises, and provides strong support for relevant policy formulation and technology research and development in the future.

Keywords: Carbon emission monitoring system, Direct monitoring method, Automatic monitoring technology, Standard system

1 Introduction

1.1 Background

According to the International Energy Agency's 2022 Global CO2 Emissions report released in March 2023, global energy-related CO2 emissions hit a record high of 36.8 billion tonnes in 2022, up 0.9% from 2021. China and Europe were the only regions in the world with negative growth, with China down 0.2% (23 million tonnes) and the EU

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down 2.5% (70 million tonnes). However, the trend of "decoupling" global economic growth from CO2 emissions has been maintained.

In 2022, the total carbon emissions of China were 12.1 billion tons, a decrease of 0.2%. The report analyzes the reasons for the emission reduction: (i) solar photovoltaic and wind power generation have increased significantly, and the proportion of coal power generation has fallen to about 60%, (ii) industrial emissions decreased by 161 million tons, and (iii) carbon emissions from the transportation sector decreased by 3.1%. Despite its remarkable achievements in reducing emissions, China is still the world's largest emitter of greenhouse gases, and the task of reducing emissions is still arduous.

China has entered the period of carbon reduction strategy officially, focusing on promoting the reform of ecological and environmental quality. Following the "14th Five-Year Plan" Comprehensive Work Plan for Energy Conservation and Emission Reduction and the "Dual Carbon" decision of the CPC Central Committee, China requires the establishment of an exclusive carbon emission monitoring system, the improvement of carbon emission assessment and assessment mechanisms, and the continuous enhancement of monitoring capabilities, and the further promotion of energy conservation and emission reduction. In terms of carbon emission monitoring, China started late and there are errors. To improve the quality of the greenhouse gas inventory and the effect of carbon dioxide emission reduction, it is urgent to study the calculation method of greenhouse gas from fossil fuel combustion in international and domestic industrial enterprises and establish a monitoring system with Chinese characteristics. Despite China's achievements in reducing emissions in 2022, the world still needs to work together to ensure that carbon emissions are "decoupled" from economic growth. Under the "dual carbon" policy, China will deepen emission reduction actions and build a more complete carbon emission monitoring and evaluation system to contribute to sustainable development.

1.2 National Policies and Standards

In June 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the United Nations Conference on Environment and Development, and the National People's Congress ratified the Convention that year. Subsequently, the Kyoto Protocol was signed in 1998; In June 2007, China issued a comprehensive policy document, China's Plan to Address Climate Change.[1] In December 2009, China pledged to reduce carbon dioxide emissions per unit of GDP by 40%-45% by 2020 at the Copenhagen Climate Conference. In 2011, the pilot project of carbon emission trading was launched, and the "12th Five-Year Plan" work plan for controlling greenhouse gas emissions was formulated, and the goal of reducing CO2 emissions per unit of GDP by 17% by 2015 compared with 2010 was established. In 2014, the carbon dioxide emission intensity reduction index was included in the performance evaluation of cadres. In 2015, China and the United States issued the U.S.-China Joint Statement on Climate Change, committing to reduce carbon dioxide emissions per unit of GDP by 60%-65% by 2030 compared to 2005. In 2017, the National Carbon Emission

Trading Market Construction Plan (Power Generation Industry) marked the launch of the national carbon trading market.

In December 2020, the Central Economic Work Conference listed "carbon peaking and carbon neutrality" as one of the eight key tasks for 2021. In January 2021, the Ministry of Ecology and Environment (MEE) issued the Guiding Opinions on Coordinating and Strengthening Work Related to Climate Change and Ecological and Environmental Protection. Among them, promoting the integration of monitoring systems, strengthening greenhouse gas monitoring, gradually incorporating into the ecological environment monitoring system, and exploring and carrying out greenhouse gas emission monitoring research and pilots. In September 2021, the Ministry of Ecology and Environment (MEE) issued the Carbon Monitoring and Assessment Pilot Work Plan, focusing on key industries, cities and regions, and selecting five key industries for pilot greenhouse gas monitoring: thermal power, iron and steel, oil and gas exploitation, coal mining and waste treatment.[2, 3] In January 2022, the Ministry of Ecology and Environment (MEE) issued the 14th Five-Year Plan for Ecological and Environmental Monitoring, which proposed to support low-carbon development, accelerate carbon monitoring and assessment, promote carbon monitoring and assessment pilots, make up for the shortcomings of carbon monitoring technology, and actively carry out other performance monitoring.

In October 2022, the nine departments jointly issued the Implementation Plan for Establishing and Improving the Standard Measurement System for Carbon Peak and Carbon Neutrality. As one of the guarantees of the "1+N" policy system, the overall deployment of the standard measurement system for carbon peak and carbon neutrality should be clarified. It is proposed that the standard measurement system for carbon peak and carbon neutrality will be established in 2025, more robust by 2030, and be fully completed by 2060, serving the comprehensive green transformation of economic and social development, and strongly supporting the realization of the goal of carbon neutrality. The Beijing Municipal Bureau for Market Regulation has also issued a relevant dual carbon work plan.

1.3 Policies and Standards of the Beijing Municipality

In October 2022, the Beijing Municipal Government issued the Beijing Carbon Peak Implementation Plan to promote the city's continued work on carbon peak and carbon neutrality in an orderly manner. It was proposed that by 2025, the proportion of renewable energy consumption will reach more than 14.4%, the energy consumption per unit of GDP will be reduced by 14% compared with 2020, and the carbon dioxide emissions per unit of GDP will be reduced to ensure the completion of the national target. By 2030, the proportion of renewable energy consumption will reach about 25%, and the carbon dioxide emissions per unit of GDP will ensure the completion of the national target and ensure that the goal of carbon peak before 2030 is achieved as scheduled.[4]

In April 2020, the Beijing Municipal Bureau of Ecology and Environment issued the Notice of the Beijing Municipal Bureau of Ecology and Environment on Doing a Good Job in the Management of Key Carbon Emission Units and the Pilot Work of Carbon Emission Trading in 2020, which published the Guidelines for the Accounting and

Reporting of Carbon Dioxide Emissions of Carbon Emission Units in Beijing (hereinafter referred to as the "Guidelines"). In January 2021, Beijing officially implemented 7 standards including the Carbon Dioxide Emission Accounting and Reporting Requirements for Electric Power Production Industry (DB11/T 1781-2020), covering 7 industries such as electricity, heat, cement, petrochemical, other industries, service industries, and road transportation, clarifying the scope, accounting steps and methods, data quality management, and reporting requirements of carbon dioxide emission accounting and reporting for these 7 industries, and putting forward operable, unified and standardized requirements and data collection and monitoring methods. The Beijing Bureau of Economy and Information Technology and the Bureau of Finance issued the 2022 Beijing High-tech Industry Development Fund Implementation Guide, which stipulates that "if the implementation entity meets the standards of national green factories, national green supply chain management enterprises (including subordinate enterprises), and the performance evaluation of heavy air pollution emergency emission reduction is above grade B (including performance guidance), or the energy consumption or water consumption per unit product reaches the advanced value of national, industry or local standards after the implementation of the project, the reward shall be given according to no more than 30% of the total investment included in the scope of the award. The maximum annual reward amount for a single enterprise shall not exceed 30 million yuan".

1.4 Main Research Content

According to the implementation plan of Beijing for carbon peaking, it is necessary to improve the statistics, measurement and monitoring capabilities, and strengthen the construction of an online monitoring system for the energy consumption of key energy-using units. Industrial enterprises are a major area of energy consumption and greenhouse gas emissions. At present, the energy consumption information of industrial enterprises in Beijing such as fuel use and purchased electricity is mainly based on accounting methods such as ledger query and enterprise statements, and it is impossible to monitor and accurately evaluate the full-caliber carbon emissions of industrial enterprises in real-time. Therefore, to objectively assess the greenhouse gas emissions of industrial enterprises, monitor the greenhouse gas emissions and energy consumption of industrial enterprises in real time, strengthen the formulation of post-management policies, and promote the work related to climate change in Beijing, it is urgent to carry out research on greenhouse gas emission monitoring technologies and methods, understand their measurement technology needs, solve the relevant problems faced by enterprises in a targeted manner, and establish and improve the carbon emission monitoring system, which will help China achieve its international commitments and play a greater role in global climate governance. Therefore, the research mainly includes the following aspects:

(1) Laws, regulations and policies. Understanding the current environmental regulations and policies set by national and local governments, as well as the compliance and enforcement of these regulations and policies by enterprises.

(2) Construction of carbon emission monitoring system of industrial enterprises. Investigating the calculation methods of carbon emissions of industrial enterprises and the implementation of relevant standards, the construction of the monitoring and measurement management system of carbon emissions, technologies and measures taken to reduce carbon emissions, problems that need to be solved urgently in the process of measuring carbon emission monitoring system construction.

(3) The development status of carbon emission monitoring instruments. Selecting domestic carbon emission monitor manufacturers with advanced technology to understand the cutting-edge monitoring methods and technology development directions, and connecting the measurement needs of enterprises at different stages such as R&D, production, and use, as well as the difficulties in the promotion and implementation of new instruments and methods.

2 Overview of the Current State of Carbon Accounting and Carbon Monitoring in Industrial Enterprises

With the launch of the carbon market and the implementation of emission control enterprises, the quality of carbon data under the carbon verification and measurement system has become the key. In August 2022, the National Development and Reform Commission, the National Bureau of Statistics and the Ministry of Ecology and Environment jointly issued the Implementation Plan for Accelerating the Establishment of a Unified and Standardized Carbon Emission Statistical Accounting System, which clearly proposed to establish a national and local carbon emission statistical accounting system, improve the carbon emission accounting mechanism of industry enterprises, and establish and improve carbon emission accounting methods for key products. Carbon emission accounting is an important foundation for carbon peak and carbon neutrality, and an important basis for the government to formulate policies, carry out assessments, and participate in international climate negotiations and implementation.

2.1 Overview of the Current State of Carbon Accounting

At present, the calculation of greenhouse gas emissions at the fuel is mainly based on the emission factor method and the mass balance algorithm. Such as the power generation industry, Chinese power generation enterprises usually use the emission factor method to calculate carbon dioxide emissions. However, this indirect method has problems such as low accuracy and inefficient data collection, as the actual emission factor varies due to a variety of factors. To solve this problem, the online monitoring of greenhouse gases has been carried out in China, and it is found that the converted emission factor obtained by the direct monitoring method is higher than the IPCC default value, and the calculation results are more accurate than the emission factor method. In terms of electricity consumption, the average carbon emission factor of the power grid is currently used to calculate indirect carbon emissions, but due to the problems of historical data calculation, power grid complexity and new energy grid integration, the method has shortcomings such as low accuracy, data lag and large data granularity (Figure 1).

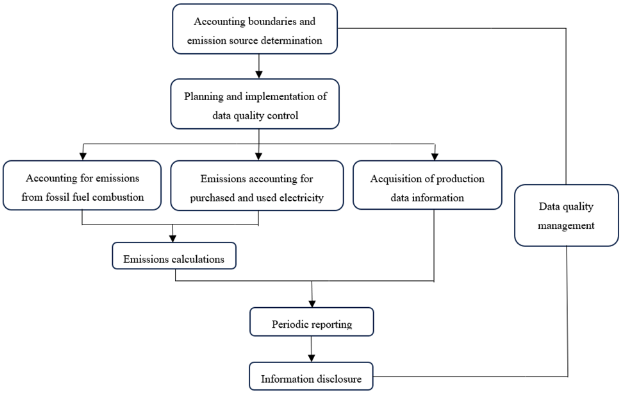

Fig. 1. The carbon accounting process of company

2.1.1 Emission Factor Method.

Currently, The emission factor method is the most widely used greenhouse gas emission accounting method, and the basic formula is "greenhouse gas emissions = activity level data × emission factors", reflecting the high correlation between energy intensity and carbon emission intensity. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories prepared by the Intergovernmental Panel on Climate Change (IPCC) elaborates on this methodology and provides detailed technical guidance for the calculation of greenhouse gas emissions in different countries, regions and industries.

This method is applicable to the country, provinces, cities, industries and other macro accounting levels, can roughly control the overall situation of a specific region or industry, is the basis for the preparation of greenhouse gas inventories at home and abroad, China's "Provincial Greenhouse Gas Inventory Compilation Guidelines" and "Greenhouse Gas Emissions Accounting and Reporting Requirements Part 1: Power Generation Enterprises" are used this method.[5]

However, due to the differences in regional energy quality and the different combustion efficiency of units in practice, various energy consumption statistics and carbon emission factor measurements are prone to large deviations, which have become the main source of errors in carbon emission accounting results.[6] For example, the local standard of Beijing stipulates that the carbon emission factor of externally sourced electricity is fixed at 0.604 tCO2/MWh, but according to the weather conditions and the power grid environment, the renewable energy power generation can change at any time, and the actual change range of the carbon emission factor is between 0.4-0.8 tCO2/MWh, and there is a large error between the carbon emission calculated by using a single carbon emission factor and the actual emissions.

2.1.2 Mass Balance Algorithm.

The mass balance algorithm calculates pollutant emissions according to the law of conservation of mass, the total amount of material fed into the system is equal to the sum of the quantity of product and material loss. Material balance calculations can be used for industries such as the steel industry or the chemical industry for defined production systems, processes, combustion plants, etc. The calculation formula of each industry needs to be formulated according to the product plan, process flow, production scale, raw material consumption and so on of the specific construction project, so it has a good pertinence, and the accuracy of the calculation results is high, but it is necessary to collect detailed industrial production process data and a comprehensive understanding of the production process, etc., involving more parameters, higher requirements for the quality of the collected data, and a great workload, which is suitable for industries with a good database.

2.2 Carbon Emission Monitoring Methods

Compared with developed countries, China's greenhouse gas emission monitoring system started late, and there is no perfect standard system at present. In 2018, the National Development and Reform Commission (NDRC) proposed in the Letter on Entrusting the China Electricity Council to Carry out Work Related to Carbon Emission Trading in the Power Generation Industry to study the application of continuous monitoring of greenhouse gas emissions based on stationary source flue gas in the power industry. In 2021, the Ministry of Ecology and Environment (MEE) announced the Outline of the Ecological Environment Monitoring Plan (2020-2035), proposing to follow the principle of "accounting first, monitoring secondary", explore the establishment of a management system and technical system for the monitoring of greenhouse gas emission sources of key emitting enterprises, and take the lead in carrying out online CO2 emission monitoring pilots in the thermal power industry.[7] In terms of carbon measurement, the State Council has successively issued the Action Plan for Carbon Peaking Before 2030 and the Measurement Development Plan (2021-2035) in the past two years, emphasizing the improvement of the greenhouse gas emission measurement and monitoring system, strengthening the research and application of key measurement and testing technologies for carbon emissions, and improving the carbon measurement standard device, so as to provide measurement support for measurable, reportable and verifiable greenhouse gas emissions, fully reflecting the work idea of developing carbon measurement through multiple measures.[8]

2.2.1 Direct Monitoring Method.
The direct monitoring method is a statistical calculation method that measures the flow, flow rate and concentration of the emitted gas through a monitoring instrument or a continuous metering facility to calculate the total amount of gas emissions. According to the different instruments used, the direct monitoring method is divided into manual monitoring method and continuous monitoring method based on the continuous monitoring system of flue gas emission CEMS. Manual monitoring is mostly used for instrument calibration, and the use of CEMS can carry out continuous monitoring of enterprises by carrying handheld monitoring equipment at the reserved chimney measurement point for a short period of time.

The direct monitoring method calculates emissions from emission sources through continuous measurement of the carbon dioxide concentration in the flue gas and the flue gas flow. It has the advantages of fewer influencing parameters, high accuracy, real-time data upload, automatic formation of monitoring reports, and reduction of uncontrollable factors caused by human measurement. Carbon emission continuous monitoring technology has attracted attention because of data traceability, simple data collection and rapid data transmission, and can be used as an important technical support for carbon emission verification. However, the development of continuous carbon emission monitoring technology in China is still in the development stage, and there is no complete technical specification system for continuous carbon emission monitoring.

2.3 Research Status of Related Technologies and Equipment of Monitoring System

There are two main methods for carbon emissions from electricity in the world: accounting method and CEMS (continuous emission monitoring system). In the power system, the existing measuring equipment is generally an independent electric energy measurement system, which can realize the measurement of single-point electricity. However, carbon emission measurement needs to accurately track the carbon footprint of the whole chain of "generation, transmission, distribution and use", and there is no mature measurement equipment and method in the world.

In China, Tsinghua University, China Electric Power Research Institute and other technical institutions and a number of manufacturers have carried out the research and development of electric energy carbon emission measurement terminals. However, at present, there is no measurement standard for carbon emissions, and it is not possible to trace the traceability and measurement performance evaluation of the measurement terminal.

Common greenhouse gas automatic monitoring technologies mainly include gas chromatography, non-dispersive infrared method, fourier transform infrared spectroscopy, cavity ring-down spectroscopy, off-axis integrating cavity output spectroscopy and tunable semiconductor laser absorption spectrometry, etc., the specific principles of these six automatic monitoring technologies are as follows. Table 1 shows the automatic monitoring technologies for different greenhouse gases, and Table 2 compares the automatic monitoring technologies for multiple automatic monitoring technologies.

Table 1. Automatic monitoring techniques for different greenhouse gases

Type of gas	Atmosphere	Stationary pollution source exhaust gas	Required sensors/detectors
Carbon dioxide	Non-dispersive infrared method	Non-dispersive infrared method	Infrared CO_2 sensor
	Fourier transform infrared spectroscopy	Fourier transform infrared spectroscopy	Catalytic CO_2 sensor
	Cavity ring-down spectroscopy	Off-axis integrator output spectroscopy	Thermally conductive CO_2 sensor

		Tunable diode laser absorption spectrometry	
Methane	Gas chromatography Non-dispersive infrared method Fourier transform infrared spectroscopy	Gas chromatography Non-dispersive infrared method Fourier transform infrared spectroscopy Off-axis integrator output spectroscopy Tunable diode laser absorption spectrometry	Infrared methane sensor
Nitrous oxide	Non-dispersive infrared method Fourier transform infrared spectroscopy Cavity ring-down spectroscopy	Non-dispersive infrared method Fourier transform infrared spectroscopy	Infrared nitrous oxide sensor Quantum cascade laser nitrous oxide analyzer
Other greenhouse gases such as fluorine	Gas chromatography	Gas chromatography	Fluorine gas sensor

Table 2. Comparison of multiple automatic monitoring technologies

Automatic monitoring technology	**Applicable scenarios**	**Advantages**	**Shortcoming**
Gas chromatography	Commonly used to detect methane	High sensitivity and reproducibility	The demand of carrier gas, auxiliary gas and working standard gas is large, and easily affected by ambient temperature
Non-dispersive infrared method	Commonly used to detect carbon dioxide, methane and nitrous oxide	Simple principle and low cost, high accuracy in measuring carbon dioxide	The measurement accuracy of methane and nitrous oxide is low
Fourier transform infrared spectroscopy	Commonly used to detect carbon dioxide, methane, and nitrous oxide in a small range of concentrations	Simultaneous detection of multiple components	The lower limit of detection is susceptible to the optical path length of gas absorption
Cavity ring-down spectroscopy	Commonly used to detect methane and nitrous oxide	Highest precision and good stability	Instrument prices and maintenance costs are expensive
Off-axis integrator output	Commonly used to detect methane and nitrous oxide in	High sensitivity and fast response time	Noisy system, the frequency modulation technology device is more complex

spectroscopy	exhaust gases, and to explore deep-sea combustible ice		
Tunable diode laser absorption spectrometry	Commonly used to detect fluorine-containing greenhouse gases and toxic and harmful gases	High sensitivity Fast detection speed It can realize the simultaneous detection of multiple components	Susceptible to the ambient temperature of the measurement

2.3.1 Gas Chromatography.

Gas chromatography can separate substances with similar properties, such as isomers, isotopes, enantiomers, and some complex mixtures (oil, contaminated water samples, etc.). The principle of gas chromatography is to use the differences in boiling point, polarity and adsorption properties of different substances to achieve the separation of mixtures. Gas chromatography has high sensitivity and reproducibility, but it requires a large amount of working standard gas and is sensitive to ambient temperature.

2.3.2 Non-Dispersive Infrared Method.

In the infrared band, some gases with asymmetric diatomic or polyatomic molecular structures (such as CH4, CO, CO2, SO2, NO, etc.) have characteristic absorption spectra. The concentration of different gases can be detected by using the principle that the concentrations of different gases correlate with their corresponding characteristic spectral absorption intensity. The non-dispersive infrared method is one of the common methods for monitoring CO2 due to its simple principle and low equipment cost.

2.3.3 Fourier Transform Infrared Spectroscopy.

Fourier transform infrared spectrometer is an interferometric spectrometer, based on the principle of coherence of light, mainly composed of light sources (silicon carbon rods, high-pressure mercury lamps), detectors, interferometers, and computers. The original spectrum and light source interference diagram were obtained by the Michelson interferometer experiment, and then the spectra were obtained by the computer by Fourier transform, which was converted into gas concentration. Fourier transform infrared spectroscopy is susceptible to the influence of gas absorption pathlength, and can realize the simultaneous detection of multiple gases.

2.3.4 Cavity Ring-Down Spectroscopy.

The cavity ring-down spectrometer is mainly composed of a light source and a ring-down cavity. The concentration of the measured medium can be calculated based on the difference in the decay time of the absorbing medium in the measured gas and in the absence of the absorbing medium. The detection accuracy of cavity ring-down spectrometry is extremely high and the stability is good, but its equipment price and operation and maintenance costs are relatively expensive.[9]

2.3.5 Off-Axis Integrator Output Spectroscopy.

Off-axis integrating cavity output spectroscopy is a cavity-enhanced spectroscopy technique based on optical resonators. By measuring and comparing the intensity of the incident and transmitted light, the concentration of the target gas in the sample can be obtained. The off-axis integrator output spectrometry has a large system noise, but its detection sensitivity is high, the response time is fast, and it has a wide range of applications in the detection of CO2 and N2O in industrial waste gas and deep-sea combustible ice exploration.

2.3.6 Tunable Diode Laser Absorption Spectrometry.

Based on the high monochromaticity of the semiconductor laser, this method measures the isolated absorption spectral lines of the gas molecules to be measured, which avoids the cross-interference of different molecular spectra, so as to accurately identify the gas to be measured. The narrow linewidth and wavelength of the tunable diode laser can vary with the injected current give the tunable diode laser absorption spectrometry the advantages of high sensitivity, real-time, dynamic, and simultaneous measurement in groups, and is often used for the detection of fluorine-containing greenhouse gases and toxic and harmful gases.

In addition to the scope of application and the advantages and disadvantages of the monitoring technologies mentioned above, there are significant differences between these technologies in terms of cost and accuracy. For example, gas chromatography, although highly sensitive and reproducible, requires a large amount of carrier gas, auxiliary gas and working standard gas, and is susceptible to ambient temperatures, which increases its operating costs to a certain extent. In contrast, non-dispersive infrared (NDIR) is simple, inexpensive and has high accuracy in measuring carbon dioxide, but lower accuracy in measuring methane and nitrous oxide. Therefore, the selection of monitoring technology needs to be based on the specific application scenarios, cost budgets, and requirements for accuracy.

2.4 Monitoring the Current Situation of the Use of Equipment Related to the System

In recent years, various regions are deeply implemented the State Council's "dual carbon" work decision-making and deployment, coordinating the management of greenhouse gas emission reduction and air pollution prevention and control activities, and achieving great results, promoting the implementation of synergies, carbon reduction and pollution reduction tasks, but due to the relatively short implementation time, it is still in the process of exploration.

The real-time supervision and monitoring system of carbon emissions and carbon sinks is not perfect, the data acquisition channels are relatively single, and the accuracy and comprehensiveness of monitoring need to be further improved, which cannot well meet the needs of comprehensive promotion of practice, the implementation of the theory of the "double carbon" goal, and the provision of refined and modern management basic data for the coordinated work of "carbon reduction and pollution reduction" in the whole region.

It is difficult to accurately and comprehensively display the effectiveness of emission reduction in carbon emission and carbon sink data monitoring capabilities. Carbon monitoring and evaluation is in its infancy, and the evaluation informatization is in the process of exploration, from the practical level analysis of various regions, the basic energy data is generally regarded as the carbon monitoring and evaluation data, and the power data is the core to promote the organic integration of carbon emissions and electricity consumption. In actual operation, power energy is only a single source of carbon emissions, and the carbon emission status formed by different energy-specific application methods has certain differences, so energy data as a monitoring basis, although it has a certain reference value, is difficult to accurately and comprehensively reflect the actual situation of carbon emissions in different fields, and needs to be cross-verified and evaluated through multi-dimensional and multi-source data.

3 Suggestion

3.1 Unifying Industry Standards and Standardizing Accounting and Monitoring Systems

In view of the phenomenon of duplicate standards, index conflicts, non-standard expressions, and non-interoperability of data in relevant industry standards or group standards, it is suggested that a carbon accounting system covering cities, products, enterprises, projects, industries, provinces and even countries should be built in the future, and a series of normative principles such as calculation methods, data standards, result testing, and calculation processes should be clarified with the help of the accounting system, to guide the standardized, scientific and unified organization and implementation of carbon monitoring and assessment tasks at all levels and in all fields. In addition, it is also necessary to build exclusive intelligent technology application standards, and exclusive manipulation guidelines at the level of technology development, information platform construction, information product innovation and development, and safety management related to carbon detection and evaluation, so as to guide the compliance and safe operation of information construction.

3.2 Formulating Incentive Policies to Promote Enterprises to Actively Participate in the "Dual Carbon" Plan

The research and development of carbon monitoring instruments and the construction of enterprise carbon monitoring systems are still in the exploratory stage, and the relevant incentive policies such as tax exemptions and financial subsidies are not sufficient. Only a small number of regions have promoted green development through green finance "loans", strengthened the financial attributes of the carbon market, and indirectly promoted enterprises to gradually establish and improve carbon emission monitoring systems. It is suggested that all departments should strengthen cooperation, refer to the existing advanced management models in China, explore the establishment of carbon emission monitoring and certification evaluation systems, carbon neutral factories and other certification methods, and introduce targeted incentive policies to promote enterprises to actively participate in the dual carbon plan.

3.3 Improving the Accuracy of Data and Ensuring the Fairness of Carbon Trading.

At present, China mainly follows the principle of "accounting first, monitoring secondary" for carbon accounting. The indirect fuel input method is not accurate, the data collection efficiency is low, and the actual emission factor will change depending on the production status, energy use, and technological process. It is necessary to improve the accuracy of carbon trading market data and ensure the fairness of carbon trading. On the other hand, the discharge end needs to be measured with a highly accurate measuring device and the data corrected.

3.4 Improving the Management Platform to Achieve the Refined Management of the "Double Carbon" Goal

Each region needs to rely on the characteristics of carbon emissions and its own actual situation to create an intelligent and data-based comprehensive management platform to fully realize the dynamic management of the "dual carbon" action in the "one map" region; Build exclusive intelligent management and park carbon detection management, create a district-level carbon detection command organization, and improve the quality level of carbon detection in an all-round way with the help of command technology; Enterprise intelligent management and carbon detection, with the help of big data technology, lead enterprises to carry out carbon energy consumption detection and analysis, energy consumption analysis and research, and provide help for improving enterprise production processes and various backward process technologies.

4 Conclusions and Achievement Transformation Measures

4.1 Promoting the Practical Application of Electric Carbon Consumption Sensing Sensors.

By carrying out research on digital energy consumption measurement standards and other projects, we will promote the improvement of the measurement performance, product functions and product quality of power carbon emission sensors, terminals and other monitoring devices, and guide carbon emission management departments, metering scientific research institutions, and power operation enterprises to carry out in-depth cooperation in the field of carbon emissions, to lay the foundation for the formulation of relevant standards and measurement technical specifications. Promote the demonstration and application of carbon emission monitoring in relevant key energyconsuming units in Beijing, as well as industrial parks and data centers, guide and encourage enterprises to optimize production plans according to real-time carbon emission factors, concentrate production in periods with a high proportion of new energy and low carbon emission factors, effectively reduce carbon dioxide emissions under the same electricity consumption, help enterprises in carbon trading, carbon asset management, and enhance enterprises' independent willingness to reduce emissions and carbon emissions.

4.2 Issuing a Calibration Specification for the Continuous Monitoring System of Greenhouse Gas Emissions from Stationary Pollution Sources

Develop calibration specifications for continuous monitoring systems for greenhouse gas emissions from stationary sources. The continuous monitoring system of greenhouse gas emissions from stationary pollution sources is used to monitor the greenhouse gas emissions of key pollution sources online and in real time, and is the key instrument and equipment to achieve the "double carbon" goal. Greenhouse gas emission data is used as the basis for the Ecological Environment Department's law enforcement inspection of key emitting enterprises, and its data quality depends on the requirements of the standards and specifications, the strictness of the implementation of the standards and specifications, and the implementation of continuous quality assurance measures. The formulation of measurement and calibration specifications for the online monitoring system of greenhouse gases from pollution sources will effectively promote the construction of China's carbon emission transmission system and support the national carbon peak and carbon neutrality goals. At the same time, in the context of the national "dual carbon" strategic goal and the adjustment of energy structure, the formulation of this specification will help promote the quality improvement of related products such as the continuous monitoring system of greenhouse gases from stationary pollution sources, and promote the virtuous cycle of product sales market.

4.3 Policy Recommendations

Governments can play a key role in implementing harmonized standards and creating incentives. First, governments should set clear standards and norms for monitoring carbon emissions to ensure that industries follow a uniform methodology for monitoring and reporting carbon emissions. Second, governments can encourage enterprises to adopt advanced carbon monitoring technologies and management methods through incentive policies such as financial subsidies, tax incentives, or carbon emissions trading. However, technological differences and emission characteristics among different industries may lead to challenges in the formulation and implementation of uniform standards. Therefore, the Government needs to work closely with stakeholders, including enterprises, research institutions and technology providers, to overcome these barriers and promote the smooth implementation of carbon emission monitoring and reduction.

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