Research on the Development of Measurement System under the Background of EU Carbon Tariff

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Abstract

As global climate change intensifies, carbon emission reduction has become a central issue for countries worldwide, with carbon markets playing a key role in addressing this challenge. Through a detailed examination of the EU's carbon tax mechanism and related carbon emission monitoring systems, this paper provides insights into the EU's pioneering role in carbon reduction strategies. The EU has implemented significant measures, including the Carbon Border Adjustment Mechanism (CBAM), to promote carbon reduction while ensuring fair trade practices. Accurate carbon emission measurement is critical to the functioning of carbon markets, ensuring transparency and fairness. The EU has established a robust carbon emission monitoring system based on internationally recognized standards. Emerging technologies, such as AI, IoT, and blockchain, offer strong support for improving carbon measurement systems, driving carbon market efficiency. Developing countries should invest in advanced carbon measurement technologies, aiming to improve emission data reliability and meet international standards, thereby enhancing their competitiveness in the global carbon market.

Keywords

Carbon Emission, Carbon Border Adjustment Mechanism, Measurement System, EU Carbon Tax.

1. Introduction

Since the industrialization of human society, fossil fuels have been widely used on a large scale. The greenhouse gases such as carbon dioxide and other pollutants produced by their combustion have intensified the trend of global warming, seriously restricting the sustainable development process of human society and becoming a major non-traditional security challenge faced by human development. In the current context of increasingly severe global climate change challenges and gradually tightening emission reduction policies, countries around the world are undergoing deep changes centered on carbon emission reduction. At the same time, the carbon emission accounting system has become the focus of international rule games. A complete carbon emission statistics and accounting system can provide data support for policy-making related to carbon emission reduction, enterprise management, and international cooperation, improving the efficiency and transparency of carbon emission reduction. In this process, metrology not only provides quantitative basis for the formulation of standards such as carbon emissions and marketization mechanisms, but also ensures the accuracy and reliability of data through internationally recognized, consistent measurement standards and measurement methods, serving as the technical foundation for inspection and testing. Especially in the context of the EU carbon tariff policy, an accurate carbon emission measurement system not only provides technical support for the fair implementation of the carbon tariff, but also promotes mutual trust and recognition in the global carbon market.

Therefore, systematically analyzing the role of the measurement system in the implementation of the EU carbon tariff policy holds significant theoretical importance and has profound practical implications in advancing the sustainable development of international carbon markets and global climate governance[1].

2. Overview of the EU Carbon Tax Policy

2.1. Origin and Background

In recent years, the severe situation of global warming has drawn increasing attention to the issue of carbon emission control. From the early concept of "low-carbon economy" to the signing of the United Nations Framework Convention on Climate Change and the Kyoto Protocol on a global scale, countries have been striving to address the problem of global warming by reducing carbon emissions. In the field of global climate governance, the European Union has always played the role of a "pioneer", actively promoting the implementation of carbon tax policies and making significant contributions to global carbon reduction. Since committing to an 8% reduction in emissions under the Kyoto Protocol, the European Commission launched the European Climate Change Programme (ECCP) in 2000 and established the EU Emissions Trading System (EU ETS) in 2005, successfully introducing market mechanisms into carbon emission control.

As a new type of trade barrier measure, carbon tax aims to impose additional tariffs on imported high-carbon products, thereby encouraging other countries to reduce carbon emissions. The EU advocates the use of a clever combination of carbon pricing and supporting policies to help member states achieve their climate goals by 2030 and ultimately reach the EU's emission reduction targets. On July 14, 2021, the European Commission released a package of plans named "Fit for 55". This plan is based on the revision and update of EU legislation under the EU Green Deal and includes a series of proposals for new measures, aiming to ensure that EU policies align with the climate goals agreed upon by the Council and the European Parliament. It covers multiple industries such as energy, industry, transportation, and construction, and commits to reducing greenhouse gas emissions by 55% by the end of 2030 compared to 1990 levels. This plan has become one of the most crucial low-carbon development policies of the EU at present. Against this backdrop, the EU carbon tax policy (i.e., the Carbon Border Adjustment Mechanism, CBAM) as an important component of the "Fit for 55" plan, aims to impose charges on the carbon emissions of imported goods to ensure that imported goods bear the same carbon costs as EU domestic products, thereby ensuring that EU domestic enterprises can remain competitive in the global market under strict carbon emission standards.

2.2. Main Measures

In May 2023, the Carbon Border Adjustment Mechanism (CBAM) was officially adopted into EU law. As a key carbon tariff tool of the European Union, CBAM is gradually evolving into a new barrier in international trade, which will have a profound impact on global supply chains and industrial competition.

2.2.1. Scope of Application and Implementation Timeline

The first batch of products included under the CBAM covers six high-emission industries: cement, steel, aluminum, fertilizers, electricity, and hydrogen, along with certain upstream and downstream products. During the development of CBAM, the scope of taxation was modified several times, with the final list being confined to these six categories. As the implementation timeline progresses, the scope will expand further. Currently, carbon emissions for products in these six sectors are calculated based on specific standards, with discrepancies between categories. For steel, aluminum, and hydrogen, only direct emissions from their production

processes are evaluated. For cement, fertilizers, and electricity, both direct and indirect emissions must be considered. After the transitional period (post-December 31, 2025), the CBAM scope will extend to new categories such as organic chemicals and polymers. By 2030, all products covered by the EU ETS will be included under CBAM regulation. During the transitional period, EU importers will only be required to report the carbon emissions of relevant products imported into the EU, with no CBAM charges applied. Starting January 1, 2026, CBAM will officially be enforced, and importers will be required to pay CBAM fees to cover the carbon emissions of their imported goods[2].

2.2.2. Tax Calculation Method

CBAM calculates taxes based on the carbon emissions of imported products and implements a pricing standard in line with the EU Emissions Trading System (EU ETS). The mechanism applies to goods imported from non-EU countries, excluding products already regulated under EU ETS. During the implementation phase, EU member states will issue CBAM electronic certificates to importers of high-carbon goods, with each certificate having a unique identification code. The price of the certificate is linked to the direct and indirect carbon emissions in the imported product: direct emissions refer to emissions from the production process, while indirect emissions are associated with electricity consumption. The price of the certificate is set according to the average auction price of EU ETS carbon allowances from the previous week. Additionally, to prevent double taxation, the EU recognizes two deduction methods:

If the carbon tax has already been paid in the country of origin or if the carbon costs under an EU-recognized ETS system have already been covered;

If the product is eligible for free allowances under the EU ETS framework, equivalent to those granted to similar EU products.

2.3. Influence

The EU Carbon Border Adjustment Mechanism (CBAM) is essentially a greenhouse gas mitigation measure aimed at preventing carbon leakage. However, this unilateral climate policy could violate the principles of fairness and efficiency in climate governance, and it has drawn negative reactions from many developing economies and the academic community. Due to the relatively underdeveloped clean technology sectors in key industries such as manufacturing in developing countries, along with higher carbon content and imperfect carbon market mechanisms, the carbon price in these countries is significantly lower than that in the EU and other developed economies. As a result, developing countries believe that CBAM violates the principle of international trade fairness, increasing the cost of their export products and weakening their competitiveness in the EU market. Additionally, foreign companies exporting goods to the EU will be required to pay the corresponding "carbon price" as per CBAM, which could diminish the position of their domestic carbon trading markets. Another issue concerns the fairness of carbon emission standards. CBAM sets out reporting obligations for importers and the methods for calculating carbon emissions of relevant products. Developing countries often struggle to influence the decision-making process, which leads to concerns about the fairness of these standards. If other countries' carbon trading markets are linked to the EU in the future, they may be forced to accept the data standards already set by the EU, thereby undermining the autonomy of their own carbon trading market construction.

3. EU Carbon Tax and Measurement System

3.1. Key Mechanisms

In the development of carbon markets, accurate greenhouse gas emission data is the fundamental basis for carbon trading. Ensuring the accurate accounting and reporting of

carbon emissions is a key task in carbon markets, which is known as the carbon verification system. Therefore, strict management of the quality of carbon-related data is necessary to ensure the reliability and accuracy of the data. The carbon market is governed by a Monitoring, Reporting, and Verification (MRV) mechanism, which ensures the accuracy and transparency of greenhouse gas data.

In 2003, the EU issued the 2003/87/EC Carbon Trading Directive, which is the foundational legal framework for the EU. This directive defines the establishment of the carbon emissions trading system, including cap-setting, monitoring, reporting, and verification mechanisms, and allows member states to develop national implementation guidelines based on this framework. The EU carbon verification MRV mechanism involves several key stakeholders: regulatory authorities, national accreditation bodies, third-party verification organizations, and operators. Each plays a different role in the verification process: regulatory authorities set policies and oversee implementation, national accreditation bodies assess the capabilities of certification organizations, and third-party verifiers are responsible for verifying the compliance and accuracy of emission reports.Under this system, carbon measurement technologies, supported by consistent international standards and methods, ensure the reliability of data, making them essential tools for carbon emission accounting and emission reduction policies. Carbon measurement relies on precise and traceable data to support carbon rights certification and trading[3].

3.2. Key Approaches

Measurement institutions in EU countries have established measurement standards covering the entire lifecycle of greenhouse gases, laying the foundational framework for the scientific quantification of shipping carbon emissions. Focusing on gases regulated by international conventions and regional policies, such as CO_2, CH_4, and N_2O, measurement agencies have utilized high-precision analytical techniques to build a complete traceability chain from reference substances to the transfer of measured values. They have transformed cutting-edge technologies, such as quantum physics and analytical chemistry, into international standards for carbon emission accounting. In the development of reference substances, the German Federal Physical and Technical Institute (PTB) has developed a multi-component gas analyzer based on optical frequency comb technology, capable of simultaneously measuring seven greenhouse gases, including CO_2, CH_4, and N_2O, with wavelength precision up to 10^-12 meters. This technology enables simultaneous online monitoring of various greenhouse gases, meeting the multi-parameter emission assessment needs of complex shipping operations, and effectively supports the implementation of EU shipping carbon emission regulations and reduction targets.

Additionally, in the shipping industry, in September 2024, PTB led a joint initiative with national metrology institutions from 17 European countries, including Czech Republic, Denmark, and France, to launch the "Green Maritime Metrology Project" (Maritime MET). This project aims to develop and improve existing traceable carbon emission measurement methods for shipping and promote the application and conversion of research results within the EU. The project focuses on four main tasks: 1) Developing and improving traceable carbon emission measurement methods, such as online and in-situ measurements; 2) Establishing dynamic pressure and temperature measurement methods for cylinders with quality assurance to improve the quality and efficiency of renewable fuel energy conversion processes; 3) Developing engine emission and performance prediction models; 4) Promoting the application of project results in manufacturing, standards organizations, certification laboratories, and end-users[4].

3.3. Future Technological Development Trends

The future development of carbon emission monitoring methods will focus on several key technological areas, driving the deep integration and advancement of the measurement technology system. Firstly, by combining satellite remote sensing data, ground monitoring station data, industrial emission reports, and atmospheric model predictions, data fusion techniques such as Kalman filtering and Bayesian integration can significantly improve the accuracy of carbon emission estimation. Secondly, the application of Artificial Intelligence (AI) technologies, especially deep learning and machine learning algorithms, can effectively analyze carbon emission data. Deep learning models, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), can identify and predict carbon emission patterns, uncovering hidden patterns within the data. Thirdly, Internet of Things (IoT) technologies, through the deployment of smart sensor networks, can enable real-time monitoring of industrial emission sources. Finally, blockchain technology can be used to establish trustworthy carbon trading platforms, recording and verifying carbon emission transactions. This ensures the fairness of the carbon market, reduces the possibility of data fraud, and provides traceable carbon emission data to support policy-making and carbon trading decisions[5].

4. Summary

From the development of the EU carbon tax mechanism and its related carbon emission monitoring system, several important lessons can be drawn. Firstly, accurate carbon emission measurement and monitoring systems are the foundation for promoting fairness and transparency in the global carbon market, especially in cross-border carbon emission regulation, where ensuring the accuracy and credibility of emission data is crucial for maintaining market fairness. Secondly, technological innovations, particularly the application of emerging technologies such as big data, artificial intelligence, the Internet of Things, and blockchain, provide strong support for carbon emission measurement and drive the efficient operation of the carbon market. Most importantly, developing countries should increase investment in the research and application of advanced carbon measurement technologies and high-end carbon measuring instruments, establishing a carbon emission monitoring and accounting reporting system that combines direct measurement with indirect estimation. Efforts should be made to achieve independent control over core technologies and high-end instruments, driving the transition from macro "carbon accounting" to precise "carbon measurement" in line with international requirements, ensuring international recognition, and securing a competitive position in the global carbon market.

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