

Research on Enterprise Carbon Accounting under the Framework of Carbon Emission Management Accounting — Taking Chemical Enterprises as an Example

Jingjuan Wang, Weili Xia

School of Management, Northwestern Polytechnical University, Xi'an 710129, China

Keywords: carbon management accounting; Carbon accounting

Abstract: The development and utilization of carbon emission management accounting tools is helpful for enterprises to realize the informationization of carbon emission management and improve the utilization efficiency of internal and external carbon resources. How to quantify carbon emission index reasonably and combine accounting practice information is a difficult problem in financial work, and it is also one of the main ways for managers to balance the contradiction between short-term economic performance and long-term sustainable development with carbon emission accounting information. Based on the research of carbon emission management accounting in domestic and foreign enterprises, this paper takes chemical enterprises as an example, puts forward the carbon emission accounting management of each accounting unit under the framework of carbon emission management accounting, discusses specific carbon emission accounting treatment methods, and suggests that enterprises combine monetary carbon accounting with physical carbon accounting disclosure through comprehensive carbon emission management system.

1. Research Background

To cope with global climate change and develop low-carbon economy has become an inevitable choice for world economic development. With the introduction of laws and regulations to limit the emission of carbon oxides, carbon emission rights begin to circulate in the carbon trading market, and developing low-carbon economy is a challenge and opportunity for enterprises. Facing such economic situation, enterprises should make overall and long-term planning as long-term development strategic objectives of enterprises, start with changing the strategic concept of enterprise development, establish the development concept of energy saving, emission reduction, low carbon and environmental protection, reconstruct the financial strategic system of enterprises, and actively develop and apply carbon accounting language. Quantify economic indicators related to carbon emissions, provide accurate financial information related to carbon emissions for stakeholders and enterprise managers, and provide reliable financial data for enterprises' energy conservation and emission reduction, institutional innovation and strategic decision-making,

considering that enterprises can realize the overall coordinated development of ecology and society while increasing economic benefits.

Under the constraint mechanism of carbon emission, enterprises can only comply with the emission regulations if they get the carbon emission right. The establishment of carbon emission rights gradually urges enterprises to separately measure and reflect the costs and risks of carbon emission, as well as profit distribution. Establishing a theoretical system of carbon accounting has become a frontier and hot issue in current accounting research. Calculating product carbon footprint and certifying carbon label can bring potential value to enterprises. More and more customers from developed countries and regions such as Europe and America explicitly require suppliers to provide carbon information of their products, and more and more consumers tend to choose products and services containing carbon emission information. The carbon footprint of products has gradually become an important factor in the differentiated product strategy of enterprises [1]. In addition, the efforts of enterprises to cope with climate change may affect the reputation of enterprises, demonstrating the development concept of low carbon and environmental protection and corporate social responsibility of actively reducing emissions and wastes.

2. The Carbon Emission Management Accounting Framework

The implementation of carbon financial accounting can increase investors' attention to low-carbon projects of enterprises and increase the possibility of future investment. The accounting of carbon accounting information is a part of accounting for realizing sustainable development, which aims to provide managers with relevant information about carbon dioxide (CO₂) and other greenhouse gases, and help managers make business decisions that are beneficial to the long-term development of the company on the long-term and short-term issues of carbon emissions related to production and operation (Maunder and Burritt, 1991; IPCC 2007). The development and application of various environmental and sustainability accounting tools is the primary work of carbon emission accounting. At present, the research on the implementation and application of sustainable development management accounting is limited, and many companies have less practical work on collecting, managing and disseminating carbon-related information. Although companies pay more attention to carbon issues, the information management practice on carbon issues is still in the exploratory stage. Managing accounting information related to carbon information is a key step in carbon finance [2]. Collecting carbon information, accurately estimating and measuring carbon emission indicators, designing a carbon information management system to meet the government's regulatory requirements for companies, and connecting with the carbon emission trading market are conducive to accurately grasping the carbon market information and improving the efficiency of internal and external carbon resource allocation [3].

Carbon emission accounting system is adopted by companies all over the world to collect carbon information, in response to the regulatory, market and information requirements formulated by more and more countries around the world, this study sorts out the main directions and indicators of the current application level of carbon emission management accounting, as shown in Table 1. This paper puts forward the framework of carbon emission accounting, and adds the concept of carbon emission management into carbon emission accounting to establish the theoretical framework of carbon emission accounting.

Based on the management accounting framework proposed by Schaltegger and Burritt, combined with the actual situation of China's chemical enterprises, a carbon emission management accounting framework is constructed from the perspective of experience and future development. The framework suggests how managers can find a balance between short-term economic performance and long-term emission control trend, and realize the strategic goal of promoting

carbon emissions by carbon emission accounting with the help of environmental management accounting tools from specific financial work [4].

Table 1: Accounting Framework for Carbon Emission Management

		Monetary carbon accounting		Physical carbon accounting	
		Short - term	Long - term	Short - term	Long - term
Guided by empirical facts	Daily information	1 carbon cost accounting (for example, sorting out the income and cost of buying and selling carbon emission rights in the market in the past)	2. Capital expenditure on carbon reduction (for example, collecting annual capital expenditure on carbon reduction technologies)	3. Carbon emissions accounting (for example, collecting daily carbon emissions flow information related to production)	4. The rate of increase or decrease of carbon capital (for example, calculate the reduction of carbon footprint of enterprises in the past ten years)
	Temporary information	5. Evaluate the short-term/related carbon cost decisions afterwards	6. Post-investment emission reduction assessment	7. Post-assessment of carbon emissions of short-term projects	8. Post-evaluation of physical carbon investment evaluation
Guided by future development	Daily information	9. Preparation of monetary carbon business accounting	10. Long-term carbon financial planning	11. Physical carbon accounting (for example, by training technicians to account for carbon emissions, it is expected to reduce carbon dioxide emissions)	12. Long-term physical carbon planning
	Temporary information	13. Relevant carbon cost calculation	14. Investment evaluation of monetary carbon projects)	15. Carbon impact accounting (for example, considering the carbon dioxide emission reduction effect of the project in the next	16. physical environmental investment assessment (for example, impact of cleaner production investment)

				accounting period)	
--	--	--	--	--------------------	--

The different purposes of enterprise carbon accounting define the nature of relevant information which is monetary carbon accounting or physical carbon accounting, the length of time, and the information source is oriented to the past empirical facts or future development; Is the way of information generation and collection routine or temporary [5]. Under the framework of comprehensive carbon management put forward by Burritt and Schaltegger, we decompose management information into physical carbon accounting information and monetary carbon accounting information. Management decision-making takes empirical facts as the leading direction and future development as the leading direction, which is the long-term and short-term development accounting information. This framework can be used as a guide for managers' decision-making. Since the collection and management of carbon information is related to actual management and technological process, the establishment of carbon emission management accounting framework provides for comparing carbon accounting methods and selecting carbon accounting tools.

3. The Design of Carbon Emission Accounting Management in Chemical Production Enterprises

3.1. Carbon Emission Activities of Chemical Production Enterprises

“General Principles for Accounting and Reporting of Greenhouse Gas Emissions from Industrial Enterprises” and 11 national standards for greenhouse gas emission management in 10 key industries such as power generation, power grid and chemical industry, which were approved and issued in China in 2015. In this paper, the management design of carbon emission accounting index is discussed by taking chemical production enterprises as an example [6]. According to the "Standard", for complex chemical production enterprises with scattered organization, complex process and difficult distinction between raw materials and products, in order to calculate carbon dioxide emissions more conveniently, the facilities and business of enterprises can be divided into several accounting units, one accounting unit can include one or more production facilities, and one reporting entity can be divided into one or more accounting units. The production facilities of all accounting units constitute all production facilities of reporting entities. Taking a chemical production enterprise as an example, the reporting entity should determine all kinds of carbon dioxide emission sources in each accounting unit based on the identification of carbon sources, and calculate their respective greenhouse gas emissions and total emissions. The carbon quota required for the carbon emission activities of the forecast accounting unit and the main carbon emission activities are shown in the following table 2:

Table 2: Carbon Emission Activity Table

Emission type	Emission activities
Fuel combustion emissions	Greenhouse gas emissions from fuel during oxidative combustion, including coal, oil and gas, and carbon dioxide emissions from oxidative combustion of fuel in combustion equipment
Process emissions	Greenhouse gas emissions caused by physical and chemical changes other than fuel combustion during production and waste treatment and disposal. It mainly includes carbon dioxide emissions from fossil fuels and other hydrocarbons used as raw materials and carbon dioxide emissions from decomposition during carbonate use

Electricity and heat emissions purchased and exported	Carbon dioxide emissions corresponding to purchased electricity and heat consumed by chemical production enterprises and carbon dioxide emissions output.
Emissions from purchasing electricity and heat	Carbon dioxide emissions from the purchase of electricity consumed by enterprises, the corresponding electricity and heat production links; The consumption of fossil fuels in the process of electric power thermal production will produce greenhouse gas emissions, which are indirect emissions of enterprises. It is necessary to calculate the greenhouse gas emissions corresponding to the purchased electric power thermal power consumed by enterprises
Output of electricity, emissions from heat	Electricity output by enterprises, electricity corresponding to heat, and carbon dioxide emission generated by heat production. The enterprise produces emissions for the production of this part of electric power, but the responsibility of its emissions should be borne by the power manpower importer, and this part of emissions should be deducted in the accounting
Carbon dioxide recovery and utilization	For the carbon dioxide generated by the reporting subject but recovered as raw material for production or supplied to other units outside the product, the amount of carbon dioxide supplied outside the product should be deducted from the total emission accounting

The main steps of accounting for greenhouse gas emissions in chemical enterprises are as follows: 1. Identify emission sources 2. Collect activity data: the characterization value of production or consumption activities that lead to greenhouse gas emissions. 3. Select and obtain emission factor data: coefficient representing greenhouse gas emissions per unit of production or consumption activity 4. Calculate fuel combustion emissions, process emissions, emissions generated by electricity and heat purchased and output respectively 5. Calculate greenhouse gas emissions of enterprises in summary. Work out a carbon accounting system, allocate carbon quotas to each accounting unit reasonably, and each accounting unit will conduct carbon emission accounting for production facilities, fuel burning, on-site recovery, electricity and heat output, etc., measure the carbon emissions of each link, and form accounting data, so as to facilitate the accounting department to summarize the carbon emission accounting information of each accounting unit.

3.2. General Idea of Carbon Emission Accounting

China's Climate Change Division has jointly drafted "Accounting Methods and Reporting Guidelines for Greenhouse Gas Emissions of Enterprises in 24 Key Industries" [7]. Although the accounting methods of 24 industries are different, the basic idea is the same: on the premise of determining the accounting boundary of enterprises, the emissions of each type of emission source are calculated separately and then added and summarized, which is the greenhouse gas emissions of enterprises. It can be expressed by the following formula:

$$E_{CO_2} = E_{combustion} + E_{process} + E_{waste} + E_{electricity\ and\ heat} - E_{carbon\ recovery} - E_{output\ electricity\ and\ heat}$$

Among them: E_{CO_2} is the total carbon dioxide emission of the accounting unit; E calculate unit all net consumption of carbon dioxide emissions from all net consumption fossil fuel combustion activities; E process is the carbon dioxide emission generated by the production process of the accounting unit; E waste is carbon dioxide emission from waste treatment; E electricity and heat are carbon dioxide emissions generated by net purchase of electricity and net purchase of heat by accounting unit; E carbon recovery is the carbon dioxide emission from the accounting unit; E output electricity and heat are carbon dioxide emissions generated by the output electricity and heat of the accounting unit. According to the types of emission sources contained in each accounting unit and referring to the accounting methods of different emission sources [8], each accounting unit sums up the emissions of all emission sources contained in its own production and counts them as the greenhouse gas emissions of the enterprise. Among them, if the type of greenhouse gas emitted is not carbon dioxide, it should be converted into carbon dioxide emission according to the accounting method in the guidelines.

According to the specific business activities and production links that produce carbon emissions, prepare carbon accounting indicators, and conduct comprehensive accounting on the estimated carbon emission demand, estimated carbon emission reduction, carbon emission reduction cost, estimated carbon emission trading volume and estimated carbon emission trading cost. According to the cost accounting method of carbon accounting, we divide the estimated carbon emission reduction into operating expenditure emission reduction and capital expenditure emission reduction, and the corresponding accounting is as follows:

$$E_{CO_2 \text{ Emissions}} = E_{CO_2 \text{ Operating expenses Emission reduction}} + E_{CO_2 \text{ Capital expenditure reduction}} \quad (1)$$

$$E_{CO_2 \text{ Operating expenses Emission reduction}} = E_{CO_2 \text{ Use original fuel}} - E_{CO_2 \text{ Use clean fuel}} \quad (2)$$

$$E_{CO_2 \text{ Capital expenditure reduction}} = E_{CO_2 \text{ Use original equipment and technology}} - E_{CO_2 \text{ Use low-carbon equipment and technology}} \quad (3)$$

In the production process, with a certain production equipment and technical level, selecting low-carbon resources or clean energy to replace the original production fuel will result in emission reduction of operating expenses (see Formula 2). Similarly, under the condition of certain resource consumption, choosing low-carbon equipment and low-carbon technology to replace the original equipment and technology will form capital expenditure emission reduction (see Formula 3). From Formula 1, it can be seen that the business decision will affect the accounting of carbon emission reduction, and the accounting of carbon emission reduction will react to the business decision at the same time. In the production stage, the choice of resource types will determine the emission reduction of operating expenditure, and the planning of capital structure will also affect the emission reduction of capital expenditure. The level of carbon emission reduction is not only directly related to the amount of carbon emission quota used in the current period, but also reserved space for enterprises to hold or sell carbon emission rights. In addition, the level of carbon emission reduction also depends on the way and input cost of enterprises to implement carbon emission reduction. Therefore, guiding enterprises to use carbon emission accounting tools to measure corporate carbon accounting information is conducive to the management's economic planning and control of carbon emission reduction activities [9], thereby balancing the cost and benefit of carbon emission reduction and realizing the rational allocation of internal carbon resources and the investment demand of external carbon financial markets.

According to the business scale and future business objectives of the enterprise in previous years, the accounting amount of carbon emission demand of the enterprise can be roughly estimated, and the accounting amount of carbon emission reduction and carbon emission is as follows:

$$Q_{CO_2 \text{Emissions budget}} = Q_{CO_2 \text{Emission demand budget}} - E_{CO_2 \text{Emission reduction budget}} \quad (4)$$

$$Q_{CO_2 \text{Emissions trading volume}} = Q_{CO_2 \text{Emission allowances}} - Q_{CO_2 \text{Emissions budget}} \quad (5)$$

Among them, CO2 Emission allowances is approved by the government according to certain procedures and methods in order to achieve the emission reduction targets and the amount of emissions allocated by the state. Some enterprises that exceed the carbon emission quota need to buy in the carbon emission trading market, and the remaining carbon emission quota can be sold to form the enterprise carbon emission trading income. According to Formula 4, the calculated amount of carbon emission is the difference between the estimated carbon emission demand and the calculated amount of carbon emission reduction [10]. The accounting amount of carbon emission reduction comes from the emission reduction of enterprises in the process of developing low-carbon production for the purpose of emission reduction. According to Formula 5, the enterprise obtains the carbon emission accounting amount according to Formula 4, and calculates the carbon emission trading amount that can be traded (sold or purchased) in the carbon trading market according to the carbon emission quota given by the government free of charge. Therefore, the enterprise's carbon emission reduction income can be estimated as follows:

Estimated trading income of carbon emission rights = estimated trading volume of carbon emission rights × fair value of carbon emission market

Estimated total carbon emission reduction income = estimated carbon emission trading income + government subsidy - transaction cost

Estimated total cost of carbon emission reduction = estimated operating expenditure + estimated capital expenditure + estimated contingent expenditure

Estimated net income of carbon emission reduction = estimated total income of carbon emission reduction - estimated total cost of carbon emission reduction

Among them, the contingent expenditure refers to the accidental compensation or penalty that may be caused by environmental negligence in the enterprise's emission reduction activities, and the loss that the enterprise prevents from going out of business or stopping work due to failing to meet the environmental protection technical standards, etc. (as shown in Figure 1).

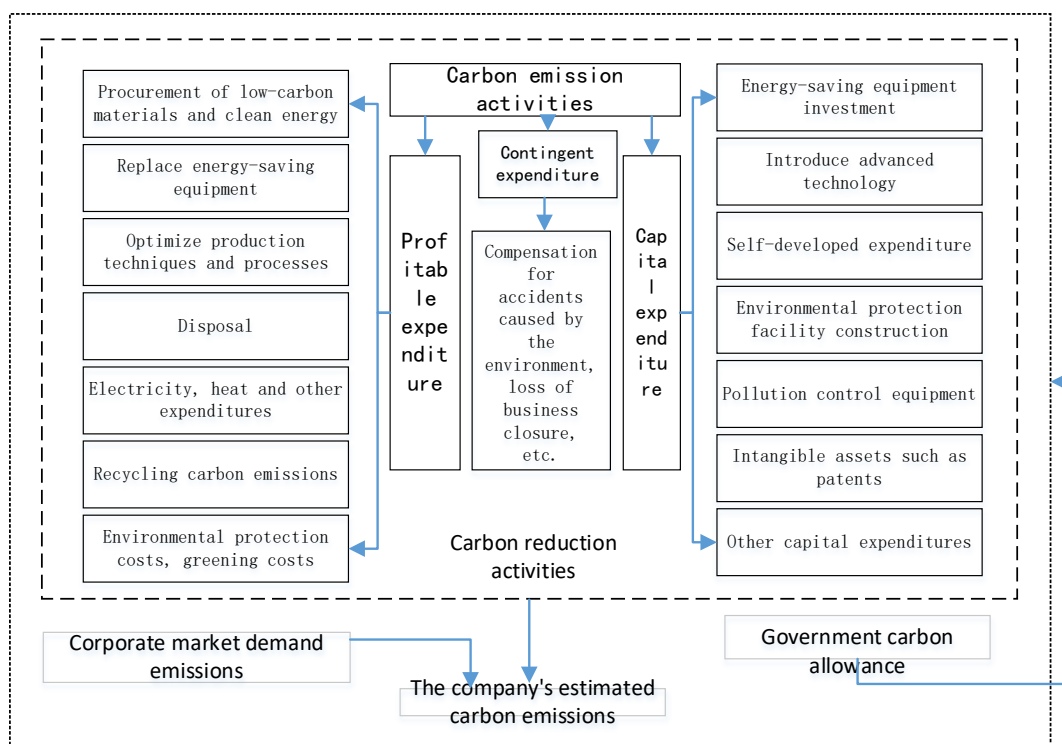


Figure 1 Carbon emission activities

It can be seen from the above figure that various carbon emissions, carbon emission reduction and trading activities of carbon emission rights in the process of enterprise carbon accounting have an impact on enterprise comprehensive accounting, and should be included in the comprehensive accounting system. The profit and loss of carbon emission trading, government subsidies and other emission reduction benefits, as well as the cost caused by Chinese nature [11], profitability and contingent expenditure in the process of emission reduction, will make cash flow into or out of enterprises, thus affecting the cash accounting of enterprises. We should incorporate carbon accounting indicators into the financial accounting statements of enterprises to calculate the estimated profits, and the traditional comprehensive accounting system can be transformed and upgraded to a low-carbon accounting system, thus promoting the development and growth of carbon emission management accounting in a low-carbon economy environment.

4. Accounting and Information Disclosure of Carbon Emissions

Based on the management design of carbon emission accounting of chemical enterprises mentioned above, we think that the accounting of carbon emission accounting can be divided into two parts: first, the carbon emission quota for the purpose of production, operation and use is included in intangible assets by historical cost measurement, and the management design of carbon emission accounting refers to the operating expenses of using clean energy instead of traditional fuels [12]. Costs related to emission reduction will occur, which is also a key factor for enterprises to consider in emission reduction management. Therefore, the cost of selecting clean energy to replace the original energy should be regarded as the operational emission reduction cost, and all expenses should be included in the current profits and losses [13]. Second, the carbon emission rights held or sold for the purpose of investment and financing are measured at fair value and included in financial assets. At the end of the period, the difference between the fair value of the carbon emission right

held by the enterprise and its book value is uniformly accounted under the account of "fair value change profit and loss-carbon emission right", and the book value of financial assets-carbon emission right is adjusted at the same time (as shown in Table 3).

Table 3: Carbon Accounting Method

Classification	Accounting subject	Secondary subjects	Meaning	Metering method
Self-use carbon emission quota	Intangible assets	Carbon emission right	Held for the production of products or management	Measured at historical cost
	Amortization of intangible assets	Capital emission reduction cost		Amortization in each benefit period of emission reduction
	Manufacturing cost and management cost	Operating emission reduction cost		
	Manufacturing cost and management cost	Contingent emission reduction cost		
Investing in holding carbon emission quotas	Financial assets	Carbon emission right	Carbon emission rights held or purchased for the purpose of earning the difference	Measured at fair value
	Changes in fair value gains and losses	Carbon emission right		Changes in fair value of carbon emission rights during holding period

Under the framework of carbon emission management accounting, the disclosure of carbon emission information should be combined with monetary carbon accounting and physical carbon accounting. The accounting unit collects physical information of carbon emission, which can not only meet the needs of regulatory reporting, but also benefit inter-departmental performance evaluation and fully understand carbon management accounting. Therefore, we suggest developing an integrated carbon emission management information system, which can collect and sort out data and solve the problems of poor data and low process efficiency. Carbon management accounting is a new information management system combining information management and accounting methods, which aims to create and provide high-quality information and support companies to achieve carbon neutrality in production and business activities. From a pragmatic point of view, the challenges faced by accountants and sustainable development managers are to propose and test new carbon management accounting methods, improve the awareness of carbon emission reduction in enterprises through carbon management accounting support and innovative carbon management accounting methods, and at the same time improve the economic performance of enterprises, thus effectively promoting sustainable development and sustainable development of enterprises, and helping management to make more wise decisions.

5. Conclusion

This study taking chemical enterprises as an example, under the framework of comprehensive financial management of carbon emissions, discusses the accounting calculation methods of carbon emissions, provides some ideas for formulating accounting methods of carbon emissions, and provides some theoretical basis for further disclosure of monetary carbon accounting and physical carbon accounting.

References

- [1] Polzin, F. *Mobilizing private finance for low-carbon innovation – A systematic review of barriers and solutions. Renewable and Sustainable Energy Reviews* 77, 525-535, (2017).
- [2] Cui Yequang, Zhou Chang. *Research on the Current Situation of Carbon Emissions Trading and Carbon Accounting in Beijing, Tianjin and Hebei. Accounting Research*, 3-10 (2017).
- [3] Campiglio, E. *Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy. Ecological Economics* 121, 220-230, (2016).
- [4] Verde, S. F., Paziienza, M. G. *Energy and climate hand-in-hand: Financing RES-E support with carbon revenues. Energy Policy* 88, 234-244, (2016).
- [5] Nie, P. -y. , Chen, Y. -h. , Yang, Y. -c. , Wang, X. H. *Subsidies in carbon finance for promoting renewable energy development. Journal of Cleaner Production* 139, 677-684, (2016).
- [6] Schaltegger, S., Zvezdov, D., Etxeberria, I. A. *Corporate Carbon and Climate Accounting. Springer International Publishing AG Switzerland* (2015).
- [7] Zvezdov, D., Schaltegger, S. *Decision Support Through Carbon Management Accounting—A Framework-Based Literature Review. Springer International Publishing*, 27-44, (2015).
- [8] Christ, K. L., Burritt, R. L. *Material flow cost accounting: a review and agenda for future research. Journal of Cleaner Production* 108, 1378-1389, (2015).
- [9] Purdon, M. *Opening the Black Box of Carbon Finance “Additionalty”: The Political Economy of Carbon Finance Effectiveness across Tanzania, Uganda, and Moldova. World Development* 74, 462-478, (2015).
- [10] Schaltegger, S., Csutora, M. *Carbon accounting for sustainability and management. Status quo and challenges. Journal of Cleaner Production* 36, 1-16, (2012).
- [11] Simon, G. L., Bumpus, A. G. & Mann, P. *Win-win scenarios at the climate–development interface: Challenges and opportunities for stove replacement programs through carbon finance. Global Environmental Change* 22, 275-287, (2012).
- [12] Li, Z., Zhang, L. *Carbon Finance Development Status and Development Strategy of Our Country under Low-Carbon Economy. 2011 Fourth International Joint Conference on Computational Sciences and Optimization*, 1150-1154, (2011).
- [13] Kaifeng, L., Chuanzhe, L. *Construction of Carbon Finance System and Promotion of Environmental Finance Innovation in China. Energy Procedia* 5, 1065-1072, (2011).