Chapter 2
The Framework of the Integration of Carbon Footprint and Blockchain: Using Blockchain as a Carbon Emission Management Tool

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2.1 Introduction

The carbon footprint is mainly produced by industrial activities such that how to manage the information to lower the carbon emission from supply chains is an essential issue [1]. The well-known enterprises such as Walmart, Nike, and Ikea requested the disclosure of carbon footprint from their suppliers in the past [2].

Under the increasing needs of products' carbon footprint calculation, the basic ability to calculate and disclose carbon footprint has become the important communication tools for government and industry to achieve carbon reduction targets, to declare its corporate social responsibility, and to market green product to the public [3].

For promoting and counseling the industry to disclose the product's carbon footprint and to evaluate the possibility of carbon reduction, many countries have started to construct not only the calculation standard or guidance but also the database for carbon footprint and life cycle assessment [3].

In Taiwan, a carbon footprint online database is thus constructed to enhance the basic ability to disclose and calculate the product carbon footprint of the domestic industry by providing the localizable and high applicable coefficients of carbon footprint [3]. However, the carbon footprint disclosure is still at high price about 120,000 to 200,000 NTD for each product. The disclosure is also time-consuming such as 12 months, especially when the composition of the tar-

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get product is complex. The life-span for some electronic products even ends before the completion of the disclosure.

The blockchain is an emerging technology now applied as a new transaction protocol with many innovative features such as decentralization, non-repudiation, irreversibility, data immutability, and transparency. As the product carbon footprint is involved in business behavior, the blockchain may bring a new opportunity or necessary change for the carbon footprint application [4, 5].

The two features of blockchain we focus on herein are decentralization and irreversibility. Decentralization means no central database will save the transaction data, and each transaction will be known to the public. Irreversibility means the information in the blockchain cannot be modified while synchronized universally.

Now the blockchain is mainly applied by banks for trade finance and cross-border payments. Other than financial field, blockchain can be implemented in any fields where agreement on shared state for decentralized and transactional data needs to be established [4].

If blockchain is accepted and used generally in the future, the carbon emission management is necessary to be enhanced to the next level because the carbon footprint may be then stored in the blockchain. For the decentralized feature of blockchain, the scattered information stored in the blockchain should be managed in one way that can be integrated and transformed for other aspects of carbon emission management. The framework is thus described, and the scenarios of carbon management are also discussed in the following sections.

2.2 The Framework

The framework illustrated as Fig. 2.1 includes three layers: the calculation layer, the blockchain layer, and the integration layer. This framework illustrates the connection of the data stream that the integration layer will retrieve the information from other two layers.

The calculation layer describes how an enterprise collects the data for carbon footprint calculation. There are two approaches happening in the layer: the traditional carbon footprint inventory and the automatic electronic data collection such as IoT (Internet of Things) technology. The data incorporate raw materials, energy and assisted resource consumption (water, electricity, fuel, or gas), and waste quantity.

After certified, the enterprise can claim the carbon footprint of the product that can be applied in trading, sale, or the demand of retailers by coding the carbon footprint in the blockchain. The blockchain layer provides three main functions: certification, consensus, and tracking. In theory, the data stored in blockchain is recorded and distributed that keeps the certification in each trading.

The information stored in the blockchain can open to the public to form a consensus if it is not encrypted. The consensus function is to raise the awareness of three types of stakeholders: the public, the industry, and the central or local

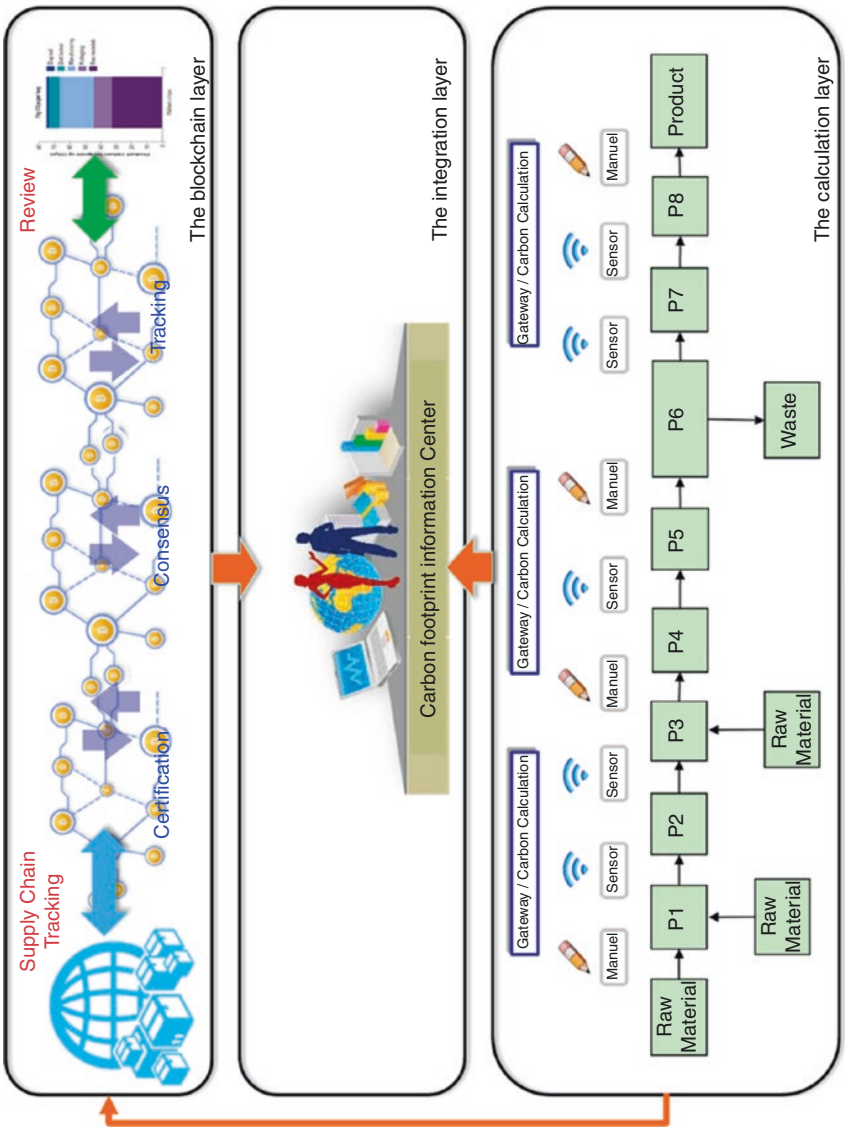

Fig. 2.1 The framework of the integration of carbon footprint and blockchain

governments. Once the carbon footprint is included in blockchain, the public, especially the environmental organizations, can search the information of the target products and adopt appropriate action to form the consensus of carbon reduction.

The integration layer herein is for retrieving the carbon footprint information of each enterprise via blockchain or the traditional reporting. When an enterprise needs to calculate the carbon footprint, it can search the information of the relevant parts of the target product if the carbon footprints of the parts are already recorded in the blockchain or reported in the database.

This database will try to retrieve or update the carbon footprint from the blockchain when it is renewed. In a certification process, the third party can use the database to speed up the process by the confidence the blockchain can provide. All carbon footprint information collected in the database is open to the public that makes the analysis and tracking possible.

In brief, the integration layer collects the scattered information from blockchain in an integrated and open database to provide the stakeholders the information they need.

2.3 The Carbon Footprint Online Database

The carbon footprint online database in Taiwan has been developed since 2013 [3]. The structure of the database is illustrated as Fig. 2.2. The database aims to provide the enterprise a calculation and storing tool for carbon footprint. It brings the benefits of the efficiency improvement of data management, the reduction of inventory cost and time, the promotion of carbon footprint inventory operation, and the enhancement of supply chain cooperation. Now the main companies have used this database such as China Airlines, Sino-American Silicon Products Inc., Taiwan Beer, and Cuprime Material Co., Ltd.

Illustrated in the aforementioned framework, the database connects the blockchain layer as another data source. The difference is the updating protocol that can connect to the blockchain-related technology used by banks and enterprise on commercial trading such as Corda [6] or Ethereum [7].

2.4 The Scenarios

2.4.1 Carbon Footprint Disclosure

In a traditional way, when an enterprise is requested to disclose the carbon footprint of the specific product, it will implement the carbon inventory process, and many relevant questionnaires and interviews arise that makes a tedious and time-consuming process.

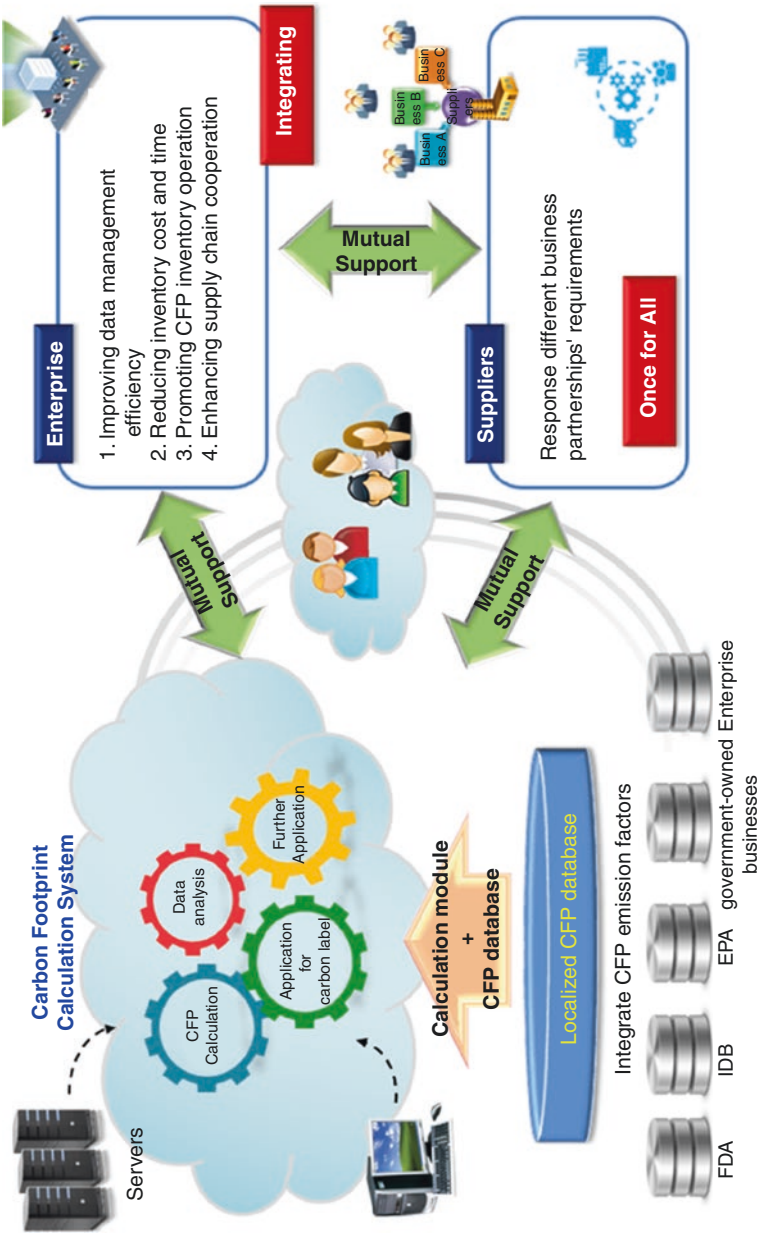

Fig. 2.2 The structure of the carbon footprint online database

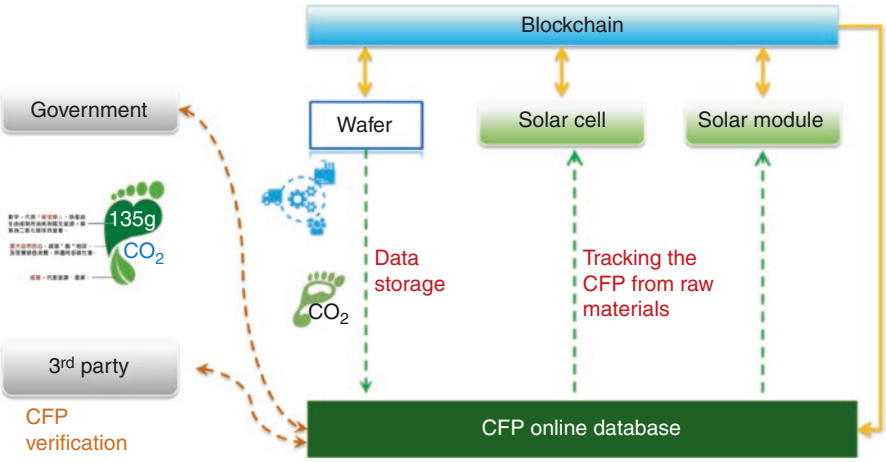

Fig. 2.3 The carbon footprint disclosure via the framework

Using this framework, as illustrated in Fig. 2.3, all companies can retrieve the certified carbon footprint for their target raw materials automatically. If the enterprise applies the IoT (Internet of Things), the certification will be enhanced more efficiently. After the certification and trading based on the blockchain, all the carbon footprint will be updated or added in the carbon footprint online database illustrated in the framework.

For third party audition, the institute can review the carbon footprint of the target product by the blockchain as a trustworthy source. The institute also can use the carbon footprint online database to benchmark of each part of the product if the carbon footprint information is existed.

2.4.2 Supply Chain Management

Supply chain management includes three types of stakeholders: the global or local industries, the government, and the environmental organizations. Their interaction is described as Fig. 2.4.

When the business of the enterprise is restricted by its buyer on the carbon emission issue, the enterprise can manage the carbon emission of the supply chain efficiently by using the framework. The enterprise can select its suppliers and raw materials with lower carbon footprint, while the carbon footprint is embedded in the blockchain and the carbon footprint online database update the relevant information constantly. Its buyer can trust the purchase process not only because the features of blockchain but also the carbon footprint online database that provide the tracking information if the buyer needs to review it.

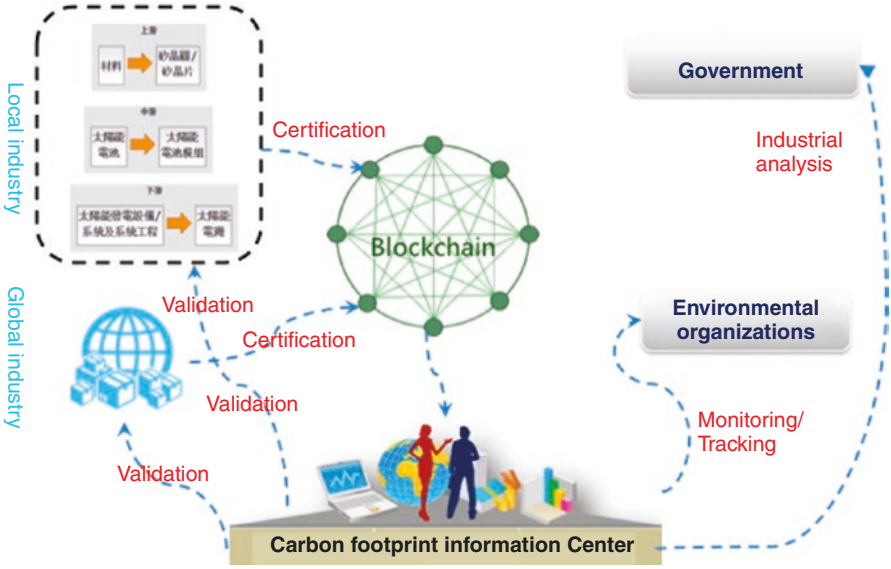

Fig. 2.4 The interaction of the management of supply chain using blockchain

This framework can also assist the government to make effective strategies to affect the whole industry. At first, the government can implement green procurement in itself to drive the low-carbon emission supply chain. When the carbon footprint and the blockchain are integrated more maturely, the government is able to evaluate and promote the target supply chain and the product comprehensively.

For environmental organizations, the framework is a convenient tool to monitor and track the carbon emission of the supply chains. It is easier for the environmental organizations to form a phenomenon to promote the low-carbon products in the country.

2.5 Conclusion

Now blockchain is a future technology that can provide a better and faster management tool in terms of carbon emissions and supply chain management by its feature as a distributed and irreversible database. When carbon footprint information is incorporated in the blockchain, it seems that the information is open to public, but it is not readable for the people without information technology expertise.

The stakeholders, i.e., companies, governments, and environmental organizations, still need a tool such as the carbon footprint online database aforementioned that can collect and integrate the relevant information to satisfy their demand for carbon footprint calculation, supply chain management, and the review of products.

By the credibility and efficiency the blockchain can provide, we believe the carbon emission management can be tracked, planned, and implemented in an easier and more systematic way in the future.

Above all, there are two main advantages of the integration of blockchain and carbon footprint information summarized: (1) The distributed information can be retrieved and integrated from transactions for governmental decision-making. (2) The industries can analyze the supply chain to find the bottleneck and the relevant strategies, and after the implementing the strategies, the industries can observe if the carbon footprints are improved in the long term. Besides the advantages, the technical issues will be the main challenges for the implementation of the framework in the future, such as which blockchain technology the financial system adopts, the multiple blockchain technologies integration when two or more technologies are adopted by different financial systems, data consistency for the blockchain, and the transformation of the carbon footprint online database.

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