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GREEN LOGISTICS DEVELOPMENT AND EVALUATION OF THE CARBON FOOTPRINT

Master's Thesis in

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TABLE OF CONTENTS page

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT:

Along with the worldwide climate changing, human activities and the rapid deterioration of the environment, Low-carbon economy in recent years become increasingly focus of attention in people's lives. The economic reform will gradually penetrate into the logistics system, modern logistics as a composite service industry, play a decisive role in the modern division of labor and cooperation under the social environment, it is a manufacturing! The important supporting business is an important bridge between production and consumption. The logistics industry is in a period of rapid development, the logistics process not only energy consumption demand is big, and the C02 emissions are also large. Coupled with the destruction of the human living environment, the greenhouse effect becomes more and more prominent, more the need of the development of green logistics, low carbon logistics. However, at home and abroad for most of the research of this aspect is still stay in the stage of qualitative analysis, quantitative analysis of the literature on energy consumption and C02 emission of less amount of logistics system. There are four objectives will be discussed.

The first objective is the relevant literature on the green logistics is summarized, which lays the foundation for the research in this paper, green logistics. The second objective is the energy consumption and C02 calculation models were summarized, to provide reference for other scholars to conduct relevant research. The third objective is through statistical analysis, master the different modes of transport energy consumption and C02 emissions, and provide the basis for enterprises to choose the mode of transport. The fourth objective combining with specific examples, analyzed the carbon footprint of the logistics process instance modeling based on LCA.

KEYWORDS: Carbon footprint; Logistics enterprises; Green logistics

1 INTRODUCTION

Along with the development of the new energy sources, more and more energy can be used in daily life. And as the growing population and pollution, how to use the limited nature source meanwhile protect the environment is increasingly focus of daily life. In this context, in Twentieth Century 90 in the global rise of a "green wave", with the aim of sustainable development of "green" revolution booming, osmotic green movement is in numerous fields.

As strong comprehensive and compelling relevance to the industry, modern logistics industry is the pillar of the national economy. Information economy, network economy new economy, gave the logistics field of "contemporary knowledge, new technology and new management idea"; encourage the development of the logistics industry in the specialization and scale. However, due to the enormous increase in the "amount of logistics, logistics management and logistics facilities and the change of tools", "the influence of logistics system on ecological environment" is increasingly serious. In this context, the developed countries have established the concept of "green logistics". The green logistics are the aim of sustainable development of "green" movement permeating into the field of logistics. At present, green logistics is still a novel concept, also lacks the mature theory system, but the social value and economic value are it shows remarkable. (Xiu,Guoyi and Xiaohua Chen 2012)

In this paper, a more in-depth study of the concept of green logistics, background and significance would be studied, and the theoretical foundation of green logistics strategy and the achievement of the system research.

In order to promote the logistics industry carbon emissions, carbon footprint management to provide operational guidelines for implementation of logistics enterprises, from the carbon emission control, demand of carbon emission reduction of logistics enterprises, three aspects of supply chain services in-depth research on driving factors of the carbon footprint of the management of logistics enterprises, "analysis of carbon footprint assessment standards" for the lack of logistics enterprises emissions management.(Gao, T.et al 2013). Select the logistics business case study, pointed out its carbon footprint management improvement direction. Finally the carbon footprint of recommendations for the management of logistics enterprises in China, provides the reference for the "carbon emission reduction of logistics enterprises", helps to strengthen the competitiveness of enterprises in low carbon. (Huang, Hua. 2010.)

1.1 The research background

Green logistics are widespread concern in recent years and countries have made significant research. Its background research can be subdivided into theoretical background and practical background.

(1) Theoretical background

The concept of green logistics was suggested by the end of the last century. As the American and European countries do this study earlier compared to other countries, so research on Green logistics in Europe and America was deeper than other countries. In general, current research on green logistics focuses mainly in road freight energy consumption and CO^2 emissions. And for other modes of transport in the logistics process such as rail and water transport is rarely studied. In addition, the measuring data of energy consumption and CO^2 emissions in the green logistics warehousing sectors is not accurate or cannot even measure, there is a massive error about the quantitative research. In order to better and more effective to develop the green logistics and low-carbon logistics, it is necessary in order to conduct in-depth study on green logistics and carbon footprint.

(2) Practical background

From the ongoing development of the logistics industry, the logistics have largely contributed to the economic development of countries around the world. However, the development of the logistics industry is also double-edged sword, it also presents a certain degree of environmental pollution. Because the logistics process consumes a lot of energy, at the same time, it will draw up a lot of pollution gases such as CO^2 and so on. Years of research have proved that transport and storage in the logistics are the primary sources of greenhouse gases CO^2. Transport link includes general transportation, distribution, etc. While storage areas include storage, handling, transport, packaging and distribution processing. Data in Figure 1 is from EUROSTAT (Nikolas Geroliminis and Carlos F. Daganzo, 2005). This picture indicates the principal sources of CO^2 in the logistics process. And Decker (2011) made all aspects of energy consumption in the logistics and warehousing by investigating, as showed in Table 1:

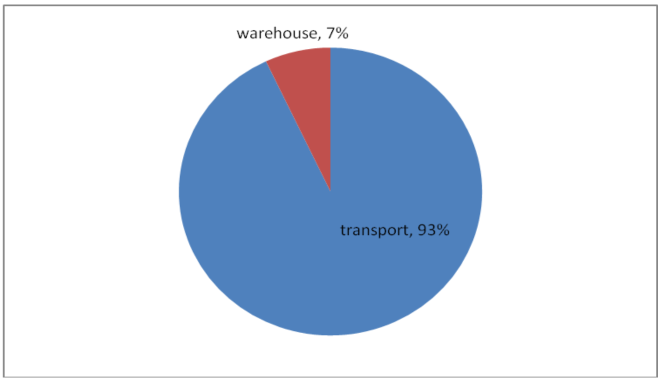

Figure 1 the main sources of CO^2 in the logistics process.

Table 1 all aspects of energy consumption in the logistics and warehousing

Types of energy	Illumination	Heating	Handling	Other
Proportion(%)	15%	35%	48%	2%

1.2 The concept and connotation of green logistics

With the economic development and social progress, human lifestyle have occurred huge changes. At the same time, human life had to face some global problems such as rapid population growth and progressive of nature technology and so on. These developments make human demand on natural resources and mining capacity gradually increase. In addition, the environmental awareness of human is still weak, a number of human activities have caused great damage on the ecological environment in recent years, and people are crazy of mining resources and consumption, so the environment is getting worse and slowly formed a greenhouse. Now the environmental volunteers coming from a number of countries have put forward the appeal of "green development". More attention to be paid of low-carbon living, green development, a "green revolution" has came into being (Li Hongyue，2007). Currently, all areas of the world is promoting a "green wave." for example “green food" "green industry", "green consumption" and so on. Modern logistics operations as an important part of merchandise trade; there are also the problems of energy-efficient, environmental protection and sustainable development. Then, the "green logistics" are increasingly attention and research.

1.2.1 The concept of green logistics

The goals of Green logistics are to "reduce environmental pollution and reduce resource consumption, advanced technology is used to planning and implementation of transportation, storage, handling, transport, distribution processing, distribution and packaging logistics activities".(Xie Sixin and Wang Yunfeng, 2010). "Green" in "green logistics" is the image of a particular language, neither will be green as synonymous of plants or agricultural products, also can't understand green as synonymous of pure natural, return to nature. The green in green wave refers to the ecological environment of protecting the earth activities, actions, plans and ideas embodied in economic activity. Specifically, the meaning of green here includes two aspects: one is to create and protect the harmonious ecological environment, reduce the utilization of resources, and ensure the sustainable development of human and economic; Second, on the basis of "red" ban, "yellow" warning shots, the practice of "green passage", using "green" permanently is scientific, normative and can guarantee the behavior of the passage.

Green logistics is a new concept and is put forward in the mid1990s, now there is no uniform definition. Different scholars on the concept of green logistics at home and abroad have different description.

H, J, Wu and S, Dunn (1995) believes the “green logistics is an environmentally responsible logistics system”. Green logistics includes both "from raw materials acquisition, product production, packaging, transportation, warehousing, until to the end user", it also includes the "waste recycling and disposal of reverse logistics".

Jean-Paul Rodriguez, Brian Slack and Claude Comtois (2013) think that the green logistics is compatibility with the environment and the "green logistics is an environmentally friendly and efficient logistics".

Study of Reverse Logistics Executive Council on the definition of green logistics is that: Green logistics is also known as "ecological logistics" and is the process of understanding and minimizing the ecological impact of logistics. RLEC also to compares the concept of green Logistics and Reverse Logistics, think that the Reverse Logistics refers to the goods and packaging materials from the consumer to the primary source of flow process, the purpose of flow is recovery value of goods or make its properly disposed. Visible, the reverse logistics is just one aspect of green logistics.

Published in Denmark by Bjorn N and Petersen Palle Petersen co-authored "Green Logistics" defined: the Green Logistics is ecological management (eco - management) of the Forward Logistics and Reverse Logistics.

China published in 2001 "logistics term" (GB/T 18354-2001), the definition of green logistics is that: "in the logistics process we inhibit logistics cause harm to the environment, at the same time, the implementation of the logistics environment purification, make full use of the logistics resources".

Compared with the traditional logistics, it is not difficult to find that the traditional logistics inefficient and does not care how to protection the environment, and the traditional logistics obtain economic benefits often at the cost of ecological damage. However, the concepts of green logistics are very different traditional logistics. Green Logistics focus from the perspective of sustainable economic and social development. They strive to achieve the development of the logistics industry and try to achieve the common development of the economy and the environment. In short, the development gradually changing the role of the logistics industry relations between economic development and logistics, the logistics effort to reduce pollution caused by the process of the ecological environment. This formed to promote the healthy development of the economy and consumer life modern logistics system. The development of modern logistics industry must be given priority to reduce the environmental pollution in the logistics process and improve the quality of the environment for human survival and development. Green Logistics came into being based on this.it is based on the "theory of sustainable development, ecological economics, ecological ethics theory, theory of internalization of external costs", as well as "logistics performance evaluation based on the theory of logistics".(Xi Zhang. 2010) Generally speaking, green logistics with features of resource conservation, low energy consumption, recyclable and so on. Here to the principle of sustainable development as the instruction, according to the connotation of modern logistics, gives the definition: Green logistics is "to reduce the pollutant emissions and resource consumption", through the new technology and oriented to the idea of environment management, and logistics system are planning, control, management and implementation process.

To sum up: Green Logistics is new multi-level concept, the Common levels of green logistics shown in Figure 2.The range of activities of green logistics also include a wide range of contents shown in Figure 3.The main drivers of green logistics development are that human consciousness to protect the environment is gradually awakening and the low-carbon economy concept is gaining in popularity. Coupled with governments and international organizations vigorously promote. The development of low-carbon in economy Economic and social, which is conducive "to reduce greenhouse gas emissions" (Ma A.J. et.al 2010) of the logistics industry and other areas, This is effective way to increase economic efficiency and control the greenhouse effect, All this can ensure sustainable social development (Wong Xingang, Jiang Xu. 2011). Nowadays, green logistics and low-carbon logistics have become an important link between the economic, social, and environmental. According to the survey, t transportation of he logistics has become the second major source of carbon emissions, second only to thermoelectric.

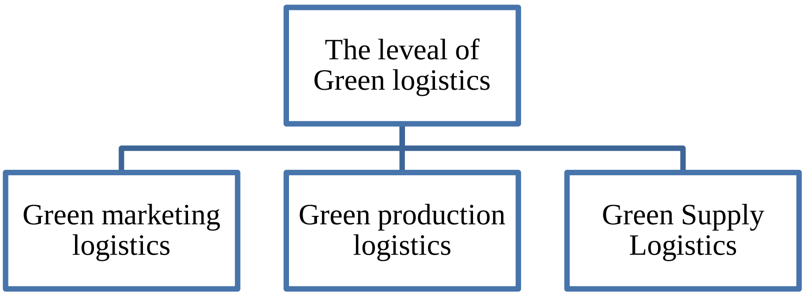

Figure 2 Commonlevelsof green logistics (Guoyi, Xiu, and Chen Xiaohua. 2011).

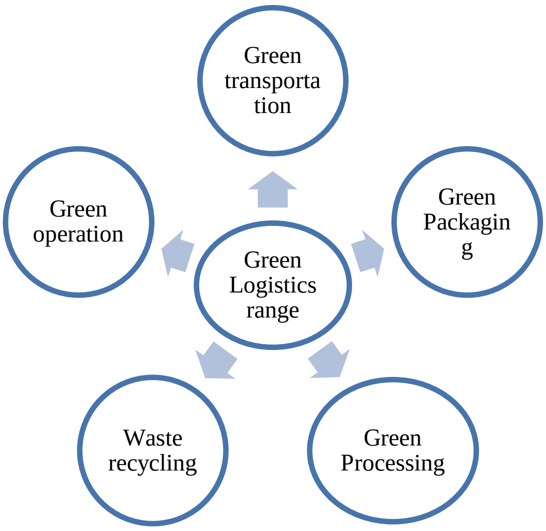

Figure 3 The range of activities of green logistics (Guoyi, Xiu, and Chen Xiaohua. (2011).

Due to the growth of the global logistics industry, it is in rapid development at the same time also brought enormous waste, some negative effects on the environment around, so the degree of environmental degradation. These waste phenomenon are due to the logistics concepts backward, lagging of management system, low degree of specialization of logistics, single technology, logistics management inefficiency, lack of scale effect, and the logistics cost control awareness is not high, the division of labor is unreasonable, the efficiency is low, etc. At the same time, the logistics directly caused great waste of resources waste, and it also has a great impact on the environment.

The waste is embodied in many aspects in the process of logistics. For example:

(1) Logistics waste directly cause the waste of resources

Highway freight is lack of reasonable logistics organizations so empty rate remains at around 50% for many years. Unreasonable freight network and distribution center bayoneted to roundabout transport goods. This can increase the vehicle fuel consumption. So, waste logistics directly cause the waste of resources.

(2) Waste logistics impact on the environment

Transportation is the most main and basic logistics activities. It is also the most serious aspects of the job in the logistics. Traffic transport emissions damage roads around the plant, bring the air pollution, noise pollution and so on, increased the ecological imbalance. In transport business activities, we are dispatching goods, many did not arrive directly, but entered the transit warehouse, the result is some unnecessary loading and unloading, handling, packaging, and the subsequent transportation link. What’s more, excessive packing wastes the resources, at the same time packaging materials are an important part of urban garbage, deal with these waste to spend a lot of manpower and financial resources. In the process of storage, there are a large number of inventories, the enterprise must be maintenance of the inventory, which is going to take some chemical methods, and this method will cause serious pollution to the surrounding ecological environment. Some of the backlog is inflammable, explosive, hazardous chemicals, because of improper safekeeping, it’s likely explosion or leakage, and this can cause serious pollution and destruction to the surrounding environment. At the same time, overproduction also produced a large number of wastes, these marginal waste hard concentration and effective reuse, so this causes the pollution of waste.

1.2.2 The connotation of green logistics

"All countries in the world are in efforts to the promotion of green logistics as the key point of the development of the logistics industry"(Liping Tang 2013), actively develop special skills to research of green logistics (such as the logistics system and logistics plan and decision of using small solution to environmental pollution as far as possible, such as emissions using small truck models, close range distribution, freight at night, in order to reduce traffic congestion, saving fuel and reducing emissions, etc.), Promote the extensive use of new materials and development, recycling logistics theory and practice research, and actively introduce "corresponding green logistics policies and regulations, and to lay a foundation for green logistics and sustainable development". The enterprise of United States, Germany, France and other countries in the process of the development of green logistics, the government's guidance and supervision plays an important role, the related laws and policies to be restriction and incentive. The U.S. government through the guidance and supervision means greatly improve the domestic enterprises of environmental protection consciousness. The reverse logistics system of United States, Britain, Japan and other countries are more perfect, this make return products, waste recycling products and packaging recycling, recycling obtain the larger income and benefits.

Green logistics is friendly to the ecological environment of logistics, also known as ecological logistics. The fundamental purpose is to reduce resource consumption and reduce the waste emissions. This is essentially the unification of the economic benefit, social benefit and environmental benefit. It is what the goals of sustainable development. As a result, the green logistics can be described as sustainable logistics.

Logistics product from the procurement of raw materials to the final consumer, to scrap the whole life cycle, could also have an effect on the environment. And green logistics includes both from raw materials acquisition, product production, packaging, transportation, distribution, until to the end user, it also includes the ecological management and planning of the goods and waste recovery reverse logistics process. Therefore, the scope of its activity includes products from production to scrap disposal of the entire life cycle.

Look from the green logistics management and control of the main body, the green logistics can be divided into social policy makers, enterprise management and operation management of green logistics activities, it also can saying green logistics layer macro, meson and micro layer. Among them, the main functions of social policy makers are spread by means of relevant policies and regulations of green concept, constraints, and enterprise logistics strategy. Enterprise layer task is that supply chain coordination, planning and management of enterprise green logistics system together, establish circular logistics system in favor of reusing resources. Operation management layer mainly refers to the green logistics operation links, such as transportation, green packing, green circulation processing of greening, etc.

1.3 Carbon emissions of logistics and supply chain

In modern society, the rapid development of the logistics plays an important role in economic activity. Logistics is now generally regarded as the logistics support system of modern society. Modern logistics have developed as a new emerging industry. Various countries around the world have given great attention to it as the "new economic growth point of profit."

Logistics process is a complex system, and the common modules of logistics system are shown in figure 4. Figure 4 show that the system of each module in the logistics process inevitably will emit greenhouse gases. Therefore, if the study of green logistics, it is necessary to measure the carbon emissions of all aspects of the logistics process of each module.

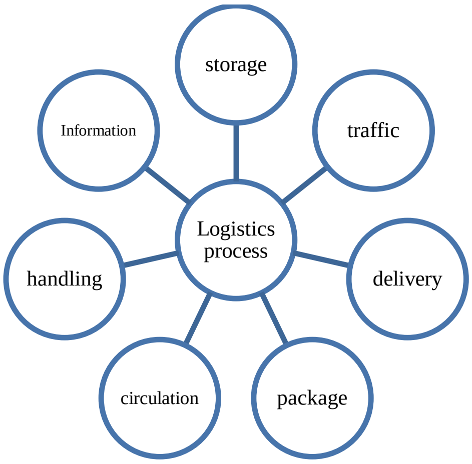

Figure 4 The common modules of logistics system.

Green Logistics includes aspects of "logistics operations and logistics management". Green logistics operations include "low-carbon transport, low carbon package, carbon distribution and processing". (De-ling, Zou, and Zhang Rong. 2011) And Logistics management process mainly save energy, improve the logistics system, promote reverse logistics system based on low-carbon supply chains. The main part of the Green Logistics is shown in figure 5.

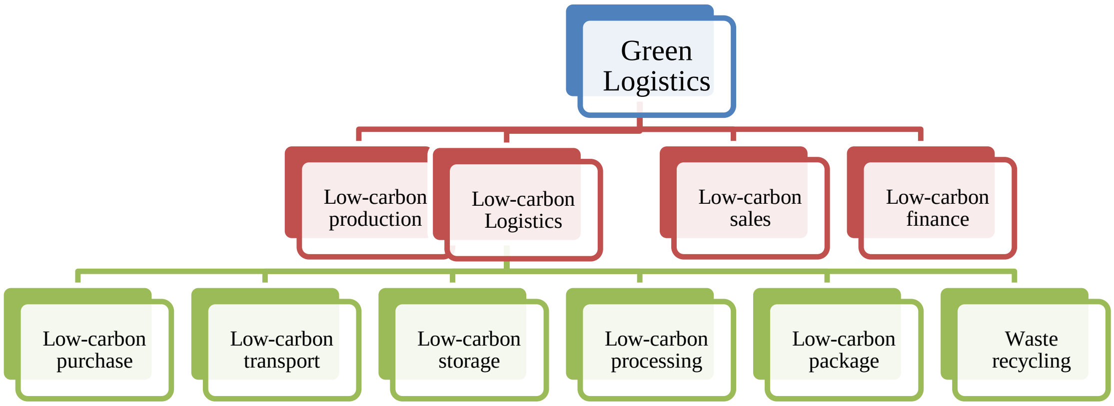

Figure 5 The main part of the Green Logistic (FJ.Hu XQ zhang and G Tian 2012).

(a) Low-carbon purchase

In the process of green logistics, the suppliers selected and raw material procurement is one of the factors affecting the entire carbon emissions of logistics. These can be a certain degree of reduction in carbon emissions in the logistics process and it is conducive to the realization of green logistics by optimizing the logistics procurement route and selecting the appropriate vendor (such as selecting simple packaging suppliers), etc.

(b) Low-carbon transport

Transportation is an essential part of the logistics. However, it is inevitable that the all means of transport produce exhaust gas. Since emissions during transport have always existed, so the whole logistics process main source of carbon emissions from transport. To achieve the goal of green logistics, we must be low-carbon logistics. Carbon logistics must be based on rational planning of logistics and transportation lines. Before transport and logistics, the transportation should be fully understood and transportation routes should be studied. So we can choose a rational and efficient transport routes and give full play to the advantages of using a variety of means of transport. We should continue to develop new energy transport, to encourage the use of cleaner fuels as power and energy, this can reduce carbon emissions and strive to green logistics.

(c) Low-carbon storage

In the process of logistics will produce large amounts of carbon emissions. Its main source comes from two aspects. On the one hand storage device at runtime would produce certain energy and produce carbon emissions. On the other hand, the products from the warehouse transportation to the destination process will produce carbon emissions. Therefore, the best selection of warehouse storage equipment should be low-power devices. In addition, the site warehouse must be careful, we have to go through the investigation of all aspects of analysis and choose the most help to reduce the cost of logistics and transport address.

(d) Low-carbon processing

The requirements of the entire green logistics process are to enhance awareness of low-carbon distribution processing such as selecting the device of less consumption energy; this will help to reduce carbon emissions.

(e) Low-carbon package

Product packaging should be as low-carbon environmentally friendly materials in the process of logistics, and we try to choose materials of high recycling utilization rate. Product packaging require simple and efficient, avoiding excessive packaging. Furthermore, we should enhance environmental awareness and pollute environment as little as possible.

(f)Waste recycling

Logistics process will inevitably produce a certain amount of waste. So, if you want to be green logistics and low-carbon logistics, you must pay attention to the logistics process waste recycling. At present, the relatively common method is to use reduction, reuse, recycle (3R) established the principle of "Resource - Production - Products - Resources" circular economy mode. Waste stream generated in the process, we collect them, species classification, reprocessing, recycling and other low-carbon logistics activities, can effectively improve the value of waste and reusability. This can reduce logistics costs, increases corporate profits, but also reduce carbon emissions.

1.4 Calculation and steps of carbon emissions in the process of logistics

Green Logistics research is required statistical analysis of the logistics process carbon emissions. The commonly used calculation of carbon emissions method is established appropriate mathematical model and calculated costs carbon emissions. Today the whole world on carbon emissions more mainstream accounting standards are PAS 2050 (2008) and ISO 14040/14044 (2006). Many of today's international logistics companies and other companies labeled with carbon footprint labels in the packaging of their products. These accounting standard transform the value of labels. Table 2 is the common International carbon footprint evaluation criteria and the implementation norms

Table 2. The common International carbon footprint evaluation criteria and the implementation norms

Promulgated time	Nation	Name
2008	Britain	PAS 2050:2008 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services
2009	Japan	JIS TS Q 0010:2009 General Principles For The Assessment And Labeling Of Carbon Footprint Of Products

Carbon footprint assessment includes goods and services. Evaluation of carbon footprint mostly use the British (BSI) published in 2008 as a basic standard PAS 2050 assessment. Evaluation method t is life cycle assessment (LCA).LCA consists mainly of four components, namely "Goal and Scope Definition，Inventory Analysis，Impact Assessment and Interpretation" (Standards China 1999). As shown in Figure 6.

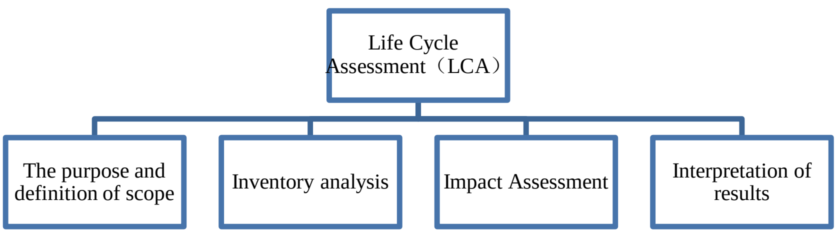

Figure 6 The four components of LCA

Step one: The purpose and definition of scope (Standards China 2000). The first step is the goal and scope of the LCA selected. This step is "inventory analysis, impact assessment and interpretation of fundamental" (R Charles & T Nemecek. 2002). The object selection is scientific and accurate will directly affect the entire evaluation work carried out and conclusions. In order to determine the scope of the study, we should consider the study of production systems, boundary conditions, assumptions and limitations. Therefore, the study scope direct affects the result depth, breadth and degree of difficulty. The boundary conditions should consider many factors. We need to ensure that all processes within the life cycle of the study within the boundary conditions of the system. As the evaluation method of LCA is calculated based on the quantitative data，description and measurement system must be based on a certain product functions as a standard. Therefore, the selected functional unit is very important. Functional unit is a benchmark and it is a measure of the production system. Its fundamental purpose is to provide a reference for the input and output, to ensure comparability of LCA results, easy to understand.

Step two: Inventory analysis. Inventory analysis is a form of expression LCA basic data. It is the foundation for life-cycle impact assessment. When you create a list, you need to establish with the corresponding input and outputting a range of systems for each component. After receiving a series of data, you need to analyze the list, process analysis is the evaluation of the object in the energy consumption throughout the life cycle of the various stages, a variety of gas, waste water, waste and other data for statistical analysis. The core of the analysis is to create an accurate inventory. It is worth mentioning that we need to repeat the calculations to ensure the accuracy of the results during the inventory analysis. Because the system in the analysis may appear to further in-depth understanding when obtained a number of data, we found that the limitations of the original data, then, it is necessary to adjust the analytical methods and procedures for data re-calculated. Of course, the situation will be encountered that the scope of activities for research purposes appropriate modified.

Step three: Impact Assessment. Impact assessment is an integral part of the life cycle assessment (LCA)(Standards China 2002). Its main purpose is to dig further study and depth analysis of the data of step two. We evaluate and characterize environmental factors by the qualitative and quantitative. This allows a more accurate description of the life cycle of the system of scientific material and energy exchange impact on the environment.

Step four: Interpretation of results (Standards China 2003). The main purpose is to summarize the description. The procedure analysis shows simplified summary for the first three phases of LCA, and shortcomings and limitations of the study are explained, moreover, the authors further suggest improvements they think are carried out and recommendations for subsequent reference of the study are provided. The results of LCA are emphasized so that purpose was easy to understand.

The evaluation method not only helps companies manage carbon emissions from a variety of products and services, but also helps companies find opportunities to reduce carbon emissions at all stages of product design, production, use, transport, etc. so that we can achieve the ultimate goal to produce a low-carbon products.

1.5 The research significance of Green Logistics

Logistics industry is in a period of rapid development, the logistics process not only large energy needs, but also large CO^2 emissions. In addition, the destruction of the human environment and global warming have become increasingly prominent, this requires the development of green logistics and low-carbon logistics. Now the

Logistics industry around the world at extensive development stage, there is much room for improvement about energy consumption and CO^2 emissions. However, at home and abroad for the majority of research in this area is still stuck at the stage of qualitative analysis, there is very little literature about energy consumption and CO^2 emissions of quantitative analysis. Significance of this study is to:

（1） Green Logistics research literature is summarized， and this can lay a foundation for the study of green logistics in this paper.

（2） Energy consumption and CO^2 calculation model is summarized, and this provide a reference for other scholars to conduct relevant research.

（3） Energy consumption of different modes of transport and CO^2 emissions are analyzed, providing a foundation for enterprises to choose mode of transport in the logistics.

（4） Combined with specific examples, LCA model is established and an analysis of the carbon footprint of the logistics process.

（5） Traffic flow theory is equipped to use and apply it on the green logistics network research.

(6) The research results can provide a reference for government and enterprises to Decision-making environment of the economy.

2 LITERATURE SURVEY

This paper mainly based on the theory research of green logistics focus on the micro and macro management, and stressed that the carbon footprint management. (LP Tang 2013)

2.1 Theory research progress of Green Logistics

The mid-1990s, HJ Wu & S. Dunn (1995) first proposed the concept of green logistics, they believe that the core of Green Logistics is that: Logistics processes are environmentally responsible, including procurement, logistics, production logistics and sales logistics are green, but should also include reverse logistics.

The related theory of green logistics can be roughly divided into two categories, one is green logistics macro-management policies and measures, and another is the optimization of micro-operations.

（1） The research progress of green logistics macro-management policies and measures

Green logistics is implemented first in Europe, and therefore in these regions of Europe estimates and reduce CO^2 emissions in the "logistics network with advanced ideas and experience". McKinnon &Piecyk (2009) summarized the development experience of UK road traffic and estimated the C02 emissions of road freight transport. They "analyzed the differences between the different sources of data" and gave several methods, providing a reference for modeling and analysis of green logistics.

South African scholar Marianne et al. (2010) pointed out that "with the development of society and economy", the amount of logistics transport increased, and transport energy consumption also increased a lot, so it will produce many adverse effects on the environment. The scholars summarized the experience of the European green logistics development, analyzed a series of energy-saving emission reduction policies adopted in Europe, what’s more, South African energy saving methods have been explored and proposed the development of green logistics road. Chinese Jiang Guoping, You Dapeng (2008) summarized the green logistics development and practice of successful experience of developed countries such as Japan, the U.S., Europe, etc. They proposed to promote green logistics legislation, improve green logistics standards, develop contingency plans, and adjust the industrial structure and a number of green logistics optimization recommendations.

The implementation of green logistics is mainly relying on green transport and green warehousing. About the area of green transport, Cadarso et al (2010) divided the influence of international freight on air pollution by industry, and responsibility is assigned to the consumer. The distance and mode of transport logistics process are regard as two key factors in carbon emissions, and input and output are analyzed. Combined input-output table data and C02 emissions data, the method is applied to the study of the Spanish economy. Matthew D. Step etc. (2009) used dynamic system tools (loop diagram), the impact of the transport sector's greenhouse gas emission reduction policies were quantitative analysis, including direct and indirect effects, as the decision making provided. Zhou Xinjun (2010) summarizes the characteristics of transportation overall energy consumption in logistics process, and several modes of transportation energy consumption are analyzed. He pointed out that in the next decade, the total energy consumption of China's logistics transportation will continue to increase, proposed that the development of green logistics and low-carbon logistics, it should be led by rail and to maximize the use of new energy instead of fuel.

About the area of green warehousing, Yu Chengxue, TanYiyan (2008) studied the global green logistics, analyzed defects and shortcomings at this stage of green logistics, constructed a composite entity green logistics integrated management model, this provides a reliable theoretical basis for the sustainable development of enterprises.

From a regional perspective, Kanaroglou & Buliung (2008) studied the Hamilton area of Canada, model has been established and they use an integrated model of urban land use and transportation, OD matrix of cargo transportation is established to study the effects of space trucking on distribution of CO^2 emissions. Zhou Ye et al (2011) establish CO^2 emissions measurement model of Chinese provincial logistics operations, carbon emissions from the provincial level of China's logistics operations were Measured and comparative analysis to identify the reasons for the gap, the aim is seeking to reduce carbon emissions within the province of the methods and strategies.

Energy consumption and CO^2 calculation method is the key research on green logistics and low-carbon logistics. Ericsson et al (2006) establish a model similar to a navigation system that provides real-time traffic information by detecting through "ArcGIS, ArcView and external network analysis", and select the optimal path to reduce CO2 emissions. What’s more, the system was tested on the basis of a large number of data and the actual transport modes combined with the road network Lund in Swiss. Zhang Ming (2009) based on the methods of Laspeyres complete decomposition and LMDI, he established energy consumption and energy intensity decomposition model, the CO^2 emissions of China 1991-2006 are studied, in addition, the CTEF model was established. Forecast and analysis of the energy consumption and CO^2 emissions can provide a reference for analysis of carbon emissions.

（2） The research progress of the optimization of micro-operations

Micro-operational level includes site selection, route optimization, recycling, green logistics of enterprise performance evaluation and so on.

About site selection, multi-objective planning method is applied by Quariguasi et al (2008) to establish logistics network model of sustainable development, balancing the benefits and impact on the environment, and the use of data envelopment analysis to estimate the efficiency of existing networks. (Tang, Christipher S., &Sean Zhou. 2012) The model was validated by an example of European paper industry. Irina et al (2009) on the location problem used multi-objective planning; logistics operations as another objective function affect the environmental costs. And he assumed that the environmental costs in logistics operations is far greater than the environmental costs of the process of distribution center operations

About route optimization, Ubeda et al (2011) studied the Spanish retailer Aiellschi. Green Logistics empirical research. He combined with the actual delivery route and assessed the impact of logistics operations on the environment. The lowest energy consumption and the shortest distance transport program is comparative analysis and some suggestions for the company's logistics solutions were provided. Andrew Palmer (2007) studies the problems of CO^2 emissions, the shortest path and the shortest time. Different levels of emission standards and different road, CO^2 emissions of different vehicles are considered. What’s more, he used Dijkstra algorithm to solve the model. Susan & Kumar (2009) pointed out that food transport, especially the transport of wine, usually have a relatively high-energy consumption. They use Cargo Scope software to analyze the delivery routes of California wine in the United States and calculate their energy consumption and CO^2 emissions. They found that energy consumption of different supply chain configurations and CO^2 emissions are very different, a difference of up to 80 times, and discussed the results of the wine distribution network strategy in such conditions.

Since 93% of the logistics network of CO^2 emissions comes from the transport process, only 7% from storage areas, so on the green warehousing research literature is very limited. Alan McKinnon (2010) is not only achieved low-carbon logistics activities from freight transport intensity, shipped with the conversion, “vehicle utilization, energy efficiency and carbon intensity”, but also studied the CO^2 emissions of warehousing activities.

Recycling Logistics is also an important part of Green Logistics. Abdelka&Rechard (2010) uses combinatorial optimization methods to study new areas of green logistics, including recycling, logistics, waste management, vehicle routing and scheduling problems. Samir K. Srivastava (2008) studied the recycling logistics network. The network includes collection centers and two different recycling equipment. They proposed a comprehensive overall conceptual framework to describe the model and optimization techniques together. The study was designed to provide a detailed logistics solutions and the model was validated by India as an example.

In the evaluation of green logistics, Yang Zhihua (2008) used the APH method and the weighted average method, and the use of dynamic DEA performance evaluation model to evaluate the extent of green logistics enterprises. In addition, Logistics enterprise performance evaluation system had been established.

2.2 The research status of Green Logistics

With the growing attention of green logistics, low-carbon logistics is proposed and has a certain degree of development. Now various countries around the world actively develop green logistics and low-carbon logistics, this has become the important way to deal with climate change and environmental protection. Many studies have demonstrated the importance of green logistics and low-carbon logistics in the logistics industry and environmental protection. There is a study have indicated that 14% of the world's carbon dioxide emissions per year comes from transportation (Stern N. 2006). Transportation is an indispensable part, so we can see the necessity of green logistics in low-carbon life. Studies have shown that transportation accounted for 14%. Meanwhile, according to a study conducted by the International Energy Agency (EIA), their reports statistics and analysis the global carbon emissions in 2007.The Carbon emissions accounted for the major proportion of the world total emissions were shown in Figure 7. As can be seen from Figure 7, the proportion of transportation in logistics is more than 20%, second only to thermoelectric, transportation has become the second largest source of carbon emissions. The meeting of the World Economic Forum in 2008,the Forum has a very broad impact papers report, titled "Global Risks 2008". The report clearly stated the supply chain and energy are two important issues in the world (World Economic Forum 2008).

In low carbon economy, logistics and supply chain management plays a pivotal role. For example: Researcher Li Shuxiang and Lu Xiaocheng (2010) pointed out by research: Facing the status of environmental pollution and global warming, the countries in the world if want to solve such problem of deteriorating living environment and achieve the strategic objectives of sustainable development, Present stage of logistics system must be improved, the development of green logistics, low-carbon logistics, We must develop green logistics and low-carbon logistics so as to achieve a healthy economic and social development. Dai Ding (2008) through the relevant data analyzed the green logistics and illustrated the position of green logistics, low-carbon logistics in the modern economy, moreover, he pointed out the low carbon economy needs to rely on the support of Green Logistics. Zhang Wei (2010) analyzed the characteristics of China's green logistics, he pointed out that green logistics is the only way to achieve the goal of a low carbon economy. Wang Lingyun combined the instance of logistics process, his analysis shows the necessity of the development of green logistics in today's society. And he pointed out the essential attributes of green logistics that is green logistics may be the most full and effective use of resources to provide economic benefits. Meanwhile, an example of port logistics was used to prove the integration and full use of logistics resources. The integration is one of the most effective ways to promote economic and social development; what’s more, this can helpful to achieve green logistics and low carbon logistics, which mentioned by Wang (2010).

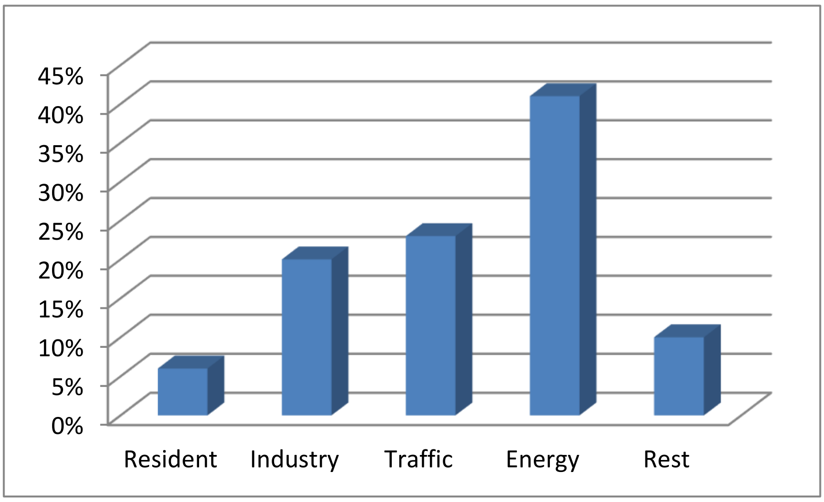

Figure 7 The major proportion of carbon emissions accounted for total global emissions

Earth's resources are limited, and the population increases every year so energy prices are raising, Meanwhile, the damage to the environment cause climate change. Therefore, in order to develop green logistics, we must think of ways to improve the energy efficiency of various logistics process. We can take a series of measures to achieve the low-carbon logistics such as efforts to reduce energy consumption per unit of carbon emissions. Low carbon logistics involving many objects is a complex system, so the study needs to track carbon footprint. (Hu, Fangjie, Xiaoqiang Zhang, and Gang Tian.2012) Green logistics needs from procurement, production, distribution, and consumer spending, and finally recycling and tracking the carbon footprint of the entire lifecycle process, it can control and reduce carbon emissions in energy consumption per unit of each process.

The measurement carbon emissions logistics process usually through carbon footprint. Greenhouse gas emissions can be used to characterize by the carbon footprint, emissions here means a direct and indirect greenhouse gas produced by human production and consumption behavior. Thus it is an important indicator of the logistics industry, and it usually used to evaluate the impact of greenhouse gas emissions on climate change. In the past many years, the study of the carbon footprint is mainly used in a variety of gases within the enterprise. However, with the progress of society and the global economy, carbon footprint study gradually applied to the entire supply chain. Especially since the green logistics, low-carbon logistics proposed, the rapid development of low-carbon footprint in logistics, the researchers coming from all over word studied low-carbon world from different angles logistics.

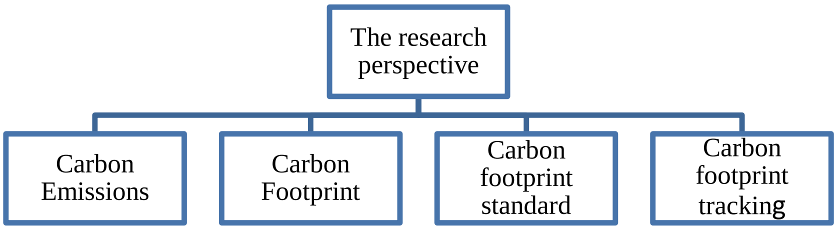

Figure 8 The major research perspective of low-carbon logistics

Among them, the study of the logistics supply chain, scholar Jonathan D. Linton (2007) pointed out that numerous aspects of logistics supply chain management operations would affect the environment. These aspects include the production, consumption, customer service, and recycle. Researchers Maja I. Picky (2010) modeled on the basis of existing research on logistics and management. During the transport vehicle, emission and fuel consumption are introduced into the logistics of carbon evaluation; he assessed the carbon dioxide emissions in the freight logistics and predictive analysis of the 2020 road transport logistics carbon footprint. Karen Butner (2008) through a series of studies pointed out logistics supply chain process needs to consider carbon management, the logistics supply chain products, information and working capital can take a series of measures to control. This can effectively control the balance of logistics costs and carbon emissions. The purpose cannot only promote the healthy development of the logistics supply chain efficiency, but also achieve a low-carbon logistics.

In terms of carbon footprint, Carbon Trust redefined carbon footprint. The report proposes carbon footprint as the total emissions of greenhouse gases within the scope of responsibility of the organization, and described the way by establishing a new business. Logistics process managed carbon emissions can increase profits and reduce the carbon footprint of its products (Carbon trust 2006).

In terms of carbon footprint labeling, many countries already have taken action research in the world. For example, the French government has enacted laws, and the legal requirements are that the sale of goods in the territory of France must be labeled with carbon footprint labels from 2011(Elgar Fleisch 2009). Meanwhile, carbon labeling of different commodities has a big difference which usually red, yellow, blue traffic light label shows the product's carbon (Upham P, Bleda M. 2009) In Germany, ten large enterprises including BASF, Henkel, Bayer has started in a small sample of the carbon footprint labeling experiments. In Japan, the Ministry of Economy (METI) has started efforts to require companies to conduct low-carbon production. Currently, Japan has reached an agreement with 30 cooperative enterprises to perform eco-product plans. In Korea the real level of carbon labeling of consumer goods has been carried out. In the UK, the largest retail supermarket Tesco has already set up a committee, the main duties of the committee is labeled carbon labeling on its stock units (SKUs) of all the goods (Alan C 2010). In China, the researcher of Huang Dalei (2009) pointed out that it is very important to control carbon emissions for carbon logistics, and using carbon footprint valued various business activities is essential with the development of society (Defra 2009).

In terms of carbon emissions tracking, a lot of researchers in the world have proposed to establish management systems (Enterprise Cloud Platform) in the enterprise. The company established the ECP system could produce a full range of product carbon footprint tracking. In this way, you can easily monitor the carbon footprint of the product in all aspects of logistics, meanwhile, because the carbon footprint track more comprehensive, so the data obtained are more convincing. Therefore, it is accurate analysis of carbon emissions footprint of the logistics process according to the data, so that we can analyze the causes and develop workable policies to reduce the carbon content of specific reasons. These can provide technical support for low-carbon logistics and green logistics development.

In terms of carbon standards, different countries have issued relevant standards. For example the world-famous of BSI organizations unite Kingdom's "Carbon Trust", several agencies jointly issued the "goods and services to assess the life cycle greenhouse gas emissions norms"(Defra 2009). In this standard, the evaluation of a carbon standard - Life cycle assessment methods have been proposed. This method through the establishment of appropriate mathematical models, the specific problems that difficult to measure are transformed, this allows quantitative evaluation and analysis of carbon emissions and logistics industry. Ultimately green logistics can reduce carbon emissions in the supply chain with the actual situation. A few years ago, the organizations of METI in Japan have developed standards for carbon labeling (Berry T, Crossly D, Jewell J 2008). Germany has recently been doing PCF project, one of its aims is to develop the basic principles of evaluation to measure the carbon footprint of product (THEMAI 2009). Global charity organization also promulgated the Carbon Standard such as World Business Council for Sustainable Development, World Resources Institute, and International Organization for Standardization etc.

In summary, in recent years, green logistics and low-carbon logistics is more attention around the world. Green Logistics has entered the research stage and achieved certain results. Now scholars generally believe that the research of green logistics and low-carbon logistics on carbon emissions is not a study of the logistics chain, it is necessary to study green logistics and supply chain as a whole, and many studies have demonstrated the correctness of this view. Moreover, many researchers around the world on green logistics pointed out that green logistics is the key and difficult to measure carbon emissions data and tracking. This is because the logistics process includes many links and affects by many external factors, which have increased carbon emissions data collected. There is also a characteristic of green logistics in the world that is many researchers research on technical aspects rather than assessing the level, for instance the related carbon logistics technology EPC and RHD. The purpose of these technical research aimed at invent a low-energy logistics equipment. This can be done green logistics and low-carbon logistics.

3 RESEARCH METHODS

This paper studies and tracks the carbon content in the process of green logistics, mainly using two methods, and established its corresponding model, which are based on the logistics process LCA's carbon footprint evaluation model and comprehensive logistics network model of CO^2 emissions.

3.1 The carbon footprint assessment of LCA

The basic steps of carbon footprint assessment:

a. Build process diagram.

The corresponding figure of assessment process is established including material flow, energy flow and the waste stream. Then the various factors that affect the process are analyzed and summarized. What's more, the actual content and operability are combined evaluation, so that we can confirm the selected product life cycle impact materials, activities and processes. Also, consider what type of object selected product met, belongs to B2C or B2B. Finally, a process diagram according to the life cycle stages is built.

B2C: Evaluation of content from the raw materials, process manufacturing, distribution and retail, to consumer use. And greenhouse gas emissions of full life cycle are evaluated. It contains the entire product life cycle, that is, "from cradle to grave". (Amy Ma, Monica English 2007) As shown in Figure 9,

B2B: The evaluated content include raw material production, and until the product reaches a new organization. It includes the distribution and transportation to the customer's location, the so-called "cradle-to-gate". As shown in Figure 10,

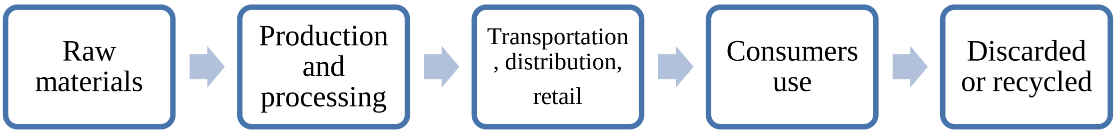

Figure 9 the processes of B2C

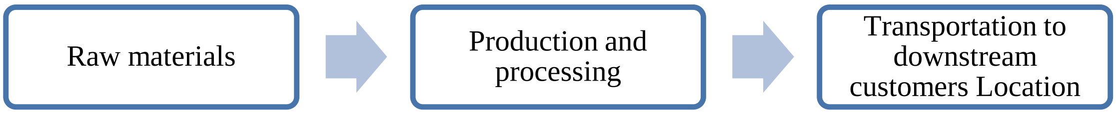

Figure 10 The Processes of B2B

b. Determine the boundaries and priorities.

The boundary system is consistent with its provisions according to the rules of ISO 14025. If the standard is not applicable to the evaluation object products, we can define the system boundaries according to standard principles.

c. Data collection.

Boundary conditions are refer, the activity data and emission factors for the various stages of the life cycle were collected and recorded

d. Calculate the carbon footprint

The carbon footprint of the various processes evaluation objects calculated according to the calculation equation during modeling to determine the carbon footprint calculation. For the accuracy of the calculation, we must comply with the principle of conservation of mass. And we should be careful "to ensure that all inputs, outputs and waste are included", (Ma, A.J., et. al. 2010) there is no omission.

e. Inspection uncertainty.

In order to understand the quality of the collected data and ensure the correctness of the results of evaluated, the results can test uncertainty.

The assessment process of Carbon footprint is shown in Figure 11.

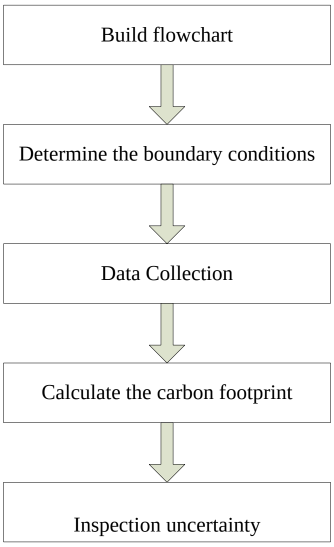

Figure 11 The assessment process of Carbon footprint

3.2 The comprehensive logistics network model of C02 emissions.

The model analyzes the energy consumption and CO^2 emissions of different transport modes freight turnover. Using SPSS statistical analysis software processes the measured data, and then consider the establishment of a comprehensive logistics network of CO^2 emissions assignment model. Finally, the results were by the model, and then the author provides guidance based on the results to promote green logistics development.

3.2.1 Analysis methods

Transportation includes road, rail, water, air and pipeline, but because of the special nature of aviation and pipeline transportation, in the study, these two modes of transport in comprehensive logistics network general does not consider.

(1) Road transport

Current international scholars in the calculation of CO^2 emissions of road freight have two main methods. One kind is based on the relevant data of Highway freight volume and energy consumption of road freight to calculate fuel consumed by Unit turnover, and then based on the CO^2 conversion rate of the corresponding fuel to derive the unit volume of CO^2 emissions. Another method is to test, that is the test of various types of vehicles, and calculation of the energy consumption of different types of CO^2 emissions in different situations. In China's various statistical yearbook, "transportation, storage and postal services' statistics as a whole, and not be subdivided, so we cannot get the amount of energy consumed by the various modes of transport respectively. Therefore, we use data test method.

According to the test program, we statistics curb weight, the total mass and overall fuel consumption of different types of vehicles. Curb weight refers to the condition of the car by the factory technical equipment complete (such as spare tire, tools, etc. installed in place), the weight of the various water fill up, that is vehicle weight； the total mass refers to the condition of the car fully equipped and accordance with the provisions passenger (including the driver and the weight of shipment).

The total mass of Truck= curb weight + the mass of truck driver and his assistant +the mass of logistics goods. As the quality of the driver and his assistant are very small with respect to baggage quality, so we can negligible and get:

The mass of Logistics cargo = total mass of truck - curb weight (1)

For trucks, the mass of the logistics goods mentioned here, which is the load of the vehicle, so the above equation can be transformed into:

Load = total mass - curb weight (2)

According to above formula, you can calculate the load of each vehicle. Then comprehensive fuel consumption divided by the load, you can get the fuel consumption per unit of cargo turnover (QQ Wei & SZ Zhao.2010):

$$F_u = \frac{C}{M} \quad (3)$$

Among them, F_u is the Fuel consumption of per unit cargo turnover, The unit is L t/km,

C comprehensive fuel consumption, the unit is L / km, *M* is a vehicle load, the unit is *t*.

Then we use fuel consumption and CO^2 emission factors to calculate the total amount of CO^2 emissions from fuels in road transport logistics process links.

(2) Rail and water transport

Logistics researchers analysis the energy consumption and C02 emissions during transport are mainly focus on road transport. (L Chen, ZF Yang B Chen. 2013)About rail and water transport have not only less research, but also statistical data in this area is very rare. This paper will combine some of the Statistical Yearbook and industry analysis reports to simple analysis these two modes transport.

CO2 volume of railway transportation unit cargo turnover can be expressed as:

$$Total\ carge\ turnover = \frac{CO_2\ emissions\ of\ electric\ locomotive + CO_2\ emissions\ of\ diesel\ locomotive}{Unit\ cargo\ turnover\ of\ electric\ locomoti\square e + Unit\ cargo\ turnover\ of\ diesel\ locomotive} = \rho_e \times CO_2\ emissions\ of\ unit\ cargo\ turnover\ of\ electric\ locomotives + \rho_d\ CO_2\ emissions\ of\ unit\ cargo\ \square urnover\ of diesel\ locomotives = \rho_e \times e_e + \rho_d \times e_e \quad (4)$$

Among them, ρ_e =(cargo turnover of electric locomotive) / (cargo turnover of electric locomotive+cargo turnover of diesel locomotive)

ρ_d = (Cargo turnover of diesel locomotive) / (cargo turnover of electric locomotive+cargo turnover of diesel locomotive) =1- ρ_e (5)

e_e is CO^2 emissions of unit cargo turnover of electric locomotive， e_d is CO_2 emissions of unit cargo turnover of diesel locomotive.

When we calculate the water transportation：

We use nautical conversion miles formula:

1 sea mile = 1.852 km

Thus you can figure out the logistics of the total energy consumption during the water transportation, and then combined with the energy of CO^2 emission factor, you can get the total CO^2 emissions from logistics water transportation process.

(3) Warehousing aspects

Sustainable technology of warehousing aspects includes micro and macro levels to achieve from three stages. Micro level includes energy, water, construction sites, etc., and then the macro level includes land, environmental and ecological aspects. Three stages of sustainable warehousing aspects are: a. The implementation of basic energy-saving measures in warehouse； b. The use of low-emission green energy； c. Establishment of sustainable warehouse.

The main use of warehousing aspects is to meet the conditions and requirements. Generally speaking, it can be divided into temperature, lighting and mechanical equipment energy consumption three aspects. Among them, the temperature is divided into two areas namely refrigeration and heating. Refrigeration mainly uses electricity, while the heating mainly uses oil and natural gas. Lighting is divided into outdoor and indoor lighting. The need for illumination intensity is different. Mechanical equipment includes forklifts and automated equipment. Forklifts is Divided two kinds, respectively internal combustion forklifts and forklift batteries forklifts. The energy of forklift engine is divided into diesel fuel and liquefied petroleum gas. The types and different energy consumption are shown in Table 3:

Table 3 the types and different energy consumption in warehousing aspects

The types		Energy Type	Influence factors
Temperature	Refrigeration	Electrical energy	Inventory temperature, building insulation levels, ventilation
	Heating	Petroleum Natural gas	
Lighting	Outdoor	Electrical energy	Intensity needs

	Indoor		Intensity，area
Mechanical equipment	Internal combustion forklifts	Diesel oil Liquefied petroleum	The amount of work, the number of jobs, energy efficiency
	Batteries forklifts	Electrical energy	
	Automation Equipment	Electrical energy	

1. Temperature

The heating methods of warehousing sectors in the logistics are mainly heating oil or natural gas, and refrigeration mainly uses electricity. Energy consumption is mainly determined by two factors:

a.The temperature of storage items required, which requires the storage temperature be adjusted to ensure a minimum temperature or the highest temperature level, and control of relative humidity.

b.Background temperature (that is comprehensive temperature) of inside the space requirements, which is related the strength of the staff engaged and workplace.

Other factors affecting the energy storage include overall thermal mass of the building, the nature of the building material, level of insulation, wind, sunlight, and the length of the heating and cooling period, the volume of the building, and the heat releasing device. Because the larger the building, the more the thermal energy released, the less energy consumption per unit area, the heat loss caused by the wall will be relatively small. Generally, reducing indoor target temperature can affect energy consumption and temperature decrease 1℃ can save 10% of energy consumption. Therefore, the temperature settings for each work area are very important. The area of logistics order picking requires 19 ℃.And the storage area of large capacity is 10 ℃ enough.

When the temperature inside the building meets the requirements, how to maintain the temperature level is related ventilation. Ventilation use air changes of per hour to represent. All buildings must ensure a good working environment and storage environment through ventilation. High air conversion rate is also more energy (Carbon Trust, 2002b, 2006a). Ventilation frequency directly affected by the level of ventilation. General structural defects or improper maintenance generates this condition, but quantity and type of door and door opening time can also cause. Hot air rises, cold air sink cause air convection, so that the air stratified, which is caused the high ventilation rate of all buildings.

The amount of energy consumption depends on the size and the temperature requirements of each zone. In large area, or the area with fast stream and lower limit temperature, the pipeline is the most efficient heating. Although bio-energy and cogeneration systems is the future trend of development, but the hating petroleum or natural gas is still used. If the area is small, suspended heaters or beam heating equipment is used, is also driven by the oil or natural gas. Because the heater does not heat tube, so its efficiency can reach 100%. However, due to the accumulation of by-products, so it only applies to large construction. Pipeline heating efficiency can reach 90%, and it is suitable for large buildings with the air less flow. Radiant heating equipment has less efficient and it can only reach about 50%.But the device have good results at a high rate of air exchange areas such as in the doorway, and high operator comfort requirements(Carbon Trust， 2002b).

Assumptions are that the required storage temperature is t0, the actual temperature of storage is t, the warehouse area is S, the energy consumption of 1 ℃ temperature decrease per unit area is m1; energy efficient of refrigeration process is e1. Then the energy consumption of the cooling process is calculated as follows:

$$M_{cold} = m_1 S(t - t_0) \times e_1 \tag{6}$$

The petroleum consumption of 1 ℃ temperature rise per unit area is m2; the consumption of natural gas is m3. The oil and gas energy efficiency of cooling process are e2, e3. The energy consumption of heating process is calculated as follows:

$$M_{heat} = \binom{m_2 S(t_0 - t) \times e_2}{m_3 S(t_0 - t) \times e_3} \tag{7}$$

In summary, the energy consumption of the logistics warehouse thermostat operation as follows:

$$M_a = \sum_{m_i} \sum_{e_j} m_i \; S|t - t_0| \, e_j \, \gamma \tag{8}$$

Among them：I=1，2，3；*j*=1，2，3，when *i*=*j*， γ=1，when *i* is not equal *j*，γ =0.

2. Lighting

For logistics warehouse lighting, its functional role, cost, energy consumption and emissions are directly to consider in warehouse management. We can comprehensive utilization the methods of simply management, a simple control, a clear performance standards demand and computing power per unit area (W/m^2). Total energy consumption of annual can easily be calculated according to the area and operating time. According Powerboss Elumacal culations, a high-pressure sodium lamp of 400W produces 1.69 tons CO^2 emissions a year (Wyatt, 2007). Therefore, lighting is essential to the energy saving of warehouse.

Lighting units is Lux. Operating time of lighting devices are affected by the dome light direction, sunshine duration, building height and width of the corridor. Parameters of the lighting units are shown in Table 4 (Carbon Trust, 2002b):

Table 4 the light level reference of shelves warehouse area in logistics process open

General warehouse lighting conditions		Electricity demand per unit area(W/m^2)	
Generally open area lighting		300Lux 5~6	500Lux 8~10
Loading width and height data			
Corridor width (m)	Vertical height (m)	150Lux	300Lux
1.2	4.5	8	14
2.4	6.5	8	16
3.0	8.0	9	17

According to the data on the table, we can see the power demand of per unit area in an open area is proportional to the lighting intensity. Open area is S_1 and the desired illumination intensity is x_1, the energy consumed in time T_1 can be roughly represented by the following formula:

$$E_1 = S_1 \times x_1 \times \frac{10}{500} T_1 = \frac{x_1 S_1 T_1}{50} \tag{9}$$

The electricity demand of unit area in logistics warehouse indoor is that:

$$x_2 = 0.333 y_1 + 0.4 y_2 + 0.049 y_3 \tag{10}$$

Among that, the electricity demand of warehouse indoor unit area is represented by x_2, the corridor width is represented by y_1, the vertical height is represented by y_2, the needs of lighting intensity is represented by y_3. And the power consumption of the warehouse area S2 in the time T2 is E2, that is:

$$E_2 = x_2 \times S_2 \times T_2 = (0.333 y_1 + 0.4 y_2 + 0.049 y_3) \times S_2 T_2 \quad (11)$$

The total energy consumption of warehouses for lighting are shown below:

$$E_b = E_1 + E_2 = \frac{x_1 X_1 T_1}{50} + (0.333 y_1 + 0.4 y_2 + 0.049 y_3) \times S_2 T_2 \quad (12)$$

3. Mechanical equipment

In order to achieve fast and efficient transfer 0f freight in logistics process. It will be used in all sorts of handling equipment. A simple non-automated warehouse will be used forklift truck for loading and unloading, as well as other tools to move goods. Other types of forklift truck include the reach truck, which is used to pile high. Picking and other labor-intensive jobs will use marking trucks, order pickers, and simple belt. If the logistics have higher yields, more product categories, as well as greater work intensity, you need to rail tunnel type exercise machine, sorting conveyor, layered picking machines, A-shaped robot (Baker, 2006). The following analysis is mainly about truck.

When you select mechanical equipment, the type of fuel is not first considered. We should take into account many other factors, including: the type of access (roadway width, shelf height), the operating environment is open or closed， and weight distribution (in order to ensure the stability of the truck, you need a heavier weight trucks).Although the balance forklift can choose a variety of fuels, but the warehouse area is restricted because it held low and have wider radius of gyration. Balance forklift is mainly used for receiving and shipping areas in logistics process, these areas are not flat surface or open. Because the balance forklift is mainly used outdoors, so you can choose LPG forklift or battery forklift. In order to adapt different operating requirements of the entire warehouse, it is mainly using battery forklift, including reach trucks, narrow path forklifts and order pickers forklifts.

For automation equipment, its energy consumption is mainly concerned with power and operating time, namely:

$$E_3 = 0.4Pt \tag{13}$$

In which: E3 represents energy consumption of automation equipment, P represents the power of automation equipment, and t represents its operating time.

The forklift is divided battery forklift and internal combustion engine forklift, and battery forklift use electrical energy. Internal combustion engine forklift can be divided into diesel forklift and liquefied petroleum gas forklift. From the above paper we can see that the battery forklift mainly for indoor use, and the Internal combustion engine forklift mainly use for outdoors. As the forklift activity is complex, involving loading and unloading, so it is not directly calculate energy consumption. However, the energy consumption of forklift is mainly related to the amount of work, so it can be transformed, we can see it as a function of the goods weight, namely:

$$E_4 = Km \tag{14}$$

In which, E_4 is the energy consumption of forklift, m is the weight of the goods. And k is a constant, which is mainly related with energy efficient, transport horizontal distance, the vertical height of handling. Its value can work through statistical analysis of the warehouse daily jobs.

3.2.2 Data sources

(1) Highway

Fuel consumption of transport in logistics process can access relevant information. Department of Transportation Motor Transport saving technology service center in accordance with the 2009 "road transport vehicle fuel consumption testing and supervision and management measures" tested various models of cars. And test results are published at http://atestsc.mot.gov.cn/pub/index.html. It includes a comprehensive automobile fuel consumption, fuel consumption of 50km/h constant speed, as well as fuel consumption at different speed and gear.

This paper selects test results of 400 kinds of different models to analyze. In which 243 kinds are heavy vehicles, including Stake truck, frontal, postal vehicles, trucks and dump trucks. 19 kinds are medium-sized vehicles, including stake truck, trucks and dump trucks.138 kinds are light vehicles, including stake truck, refrigerated trucks, light trucks, frontal and trucks. Part vehicle type and energy consumption in the road transport logistics are shown in Table 5. Tanker truck, concrete mixer truck, water truck, chemical liquid truck, etc. Due to the special nature of their delivery, this paper will not be considered. In addition, because the carload data cannot get, tractors, tractor-trailer, container semi-trailer tractor is not considered.

Table 5 Part vehicle type and energy consumption in the road transport logistics

Product Model	Product Name	Curb weight(Kg)	Total mass(kg)	Loads	Fuel L/100Km	The fuel 50Km/h(L/100Km)	Car stalls
LST3250Z	Dump Car	12380	25000	12620	23.1	17.6	9
13100D47J7	Cargo Car	14400	31000	16600	31.8	21.5	9
SXQ5120CYS	Stake truck	6180	12365	6185	21.3	14.7	6
SXQ3140G	Tipper	6650	13550	6900	21.7	14.2	5
CQZ5044XL	Car	2762	4420	1658	11.1	8.0	5
CA5042XXB	Container wagon	2150	3965	1815	11.2	7.4	5

(2)Rail and water transport

Railway traffic data in the logistics process derived from <China Statistical Yearbook> of "transportation, storage and postal services". For rail transport, the paper will count the number of steam, diesel and electric locomotives based on the year of China's major railway locomotives ownership. Meanwhile, the power source of electric locomotives can compute through the "balance of power" in the “China Energy Statistical Yearbook”(NBS. 2011). The energy consumption and C02 emissions of rail freight can be roughly calculated combined with "national rail transport technical and economic indicators “in the "China Statistical Yearbook 2011" 16-23.As the waterway is diesel powered, so the combination of C02 diesel conversion rate, you can get CO_2 emissions of cargo turnover in water transport (CCTA 2009).

（3） CO_2 conversion rate of different fuel

The logistics process have different modes of transport, so fuel use are not the same, which need to consider the CO_2 conversion rate of different fuel. For example, water transport includes inland waterways, coastal shipping and ocean-going vessels. These are the use of diesel as power source. Road transport also use diesel, and road passenger transport generally use gasoline. Type of fuel used in rail transport is not the same according to the different types of locomotives, steam locomotives mainly use coal-fired, diesel locomotives mainly use diesel. But the power source for electric locomotive power. The specific fuel consumption of different modes transport are shown in Table 6:

Table 6 Structural compositions and fuel consumption of logistics transport system

Logistics major categories	Main transportation	Fuel type
Aviation	Common aircraft	Aviation kerosene
Water transport	Various vessels	Diesel fuel
High road	Diesel, petrol vehicles	Diesel, petrol
Railway	Diesel, electric locomotives	Coal, diesel, electric

"2006 IPCC Guidelines for National Greenhouse Gas Inventories" and "China Energy Statistical Yearbook 2009" were used by Zhou Ye et al (2011). Authors use CO2 emission coefficients = CO2 emission factor x the heat of average position / $1x10^9$. And the authors summarize the C02 emission coefficients of different energy, as shown in Table 7.

Table 7 CO2 emission coefficients of different energy

Energy type	CO2 conversion rate(Kg/Kg)	Energy type	CO2conversion rate(Kg/Kg)
Crude	3.0651	The briquette	2.5685
Gasoline	2.9848	The coke	3.0425
Kerosene	3.0795	Coal tar	2.6997
Diesel fuel	3.1605	Liquefied petroleum	3.1663
Fuel Oil	3.2366	Refinery gas	2.6528

Other oil products	3.0651	Natural gas	2.1840
Raw coal	2.0553	Coke oven gas	0.7705
Washed coal	2.4921	Other gas	0.7359
Other coal washing	0.7911	Energy	0.9439(Kg/kwh)

4 RESULTS

4.1 Examples of the logistics process modeling and analysis based on LCA's carbon footprint

One example is China Shenghua Chemical Co., Ltd. Hebei Province. The Company produced PVC products in 2009 and modeled analysis of carbon emissions in logistics process. The goal of the evaluation is to study the carbon green logistics life cycle. We assess the company's PVC products energy consumption and greenhouse gas emissions by quantifying, so that we can provide a reference for the company to achieve green logistics。

4.1.1 Build flowchart

The examples flowchart in this paper is shown in Figure 12.

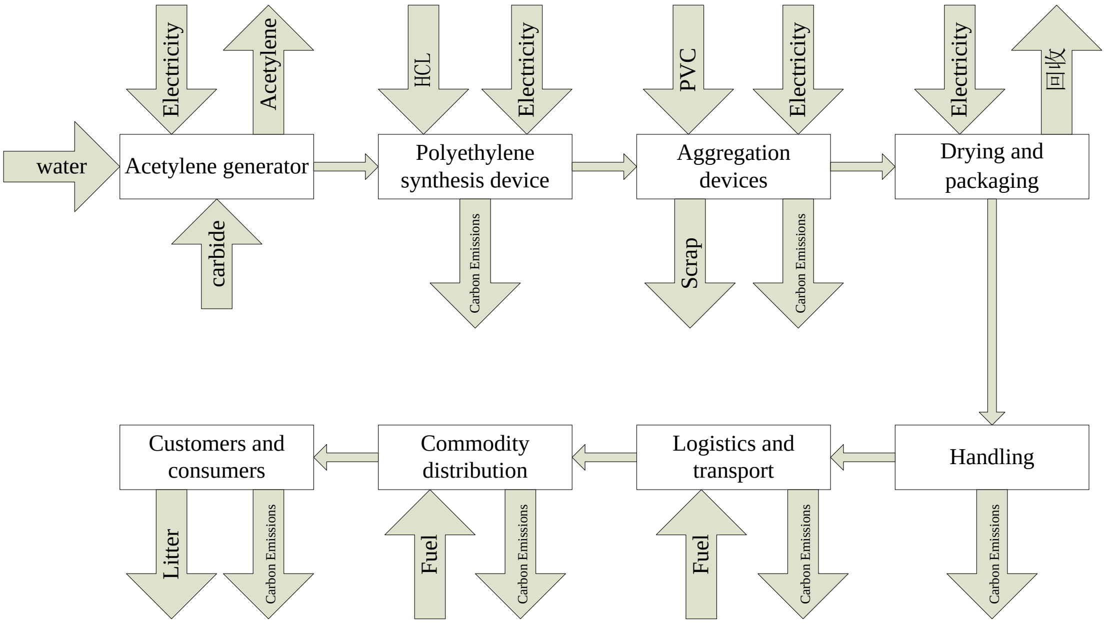

Figure 12 The green logistics process diagram of Shenghua Chemical Co., Ltd. PVC products

4.1.2 Determine the boundary conditions.

Production and logistics processes of the company's PVC products determine the boundary conditions. Figure 13 shows the boundary conditions determined. In order to facilitate the subsequent measurement and analysis of the elements carbon, the selected object of study materials only consider calcium carbide and lignite. Due to the entire life cycle have a lot of aspects generate carbon emissions, so we focus on the process of transport carbon emissions.

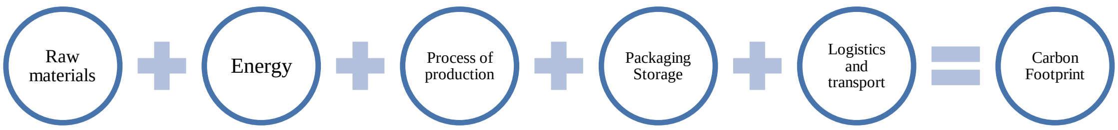

Figure 13 Boundary conditions

4.1.3 Data collection.

Carbon footprint of the logistics process throughout the life cycle was analyzed. We find ways to measure two types of data: namely, activity data and emission factor data (Ma.A.J. et al. 2010). Activity data refers to the data measured in the process of production and logistics operation. Activity data mainly include the production of power source such as raw coal, heavy oil, and spontaneous and purchased electricity. It also includes sources of raw materials logistics products, such as calcium carbide, HCL, deionized water and desalination of water. The missing values of the provisions IPCC referred to as emission factors. Table 8 shows the level of logistics and transport activities table.

Table 8 Logistics and transport activity table

Logistics and transport	Total transport /t.km	CO_2equivalent emission factor/t	Emissions of CO2 equivalent/t
Coal transportation	100077000	5.1925x10-5/t.km	5196.631
Product transport	142668585.7	6.3862x10-5/t.km	7408.138
Total CO2 emission/t		12604.769	

In order to facilitate the calculation and subsequent data analysis, you must also know the energy consumption level of activity (shown in Table 9) and raw material consumption levels of activity (shown in Table 10)

Table 9 the activity level of Energy consumption

Energy species	Constituent	Consumption quantity	Emission Factor	GWP	CO2 equivalent/t
Coal fuel(/t)	CO_2	333590	0.101kg/MJ	1	421157.380
	CH_4	333590	$1.0x10^{6}$kg/MJ	25	104.247
	N_2O	333590	$1.5x10^{6}$kg/MJ	298	1863.934
	Coal	333590	0.144t/t	1	48170.396
Diesel fuel(/L)	CO_2	1876443.8	2.76kg/L	1	5178984.9
	CH_4	1876443.8	$1.1x10^{4}$kg/L	25	5207.131
	N_2O	1876443.8	$2.2x10^{5}$kg/L	298	12357.88
Heavy oil(/t)	CO_2	22.543	2.76t/t	1	62.21868
	CH_4	22.543	$1.1x10^{-4}$t/t	25	0.063684
	N_2O	22.543	$2.2x10^{-4}$/t	298	0.151823
Frozen oil(/t)	CO_2	13.6	2.76t/t	1	37.666
electricity (/kW. h)	CO_2	15409360	1.0069kg/kW. H	1	15515.684
The total amount of CO2 equivalent/t	5683461.652				

Table 10 the activity level of Raw material consumption

Substance	Consumption of raw materials(/t)	CO2 equivalent emission factor/t	Emissions of CO2 equivalent/t
Calcium carbide($CaC_2$80%)	1548866	1.412	218670.961
Deionized water	225400	4.125	929.775
HCL	75073	1.603	120341.506
Desalinated water	173674	4.125	716.405
Running water	7989	0.91	2.71
Acid with tap water	18173	0.91	16.532
Total CO2 emissions		340677.889	

4.1.4 Calculate the carbon footprint.

Under normal circumstances, the carbon footprint = dynamic data (quality / capacity / kWh / km × carbon emission factor (CO2 / unit).

Specifically, carbon footprint calculation and statistics composed of the following steps:

(1) A series of activities data measured multiplied corresponding emission factors (GHG emissions per unit), the basic formula is as follows:

GHG emissions=the activity data x Emission factor (15)

(2)GHG emissions calculated in the first step will be multiplied by corresponding GWP values. Thus, GHG emissions can be converted to CO2 equivalent emissions.
(3)Product-related effects of carbon storage logistics process should be expressed in the form of carbon equivalent. Amount of CO2 stored in the logistics life cycle can also be calculated by the method d of step (2).

(4)The calculation results of logistics process are summed to obtain the corresponding functional units of carbon dioxide equivalent. Then all aspects of carbon dioxide equivalent value are compared and you can clear the logistics process which part of CO2 emissions is more. So you can accurately determine the environmental pollution, which occurs mainly in the logistics. Therefore， we can look for the causes of pollution and develop a viable countermeasure to reduce carbon emissions and achieve green logistics.

The total amount of CO2 emissions in logistics transportation process are calculated in accordance with the following formula:

$$Logistic\ tansportation\ capacity = \frac{Tools\ amount\ of\ freight\ rail \times railway\ mileage}{Max(tools\ amount\ of\ freight\ rail \times railway\ mileage)} \times Rail\ freight + \frac{Tools\ amount\ of\ road\ freight \times Highway\ mileage}{Max(Tools\ amount\ of\ road\ freight \times Highway\ mileage)} \times Road\ freight \quad (16)$$

$$Logistic\ tansportation\ turnover = \frac{Tools\ amount\ of\ freight\ rail \times railway\ mileage}{Max(Tools\ amount\ of\ freight\ rail \times Railway\ mileage)} \times Railway\ turnover + \frac{Tools\ amount\ of\ road\ freight \times highway\ mileage}{\max(Tools\ amount\ of\ road\ freight \times Hightway\ mileage)} \times highway\ turnover \quad \textbf{(17)}$$

It can be calculated the total traffic volume in accordance with the above two equations and then multiplied by the carbon emission factor, you can get the sum of carbon emissions within the logistics of the life cycle. (Ma.A.J. et al. 2010)

Carbon emissions of raw materials and product processing stages are the initial session of life-cycle assessment in logistics. (Ma.A.J. et al. 2010)
Carbon emissions can be calculated according to the emission factors (IPCC 2007). Emission factors of various materials are shown below in Table 11.

Table 11 The emission factors of raw emissions CO2, CH4, N2O

Name of raw materials	Name of greenhouse gases	Emission Factor
Coal fuel	CO_2	2.53kg/L
	CH_4	$2.68x10^{-5}$kg/L
	N_2O	$4.02x10^{-5}$kg/L
Heavy oil	CO_2	2.76kg/L
	CH_4	$1.13x10^{-4}$ kg/L
	N_2O	$2.26x10^{-4}$ kg/L
Diesel fuel	CO_2	2.76 kg/L
	CH_4	$1.11x10^{-4}$ kg/L
	N_2O	$2.21x10^{-4}$ kg/L

Different greenhouse gases have different effects on the environment. Therefore, the warming trend of different gases has some differences. In order to study the sensitivity of the life cycle of green logistics CO2 emissions and the CO2, the warming trend of different greenhouse gases needs to be known (Xiu, Guoyi, and Xiaohua Chen.2012). The warming potential of different greenhouse gases is shown in table 12. (Stojanović, Djurdjica and Veličković, Marko.2012) The relation consumption and carbon emissions in North China are that electricity consumption per 1KW.h; CO2 equivalent emissions are about 1.0069kg(UNFCCC 2009).

Table 12 The Warming potential of different greenhouse gases (IPCC.2007)

Name of the gas	Chemical formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

The above data is calculated in accordance with the formula (11):

$$E_i = A_i \times EF_i \tag{18}$$

In the formula,$E_i$is the carbon dioxide emissions of i-th part in the carbon green logistics life cycle;A_i is i-th level of activity part in the carbon green logistics life cycle (Such as logistics and transport fuel consumption, raw material consumption, etc.). $EF_i$is the emission factor of i-th part in the carbon green logistics life cycle. That is carbon dioxide emissions per unit of fuel. Because many types of fuel, such as coal, electricity, oil, so the unit emission factors are also different.

The total CO2 equivalent emissions are calculated according to the formula (18):

$$E = \sum_i A_i \times EF_i \tag{19}$$

Methane and nitrogen oxides are also produced in the carbon green logistics life cycle. Equivalent emissions are calculated according to the formula (13):

$$E_{ij} = A_{ij} \times EF_{ij} \times GWP_j \tag{20}$$

In the formula,$A_{ij}$is i part and the j-kind activity levels of greenhouse gases in the carbon green logistics life cycle (for example transport fuel consumption, the production process of coal consumption, etc.). $E_{ij}$is i part and the j-kind greenhouse gases emissions in the carbon green logistics life cycle.$EF_{ij}$is the emission factor of the i part and the j greenhouse gases. When the fuel is not the same, emission factors have different units. $GWPj$ is j-kind of warming potential of greenhouse gases.

Total equivalent carbon dioxide emissions are calculated according to the formula (14):

$$E = \sum_i \sum_j A_{ij} \times EF_{ij} \times GWP_j \tag{21}$$

Based on the above analysis shows, CO2 emissions from the annual logistics life cycle can be calculated as 7039588.68t.Total production of PVC products required logistics are 108638.75t.Comparative analysis can be seen that logistics and raw materials activities are the main part the carbon emissions produced, accounting for the total carbon dioxide emissions by 92.1% and 6.4%, respectively.

The carbon footprint assessment of product in the carbon green logistics life cycle conducted uncertainty analysis. The main source of uncertainty is the use of secondary data in the calculation process, and some of the data is taken from the literature. With the advancement of technology, the means of measurement have improved and some data can be more accurate. In the use of LCA model to evaluate, we calculated the actual issues appropriate simplification in order to facilitate subsequent analysis, such as methane and nitrous oxide, the amount of production in the logistics and other parts of links generated very little, so we ignored them. Methods of reducing the uncertainty are that using a higher accuracy rate primary data instead of secondary data; each procedure are tracked on-line monitoring of energy consumption so that we can improve the accuracy of primary data.

In summary, the analysis results based on the calculation of carbon emissions can be used to propose some suggestions on the development of green logistics. (CL.Rong. 2011)

a. Strength the construction of green logistics network infrastructure. (CL.Rong. 2011) Since carbon emissions mainly produce from vehicle emissions during transportation in the logistics, so the rational development of transport infrastructure such as roads, railways, waterways, shipping, pipelines, etc., those can provide the necessary conditions for the optimization of logistics routes and promote the rapid development of green logistics.

b． Develop means of transport logistics with new energy. The existing transport with high-energy consumption and high pollution are carried out with the replacement. Eco-friendly new energy vehicles or other means of transport should be chosen as much as possible.

c. Changing concept, step up publicity efforts and improve people's awareness of green logistics. Green Logistics improve recognition and influence in social life, and logistics management is strengthened. A complete framework for the development of green logistics is constructed.

d. Introduced a series of policies to provide policy environment for green logistics. Because green logistics is an emerging industry, so the government needs to conduct a series of policies to promote and support the development of green logistics. For example, the existing logistics management system is reformed. In order to provide the greatest degree of green logistics efficiency, the government should guide and break the limitations of the logistics industry in different regions, sectors and industries.

e. Develop green logistics technology. Green Logistics performance mainly in the field of logistics comprehensive development of green logistics technology, including standardized technology, information and communication technologies, new materials technology, biotechnology, environmental technology, security and defense technology, monitoring technology, preservation technology, a variety of waste disposal and waste utilization technology, special techniques of the logistics function, quality management and process reengineering and so on. Advanced technology is an important pillar of green logistics. Therefore, the need to vigorously develop green logistics technology, and actively absorb advanced technology. (LP. Tang. 2013)

4.2 Examples of the logistics process modeling about the comprehensive logistics network

In order to more accurately analyze CO2 in logistics process, we can use hyper graph decomposition method, and the comprehensive logistics network is converted to general plane of the network. Then logistics network model with CO2 emissions flow is established and use the Frank-wolf algorithms to solve the problem. (Li.XW 2012)

This can track the process of carbon, and provide feasible suggestions for green logistics.

4.2.1 The comprehensive logistics network concepts and features

Green comprehensive logistics network by definition is the logistics network includes a variety of modes of transport, advanced technology constituted by the various modes of transport, and the logistics system with network layout and logical structure. Comprehensive logistics network includes road, rail, air, waterways and pipelines, etc.; it can be more comprehensive understanding of carbon emissions. Since the special nature of air transport and pipeline transport, this paper would not be considered.

Compared with a single logistics network, comprehensive logistics network has the following characters:

(1) Comprehensive logistics network contain many modes of transport. Mutual coordination between different modes of transport, and cooperate with each other in ensuring the quality of service, at the same time reducing costs. This can reduce costs and achieve low carbon environmental protection objectives.

(2) Comprehensive logistics network contains a finite number of transport hubs. Transportation hub is in the intersection of several modes of transport or several transportation routes, and can handle a variety of complex technical equipment. Under normal circumstances, the constituent elements of transport hub include stations, ports, airports and various transport routes, libraries, courts and facilities such as the handling of transport, codec, repair, maintenance, security, navigation and supplies, etc.

(3) Road sections between two adjacent nodes are not unique. In consideration of the various modes of transport. Road sections between two adjacent nodes are not unique in transport networks. For example, between two points can be simultaneously used road transport and rail transport, and between this two points have two different Road sections, so the number of Road sections between two points is 2. In the conventional literature of path selection or optimization, the Road sections between two adjacent nodes are unique, so a two-dimensional graphic can be described. In Comprehensive Transportation network, the original two-dimensional graphics has not representation its network structure, so it is necessary to use a three-dimensional "super network."

4.2.2 Construction of the carbon footprint management model of logistics enterprise

According to the operation characteristics of logistics enterprises, with reference to the "2006 IPCC guidelines for national greenhouse gas inventories", (IPCC.2004) on the basis of ate greenhouse gas accounting system of the World Resources Institute compiled: "enterprise accounting and reporting standards", "greenhouse gas accounting: Accounting and reporting system of value chain enterprise standard", construct the logistics enterprise management models such as carbon footprint shown in figure 1. It consists of determining the carbon footprint management objectives; define the logistics company logistics enterprise organization and operational boundaries, part of the selection of carbon emission calculation approach

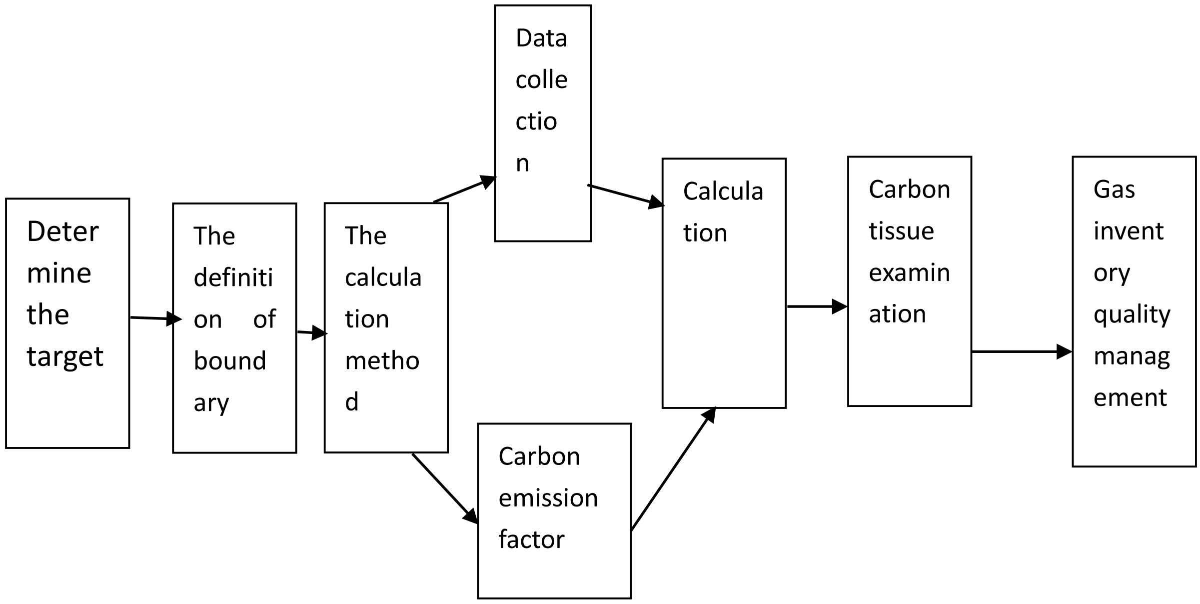

Figure 14 carbon footprint management models of logistics enterprise

4.2.2.1 Different goods

For different goods of different metamorphic rate, because the assumption here is the same price, as can be seen from the graph, the lower the rate of deterioration of the goods, the basic profit and considering a carbon cost profit two maximum profit than the deterioration rate high goods to high. When the deterioration rate is lower than 0.55, the carbon profits has become negative, and the deterioration rate is less than 0.7, does not consider the basic profit carbon has become negative, therefore, the deterioration rate high goods should be formulated by higher prices, thereby increasing its profit. For example, if the market demand of constant, the deterioration rate is 0.3 of the goods with the deterioration rate compared to 0.2 of the goods, the price should be at least increased 5% and 10.1% respectively, in order to obtain and the deterioration rate is the basic profit 0.2 of the goods are the same and carbon containing profit.

4.2.2.2 The same goods

For the same goods, the use of cold chain reasonable and perfect with room temperature chain can reduce the deterioration rate compared to the goods. From the chart analysis and in front of the knowable, unchanged in the market price of the circumstances, reduce the spoilage of goods rate can increase corporate profits can also reduce carbon emissions, through the cold chain here, the use of cold chain is a kind of economical and environmental behavior. For example, when the goods deterioration rate reduced from 0.3 to 0.2, the basic profit and carbon containing profits were increased by 20.11 RMB and 23.30 RMB, while the carbon 70.37g reduce footprint.

Due to the use of cold chain need to invest in the relevant facilities and equipment's, compared with not using cold chain, the cost will be increased. Considering the cold chain equipment cost change, for cold storage of 20 cubic meters, the cost is about 20000 RMB, daily consumption of about 1 kWh. If 10 years of depreciation, the depreciation per day is about 5.48 RMB; the current general industrial enterprises in electricity price for an average of 0.6 RMB /kwh, charge of electricity every day is about 6 RMB; investment daily equipment costs 11.48 RMB. At this point, the basic profit and carbon containing profit still better than not using cold chain must be high. Therefore, in this example, for the same kind of perishable goods, should use cold chain.

4.2.2.3 Numerical calculation and discussion

For example, assume that the product purchase price is 2 RMB /kg, the sale price is 4 RMB/kg, replenishment cost of preparing K for 100 RMB, holding stock cost coefficient h is 0.2 RMB/kg day, the spoilage of goods rate of 6 for 0.3kg/kg/ days, the market demand rate is 100kg/ days.

The correlation coefficient of carbon emissions by fourth chapter calculated results. Carbon emission coefficients of fruit in the production process of unit product is 192 g/kg; transport by road long-distance transport data, unit weight of the products in the carbon emission coefficient per unit distance is 0.0818g/kg.km; weight per unit of storage products in the 0.2355g/ kg day coefficient of carbon emissions per unit of time; coefficient of carbon emissions of waste product of 41.21 g/kg. (Zhang Jun et al. 2011)

With the carbon footprint for a minimum of the objective function, compared with the basic maximum profit situation, the order cycle and order quantity increased significantly, respectively 3 times and 5 times of the original. Although the carbon footprint is reduced by 39.6%, but profits are also significantly reduced, the basic profit and consider carbon profits has been negative, decreased respectively 2.4 and 3.1 times. Visible, in some cases, to consider only the least carbon footprint is unrealistic, although from the environmental point of view is the best policy, but to the enterprises to increase the heavy economic burden, or even negative profit. Therefore, the carbon emissions equivalent to a part of the cost of the calculation is more reasonable and feasible.

Consider the cost of carbon emissions when compared with the maximum profit, the basic maximum profit situation, the order cycle and order quantity is slightly larger, basic profit decreased 0.6%, and consider the costs of carbon profits increased by 0.9% and carbon footprint by 5%. This strategy is more reasonable than only considering the carbon footprint of the case, considering only the basic profit situation should be comprehensive, not only to reduce carbon emissions, but also has less impact on profits, to balance the two aspects of economic and environmental benefits.

It can be seen that if a carbon tax, while the enterprise is still in the primitive does not consider the strategy of operation costs of carbon emissions, will lead to corporate profits decline, at this time, the enterprise should change strategy, will reduce carbon emissions into the optimization of the business operations

4.2.3 Functional elements of the green logistics system

Logistics system is composed of the functional elements of different function; different elements may belong to different enterprises, located in different geographical location, subject to different policies and regulations. Therefore, a green logistics system corresponding is with different classification methods. The following will be in accordance with the functions of different elements and different behavior subjects to explore the composition of the green logistics system. A mode of transportation, the environment but, due to its unique flexibility, convenience, has become indispensable in the logistics transportation, and is getting more and more important of transport mode.

The so-called green transportation, means to save energy, reduce exhaust emissions characteristics of transportation, green transportation is an important content of green logistics. According to the characteristics of influence of transport links to the environment, the key principle of the green transport is to reduce the truck in the path of the total mileage. There is several of green transportation way around this principle.

The environmentally friendly means of transport, mainly for freight cars, using energy-saving type or to clean fuel powered automobile. The green logistics network is necessary, which is the most reasonable logistics transportation network with the shortest distance, in order to reduce the invalid transport. The green transportation organization mode, refers to the city of freight system, through the innovation of organization pattern, reduce truck dispatched times, mileage, turnover etc.

Approach to green circulation-processing implementation of the two:

With the scale of operation mode to improve the efficiency of resource use; and the waste logistics smooth docking, reduce waste pollution and waste pollution in logistics process.

4.2.3.1 The processing of green flow

Distribution processing has strong production characteristics, the impact on the environment mainly displays in: the dispersion of low energy utilization rate of circulation process, produce leftover materials, emissions, waste pollution to the surrounding environment, and may produce two pollution etc. In the final analysis, there is two key reasons for the flow of processing affect the environment: one is dispersed; two is the distribution processing center location is not reasonable. In order to solve the two problems to find solutions is relatively easy, it can be said that, the processing flow of green is circulation.

4.2.3.2 The behavior subject of green logistics

From the goals of the logistics system, green logistics is a new logistics form, new connotation embodied in the stressed from the contribution of logistics to economic efficiency of enterprises and the role in promoting the national economy, logistics and logistics decision to emphasize the full impact on business and society, including the staff education and training, sales / service, occupational health and safety, environmental and ecological problems.

4.2.4 Logistics system based on circulation mode of operation of the supply chain

With the improvement of living standards, people are spending more and the pursuit of individuality, diversity, resulting in faster product replacement. This generated a lot of production - a lot of circulation - mass consumption - the inevitable result of a lot of waste, and thus will lead to deterioration of the depletion of natural resources and social resources. Therefore, to build a green logistics system, not only to consider a single enterprise logistics system, it must also be coordinated with those associated with the supply chain, from the field of view of the entire supply chain to organize logistics, and ultimately established, including manufacturers, wholesalers, retail and consumers, including the production - circulation - Consumer - reuse.

4.2.4.1 Circular Economy

For a long period of time, human society almost all the attention placed on the development of material production, ignoring the harmonious coexistence of man and nature, ignoring the existence of resources and environmental values, ignoring the efficient use of resources and the environment protection, forming a simple pursuit of economic growth, development model; and the product during processing and use of large quantities of waste discharged into the natural environment of the human being to survive. As the human population and material consumption demand uncontrolled growth defect of this model of economic development is undoubtedly exposed, such as energy, mining, water resources lack medical, environmental hazards practices occur frequently, a large area of forest and grassland degradation, soil erosion and desertification, ozone depletion and the greenhouse effect, etc.; in short supply and tend to cause depletion of natural resources, but also lead to reduced capacity of the natural environment consumptive pollutants, rapid deterioration of environmental quality; natural resources will eventually lead to the destruction and environmental regeneration system the serious imbalance, so that human survival and development of the troubled and difficult to sustain.

For environmental pollution after the "end of pipe" there are many limitations, it is impossible to avoid the occurrence of contamination fundamentally; environmental market by the "end of pipe" is formed to produce a false, non-benign economic benefits; "the end of treatment "to enable enterprises to comply with environmental regulations, rather than just be satisfied with R & D investment in new technology, less pollution, and increased reliance of developing countries in terms of environmental governance in developed countries, hindering these countries directly into more modern economic way.

In the above context, the source of prevention and the whole process of governance instead of the end of the treatment, to become truly mainstream national environmental and development policies, "the circular economy" has become a strategy. Its purpose is to protect the mouth of “increasingly scarce environmental resources, improve the efficiency of environmental resources”. (Li Ming 2010) Circular economy requires all areas of human production and consumption can make the best use, without causing harm to the environment, circular economy is the traditional industrial economy to a sustainable economy provides a new theoretical paradigm, but also for green logistics system the establishment and operation provides another theoretical basis.

4.2.4.2 Cycle logistics system

For the concept of recycle logistic, there is no single definition. Protection of the environment, sustainable development of maintaining the environment is the fundamental objective of recycling economy; conserve resources and energy, reduce waste emissions is the essence of circular economy. According to this understanding, the so-called "loop logistics" is material and its accompanying information on the spatial coordinates and time coordinates of the raw material manufacturers, product manufacturers, wholesalers, retailers and flows back and forth between the user; in this species circulating in the material flow and information flow through the node, the path linkages and interaction mode and so the overall logistics system is composed of circulation; the target of cycle logistics system is resource consumption and energy consumption minimum quantified.

To understand the concept of recycling logistics system can be analyzed from two aspects of logistics objects and logistics channels.

① Logistics object of loop logistics system

There are two Cycle logistics system "item": First, consumers need items; the second is the consumer unnecessary items. The former includes the necessary raw materials, components, semi-finished products, packaging materials of goods; the latter include various derivatives formed during the logistics, such as damaged goods caused by logistics activities, returned goods, waste packaging, logistics process produces waste gas, solid waste, waste material deterioration, traffic congestion and so on. As the cycle logistics system must be optimized considering this flow, flow, flow routes of two logistics objects.

4.2.4.3 The basic principle

Conserve resources, reduce waste emissions in different ways, according to the value of the size of the resource recycling and recycling process of secondary effects on the environment of the extent of the basic principles of the recycle stream is Reduction, Reuse and Recycle, namely 3R principles. The importance of the three principles of logistics systems for recycling is different.

Minimization principle is to use the least amount of raw material and energy inputs to achieve the intended purpose of the production or consumption purposes, namely the principle of shrinking resources. By reducing the flow into the production process and, of substance consumption sectors, it could also reduce the amount of forward logistics and waste flow; therefore, resource reduction is the most effective way to solve environmental problems.

"Resource reduction" principle embodied in production, is to ask the volume of product miniaturization and light weight of the product, product packaging, simplified or even zero packaging, so as to reduce resource consumption, waste reduction goal. Reducing the amount of raw materials for each product design can save factory and manufacturing processes to improve resources and reduce emissions; for example, light metal car saves resources but also saves energy and still meet consumer safety standards on a variety of cars. Shrinking resources also include the use of environment-oriented product design methods, such as design for disassembly, recycling-oriented design, etc., sufficient consideration in the design phase of new products in the disassembly and re-use of components removed after product obsolescence problems, will make it easier to recycle the resources.

4.2.4.4 The empirical analysis

Carbon footprint is the total volume of a product or service in the whole life cycle emissions of carbon dioxide and other greenhouse gases.(The guardian. 2014) "Carbon" consumed much, the cause of "global warming carbon dioxide" also made many, "carbon footprint" is big, and the "carbon footprint" is small.

At present, calculating product carbon footprint mainly use of the product life cycle assessment method, namely LCA (Life Cycle Assessment), the main basis for calculation of PAS2050 o PAS2050 by the British Standards Institution, the Carbon Trust and the British environment, food and rural affairs ministry issued, provide the basis for the enterprise the carbon footprint of its products and services calculation. PAS2050 includes the product life cycle from raw material procurement, production, and use to scrap the whole process of carbon emission calculation.

Specification for the assessment of the life cycle greenhouse gas emissions of goods and services is an independent standard. (Carbon Trust. UK) The standard is used to calculate the products and service in the whole life cycle (from raw materials acquisition, production, distribution, use and waste after treatment) greenhouse gas emissions. The purpose is to help enterprises in the management of their own production of greenhouse gas emissions by the formation process and look for the reduction of greenhouse gas emissions in the product design, production and supply in the process of opportunity. Carbon dioxide emissions and it will help the enterprise to reduce the product or service, and ultimately developed new products of smaller carbon footprint.

From the above the green agricultural product logistics financial support status analysis can be seen, the financial institutions to credit support for less, but with the banking financial institutions in the city financial market competition more and more fierce, further deepening the rural finance, government policy to tilt three agricultural, logistics the third profit source of temptation. The banking system credit funds flows to the inevitable products of green logistics. Because of the role of market mechanism, financial institutions credit support will be far greater than the policy financial support; and because the green logistics of agricultural products to enterprises are mostly small and medium sized enterprises.

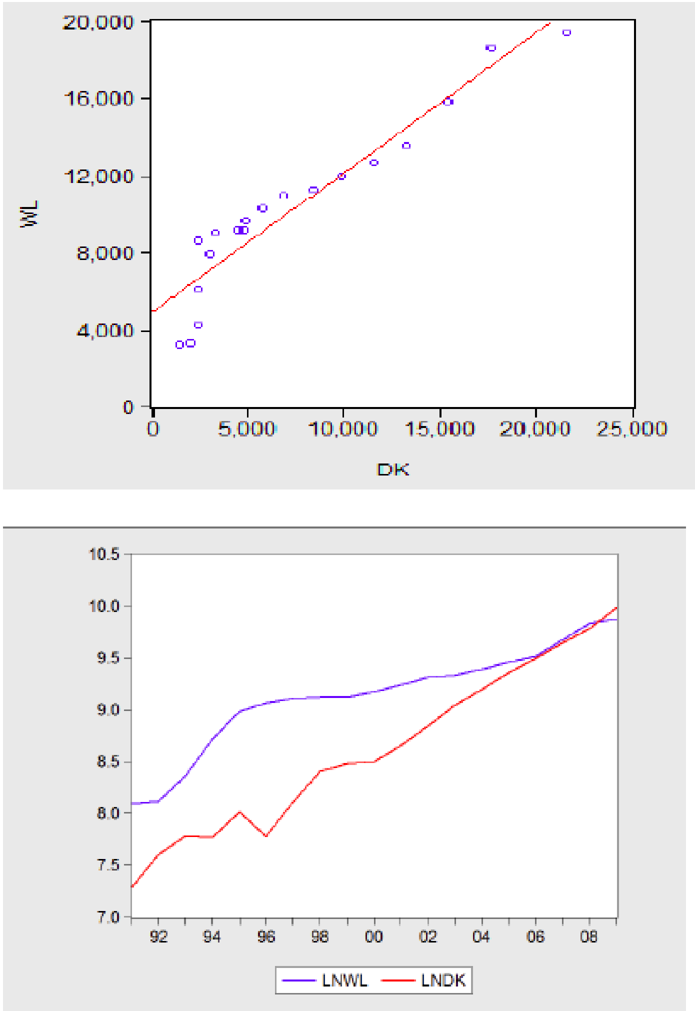

Figure 15 The green agricultural product logistics financial support status analysis

4.2.4.5 Integration test

After the ADF unit root test, the original sequence that LNWL and LNDK are non-stationary series, and first difference sequences of DLNWL and DLNDK is stable, can determine the LNWL and LNDK is a single whole sequence, satisfies the integration analysis. Figure 3-3 shows that LNWL and LNDK have approximately the same growth and change trend, in order to determine whether there is a long-term equilibrium relationship between green logistics of agricultural loans and agricultural products of financial institutions, we use EG integration test further explanation. EG two step test method is proposed by Engle and Grange, they think that if the linear combination of two or more than two of non-stationary time series can be composed of a stationary time series, then called the “non-stationary time series are cointegrated” (Chakrabarty et al.2012), the resulting stationary linear combination for the cointegration equation, can think the cointegration equation, shows that there is a long-term equilibrium relationship between these variables. First, the dependent variable in LNWL, with LNDK as the independent variable, the estimated regression model using ordinary least squares, we obtain the following results:

LNWL=0.578165LNDK+4.148886 (22)

(9.662680) (8.016769)

(DW=0.444859 F=93.36739 RZ=0.845969 modified R2=0.836908)

Autocorrelation test: n=19, k=1, take a significant level when the tables P=0.05, dL=1.180, dU=1.401, and 0<0.444859=DW<dL, so there is (are) autocorrelation. For the existence of a few order autocorrelation to determine, by BG test Display is shown in Figure 3-4, nR2=13.04795, critical probability P=0.0015, therefore the auxiliary regression model is significant, namely the existence Self-correlation. And since et_1, regression coefficient et_Z was not 0, explain the double logarithm model in the presence of one order and two order Self-correlation.

The model was corrected by Keao iterative method, the results are as following:

LNWL*=6.3930130+0.331014LNDK* (23)

(10.194/s) (4.818309)

Among them, RZ=0.978283, RZ -0.973271, DW=2.1700s9, F=19s.20090

Model (16) the inspection through the value of the residual sequence, estimation of the model of the E as shown in Figure 3-s, ADF unit root test of the residual sequence e, choose to have the test equation intercept, optimal lag variables are determined according to the A C and SC criteria Post number, results show that the ADF value of a 4.288ss7 less than 1% level of significance of the critical value of 3.9203s0, can be considered to estimate the residual sequence e as stationary sequence, indicating that LNWL* and LNDK* have cointegration relationship. So there is a long-term stable equilibrium relationship in the total amount of agricultural loans and agricultural financial institutions of green logistics, that is to say, in long-term, credit support has an obvious effect on the green logistics of agricultural products.

A modified ECM model

In 1978, Davidson, Hendry, Srba and Yeo proposed the error correction model (ECM: Error Correction Model) is the basic form, called the DHSY model. Error correction model to explain the dependent variable short-term fluctuations has been affected by the independent variable short-term fluctuations, on the other hand, depending on the ECM.

By a first-order autoregressive distributed lag model:

$$Yt = \beta_0 + \beta_1 X_t + \beta_2 Y_{t-1} + \beta_3 X_{t-1} + \varepsilon_t \qquad (24)$$

By (24) of the equation of deformation:

$$\nabla Y_t = \beta_0 + \beta_1 \nabla X_t + (\beta_2 - 1)\left(Y - \frac{\beta_1 + \beta_3}{1 - \beta_2} X\right)_{t-1} + \varepsilon_t \qquad (25)$$

Period fluctuations in the deviations from their long-run equilibrium relationship between the extents of, called balanced error.

Model (18) can be called

$$\nabla Y_t = \beta_0 + \beta_1 \nabla X_t + \lambda ecm_{t-1} + \varepsilon_t \tag{26}$$

By the regression equation (16) shows that the financial institutions of agricultural loans increased by 100000000 RMB, a total of 33100000 RMB to improve the logistics of agricultural products. The above analysis shows that there is a cointegration relationship between LNWL* and LNDK, it can establish the ECM model.

4.2.5 The definition of the organization boundary and operational boundaries

Logistics enterprises based on own or control the business determines the organizational boundary, so as to make clear what the logistics business included in the scope of greenhouse gas emissions in the enterprise. Logistics enterprise is the organization boundary spanning logistics enterprise group, including subsidiaries, independent legal entity. Operational boundaries for determining and distinguishing of logistics enterprises emissions range [[IS], including direct carbon emissions (range I), thermal power, indirect carbon emission (range 2) and other indirect emissions (range 3). Direct greenhouse gas emissions refer to hold or control of logistics enterprises boiler, vehicles, and circulation processing equipment to produce greenhouse gas emissions. Thermal power, indirect greenhouse gas emissions refer to the logistics enterprise procurement for lighting, heating, gas supply and refrigeration equipment required for thermal power, carbon emissions, it occurs in the electric power, heat production facilities. Other indirect emissions, refers to hold or control non logistics enterprise greenhouse gas emissions, such as enterprise required fuel refining and production and logistics enterprise employees to work, travel, logistics outsourcing, the subcontractor belongs to vehicle emissions of carbon. The 3 ranges provide a framework of carbon footprint management of logistics enterprise.

In order to facilitate the carbon footprint management, logistics enterprises will be sources of carbon emissions is divided into static combustion sources of carbon emissions, mobile combustion sources of carbon emissions, carbon emissions and non organized process source of carbon emissions (emissions of carbon emissions). The static combustion sources of carbon emissions, carbon emissions and combustion of fuel to produce internal logistics enterprises static equipment, such as boilers, generators and other [D] l. Mobile combustion sources of carbon emissions, vehicle transportation equipment logistics enterprise all control in cargo transport, handling and transportation process, logistics equipment used in fuel combustion produces carbon emissions. Technology of carbon emission source is to produce goods circulation processing or packaging process of carbon emissions. No tissue sources of carbon emissions, refers to the packaging of the goods produced by the intentional or unintentional leakage, wastewater treatment, natural gas processing facilities caused by carbon emissions.

4.2.6 Activity data collection and selection of carbon emission factor

Logistics enterprises according to the determined the organization and operation of collecting data, moving boundary static combustion data, process data and unorganized carbon emissions carbon emissions data, and select the corresponding emission factor. Data sources such as shown in table 1. Emission factor refers to the carbon emissions generated some energy burning or in the process of use. Our unpublished emission factor database can refer to "2006 IPCC guidelines for national greenhouse gas inventories"(IPCC. 2016) and American Environmental Protection Agency (USEPA) carbon emission factor data organization published. Logistics enterprises should choose the most close to the actual situation, the easiest to carbon emission factor, obtaining more accurate.

4.2.7 Carbon footprint calculation

Select the carbon footprint calculation method, collect activity data and emission factors after selection, calculation of summary data for carbon emissions and greenhouse gas emissions. Carbon footprint calculation need for the conversion of carbon dioxide equivalent. Method of logistics enterprise summary carbon emissions has focused method and dispersion method. Centralized method refers to the branch or throughout the facility to logistics enterprise top report fuel consumption, and then by the logistics enterprise calculated carbon emissions. Dispersion refers to each branch or throughout the facility were collected activity data, and then by the enterprise top approved calculated carbon emissions.

4.2.8 The carbon footprint of reporting and verification

Carbon footprint calculation is completed, making the emissions inventory report to the logistics enterprise, enterprise management, regulatory authorities or other stakeholders report. The contents of the report include the organization boundary, boundary, the operation of data collection and other information. Logistics enterprises can conduct its own assessment verification or entrust third party verification mechanism for verification, verification is a process of independent evaluation according to the agreed verification criteria and the formation of assessment files. The contents of verification: logistics enterprise profile, activity data, emission factor data source, and carbon emissions.

4.2.9 Greenhouse gas inventory quality management

Logistics enterprises should set up a carbon footprint management team, the formulation of greenhouse gas emission inventory quality management plan, ensure the collected activity data record accurate and reliable, complete; check the carbon emissions information carefully calculation process, conversion coefficient, emission factor choice is correct and reasonable, and the business data collection on whether there is a mistake; making file reports for safekeeping carbon footprint, and the establishment of management feedback mechanism. To achieve greenhouse gas emission inventory quality management system and program.

5 CONCLUSIONS

The carbon footprint of recommendations for the management of logistics enterprises in China

(1) The transformation of the mode of transport, the implementation of low carbon transportation. According to each driving ton kilometer carbon emission calculation, the carbon emissions of different modes of transport of different are necessary. Should reduce the highway transportation in logistics in sharing proportion, can satisfy the customer service needs of the premise, LTL road transport into the railway transport and short sea and land and sea transport way to reduce carbon emissions in logistics enterprises.

(2) To improve the logistics enterprises in “low carbon supply chain service”. (Li, Xinwu.2012) In order to reduce the carbon emissions of the enterprise value chain, the third party logistics enterprises should cooperate with the upper reaches of the consignor enterprise and customer, improve the loading and unloading process, optimization of transportation planning, formulate flexible best delivery time, reduce no-load phenomenon, avoid invalid and repeated traffic; the use of advanced green transportation technology and ‘clean energy vehicles, repair maintenance on a regular basis transport vehicle, improve vehicle efficiency, as same as reduce the carbon emission.

(3) The construction of low carbon logistics facilities, using low carbon logistics equipment. Encourage and support the logistics enterprises or logistics enterprises cooperation investment for the construction of low carbon logistics facilities, increase the logistics facilities renovation efforts; selection of low energy consumption of equipment, reducing electricity, heat and steam consumption. Construction of the

carbon footprint of the management information system and carbon emission monitoring system [] z o, realize the logistics enterprises in the carbon footprint of information collection, transmission, storage, monitoring and calculation. Monitoring and evaluation of logistics activity level of carbon emissions, and provide decision support for the carbon footprint of the management of logistics enterprises.

(4) The optimization of logistics service network. Logistics enterprises to build large, closed loop through the allocation of logistics service network, integration, and customer network cooperation network of route optimization of logistics nodes, ensure the seamless connection and efficient delivery operation. Maximize the use of direct delivery strategy, to reduce the number of ton kilometer of the vehicle, transportation routes optimization, especially shorten transit route for the transport of dangerous goods, not only can reduce carbon emissions, but also can reduce the risk of transportation way.

(5) To strengthen the recycling logistics management. Establishing a scientific and reasonable system of recycling of waste materials, recycling, reuse efforts to increase the logistics of waste equipment, to strengthen the recycling logistics management of logistics enterprise. Improve the logistics packaging design, insist on packaging reduction, reuse, and recycle principle.

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