Smart Systems and Green Energy (2018) 1: 1-14
Clausius Scientific Press, Canada

Research on the Energy-Saving and Reduce Emission of Logistics Park Based on Dynamic System

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Keywords: Logistics park, energy-saving, dynamic systematic, simulation

Abstract: There is a closer relationship and a complex system with the sustainable development of Logistics Park and region's economy, environment and resources. This report makes the energy-saving of Logistics Park as an entry point, as well as using systemic analysis and research on adopting dynamic system method for energy-saving system of logistics. First of all, from the macro view to contribute the energy-saving system and identify the factors and foundation of it, as well as analyze the effective connection of the relationship for the relevant cycle of logistics park system , energy consumption and environment. After that, put forward the relevant factors of the energy-saving and environment effect which belong to the working progress plan in logistics function park, through analyzes the output relationship in production progress. Consider the interactional with each factors and external environment affection, it set up the dynamic system mode which as the energy-saving goal includes environment subsystem of logistics part, demand subsystem for logistics, supply subsystem for logistics and energy consumption for logistics part. Then, the report collect plenty of data to simulation exam the system mode, study the effective of policy, technic and management factors to evident the system mode has advance simulate actual condition. Meanwhile, report combine with construction and actual operation for a multi-module transportation logistics park Sichuan. It utilizes a simulation for that logistics park energy-saving system and makes the compare the exam result and actual condition. Finally, based on the theory and simulation analysis, it put forwards suggestions to set up environment friendly logistics park. This report would to adopt several theory such as system engineering theory, relevant theory of industrial ecology and multi-objective planning to combine with case study to make the logistics plan as a research item, use the ecological and economic efficiency as the objective, systemic research the relationship of resources emission and logistics progress, recycle economy and direct action of logistics. These can provide new idea and theory basis for logistics system planning and construction.

1. Introduction

Logistics industry has a rapidly development than before relies on the global economy connection and prosperous to bring the demand sharply increase of it. The amount of legal units for China logistics enterprise is close to 0.3 million, the total value of annual social logistics is 2528 billion, according to the comparable price, it increased by 6.7 over the same period, until the last 2017. The achieving of logistics activities consume plenty of energy, it also cause the environment pollution. As a significant point of logistics system, logistics park response most of logistics activities, it is the storage, delivery and distribution processing, it operation needs consumption lots of energy. With the booming development of Logistics Park, the energy-saving and reduction emission of it becomes important focus item in current industry. This research makes a scientific analysis on energy-saving system, look forward to improve the logistics intensification level, decrease the energy consumption and pollution emission roads/path. This has a significant meaning to improve green and sustainable of logistics.

In the earlier of 21 century, many countries had discovered that environment issues come from logistics activities and developed serious studies. In the year 2001, Japan passed a ‘new comprehensive logistics outline’ which combined with national condition, it pointed that needs to adopt ‘centralization of circulation strongholds’ strategy. That is plan and contribute logistics distribution land at the suburb of city, ports and main transportation terminal region, to reduce the bother and harmful for environment and achieve the goal of green logistics. [1]Paul and Richard discussed the relationship between environment problem and logistics value chain. Their research displays packing material play a role in driving to reduce energy consumption and promoting material reuse thereby achieve green logistics.[2] Base on the management theory of green supply chain, Sheu carries out a multi-objective optimized method to solve the reverse logistics problem of nuclear-electric. According to the calculate result of mode, adopting this method can affect decrease cost and risk in supply chain environment.[3]Patroklos and Maria studied the role and affection of innovation of ecological technic behavior in the long term supply chain cycle, it utilizes dynamic system method to contribute closed supply chain cycle mode under the multi-environment system. [4]

In fact, the earlier for china focus on logistics and sustainable development problem is ‘Asia-Pacific International Logistics Conference’ which held in Beijing in June of 1997. Experts in conference put forward that logistics industry must treat the ‘sustainable development’ as the maximal profit principle and find its own development direction in the current world economy development. Guang-yin Xu et.al set up an index system which focus on road logistics energy consumption from several perspectives of environmental factors, resources factors, demand factors and use the gray connection analysis quantification to revel the influence factors on relevant economy factors, to provide condition for system study on logistics energy consumption.[5] Liang Li and ruiming Wu aiming at the current situation of energy conservation and emission reduction in China, propose to integrate the two tasks of energy saving and emission reduction into one system for utility analysis and evaluation. Its construction includes COD (chemical oxygen demand chemical demand), SO2, energy saving and emission reduction system of three subsystems per unit of GDP energy consumption.[6] Meanwhile, a comprehensive utility model for energy-saving and emission-reduction systems is presented, and a comprehensive evaluation and assessment method for the entire system of energy-saving and emission-reduction is proposed. Xiao hua Wang make the international metropolis Beijing as the background, through compare the mode, use LEAP mode to calculate and analysis the logistics energy demand and emission environment in different condition from 2000-2030 in Beijing.[7] Li pang proposed an environment-friendly logistics system and established a dynamic model based on environmentally friendly features. This has carried out a policy simulation of the reduction of nitrogen oxides in the logistics transportation sector in terms of strengthening governance investment, reducing unit energy consumption, reducing energy nitrogen oxide emission factors, and improving transportation structure.

Most of the above studies systematically studied the energy conservation and emission reduction work from the perspective of the overall logistics industry, and gave relevant recommendations. However, there are few researches on physical projects in logistics parks, especially the lack of research from the perspective of the construction and operation life cycle. In addition, the current research on energy-saving and emission-reduction of logistics systems is mostly accomplished through qualitative discussion. There is a lack of quantitative research methods and it is subjectively influenced by subjective factors. This article selects logistics parks that play an important role in the energy saving and emission reduction of the entire logistics system. Comprehensively study the relationship between logistics park operation and regional economy, policies, park management, park technology and park structure. Establishing a framework for energy-saving and emission-reduction systems in logistics parks, and introducing system dynamics methods to simulate and enhance the objectivity and science of research.

2. The construction of energy-saving and emission reduction system in logistics park

There are still plenty of problems in terms of energy-saving and emission reduction that need Logistics Park to face in current time. Firstly, many logistics park management and management personnel do not recognize the significance of energy conservation and emission reduction work, or do not care about their own energy consumption and the harmful effects of waste emissions on the environment. Secondly, as of now, the national and local governments have not formulated corresponding policies to incentivize the energy conservation and emission reduction work in the logistics park, and the enthusiasm of the enterprises is insufficient. Thirdly, the structural problems of logistics parks are in conflict with each other, including the layout of the functional areas, transportation structures, complementarity of enterprises, and energy use structure. Fourthly, most logistics parks did not introduce and promote advanced logistics technologies. Fifthly, the management level of logistics parks needs further improvement. It can be seen that energy conservation and emission reduction in logistics parks are closely related to policies, structures, technologies, and management factors. Based on this, Figure 1 can construct the theoretical framework of the energy conservation and emission reduction system in the logistics park.

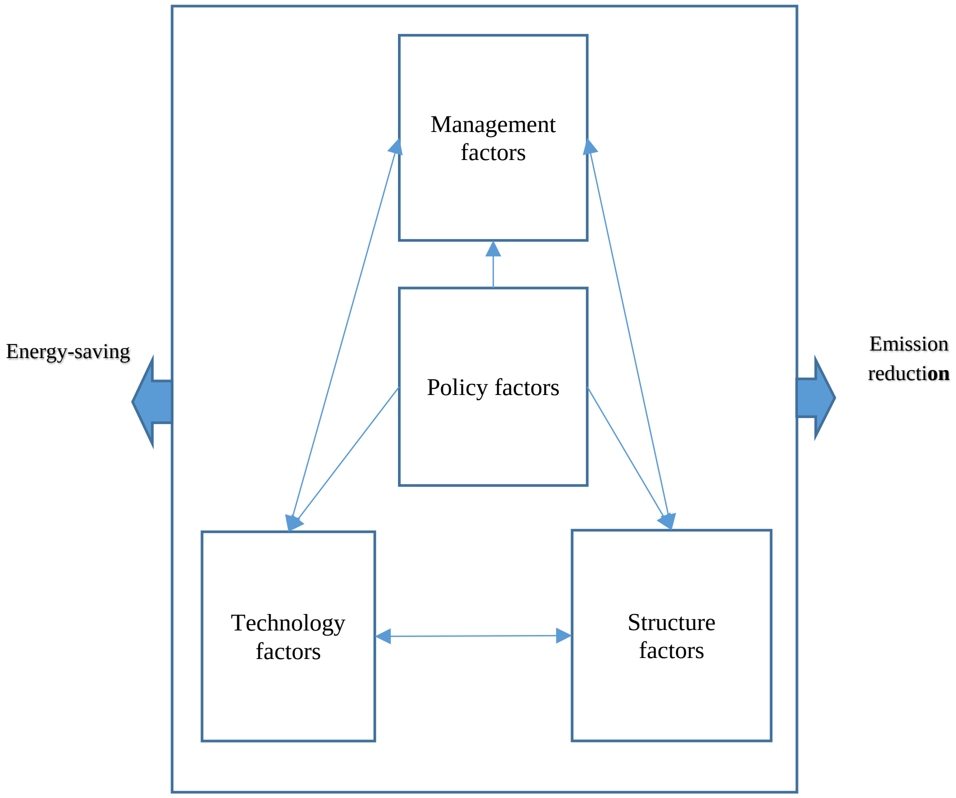

Figure 1 The frame of energy-saving and emission reduction in Logistics Park

(1) Policy factors

Policies are concrete measures and codes of conduct adopted by the organs of state power in order to realize the interests of the country and the people. This includes incentive policies and punitive policies. It has strong binding force and is the biggest and most direct factor affecting the energy conservation and emission reduction of the logistics industry.

(2) Structural factors

Structural factors are reflected in many aspects such as functional structure, transport structure, corporate structure, and energy use structure. The improvement of structural factors will fully enhance the effect of energy conservation and emission reduction. For example, through the scientific planning of the internal structure of the park, it will help reduce the internal transportation distance of the park, attract enterprises to settle in, avoid repeated investment and construction, and improve the utilization rate of logistics facilities. Through the optimization of energy structure, it can increase the use of clean energy and reduce carbon emissions.

(3) Technical factors

Advanced science and technology can effectively reduce the energy consumption during the logistics operation process, and at the same time reduce the pollution emissions at the end of the logistics chain. For example, the promotion of new energy vehicles, the active use of photovoltaic technology for roof storage, procurement and application of electric forklifts, the use of logistics box recycling mode, etc., take a new path of economic development.

(4) Management factors

The good or bad of a company's operation largely depends on whether the company adopts the correct management method. Similarly, effective management measures can speed up the implementation of energy conservation and emission reduction in logistics parks, increase the effectiveness of energy conservation and emission reduction, and bring greater economic, environmental, and social benefits to the park.

3. Construction and inspection of SD model of energy saving and emission reduction system in logistics park

A. The systemic analysis based on system dynamics

The logistics park energy-saving and emission-reduction system is a complex, nonlinear, and dynamic feedback loop involving the dialectical relationships among logistics, regional economy, policy, energy, and environment. At present, the data of the logistics system lacks specific statistics, so traditional mathematical tools are difficult to apply. System dynamics is suitable for solving difficult problems that are difficult to quantify in complex systems, and is conducive to simplification of complex problems and the clear appearance of the problem.

a. The overall framework of the system

The logistics park is an open system. It connects logistics activities in different regions and is an important node in the logistics chain. Therefore, the scope of its research should not be limited to the interior of the park, but should extend to the surrounding area of radiation. The logistics park energy-saving and emission-reduction system includes the logistics development environment (regional economy, policies, etc.), resource recycling, energy consumption and other factors. Among them, the driving force of system development is the logistics development environment. Resource recycling and energy consumption are the main part of the system. The improvement of the logistics development environment will bring more multiplier effect to the logistics park and will promote the sustainable development of the logistics park. More and more logistics companies are attracted to enter and the total output value will increase. This will be beneficial to the application of advanced science and technology in logistics parks. Advanced science and technology can promote structural adjustment, promote management upgrades, and directly improve the logistics development environment. Meanwhile, advanced science and technology are conducive to the park to reduce energy consumption and improve resource recycling, thus further improving the logistics development environment. From the perspective of system theory, the above-mentioned related factors are interrelated and interact with each other, and together constitute a coordinated development of a complex system of energy-saving and emission reduction in logistics parks. After the research is defined, the above factors can be summarized into two aspects: On the one hand, it is the actual field elements, including logistics demand, logistics supply, regional economy, energy consumption, environmental pollution level, and resource utilization level. On the other hand are the elements of control, economic development policies, environmental protection policies, investment policies, and science and technology policies.

b. Systematic Assumption Analysis

Considering the complexity of energy-saving and emission-reduction systems in logistics parks, it is impossible to take all factors into consideration when building models. Therefore, when selecting variables, only factors that have a significant influence on the construction model are considered and the following assumptions are made.

(1) Only study the logistics industry, regardless of the impact of other industries on the regional economy, energy consumption, and the environment.

(2) It is assumed that the logistics throughput will increase as the economy grows, and the energy consumption and emissions will also increase.

(3) Based on the characteristics of logistics operations and the availability of data, this study intends to use the total amount of nitrogen oxide emissions to measure exhaust emissions.

c. Causality analysis

According to the overall framework of the model study, the subsystems in the model are divided into logistics development environment subsystem, logistics demand subsystem, logistics supply subsystem, and logistics energy consumption subsystem. Based on the characteristics of logistics operations and the attributes of the park, a causal analysis of the park's energy-saving and emission-reduction systems was conducted, and the causality diagram shown in Figure 2 was obtained.

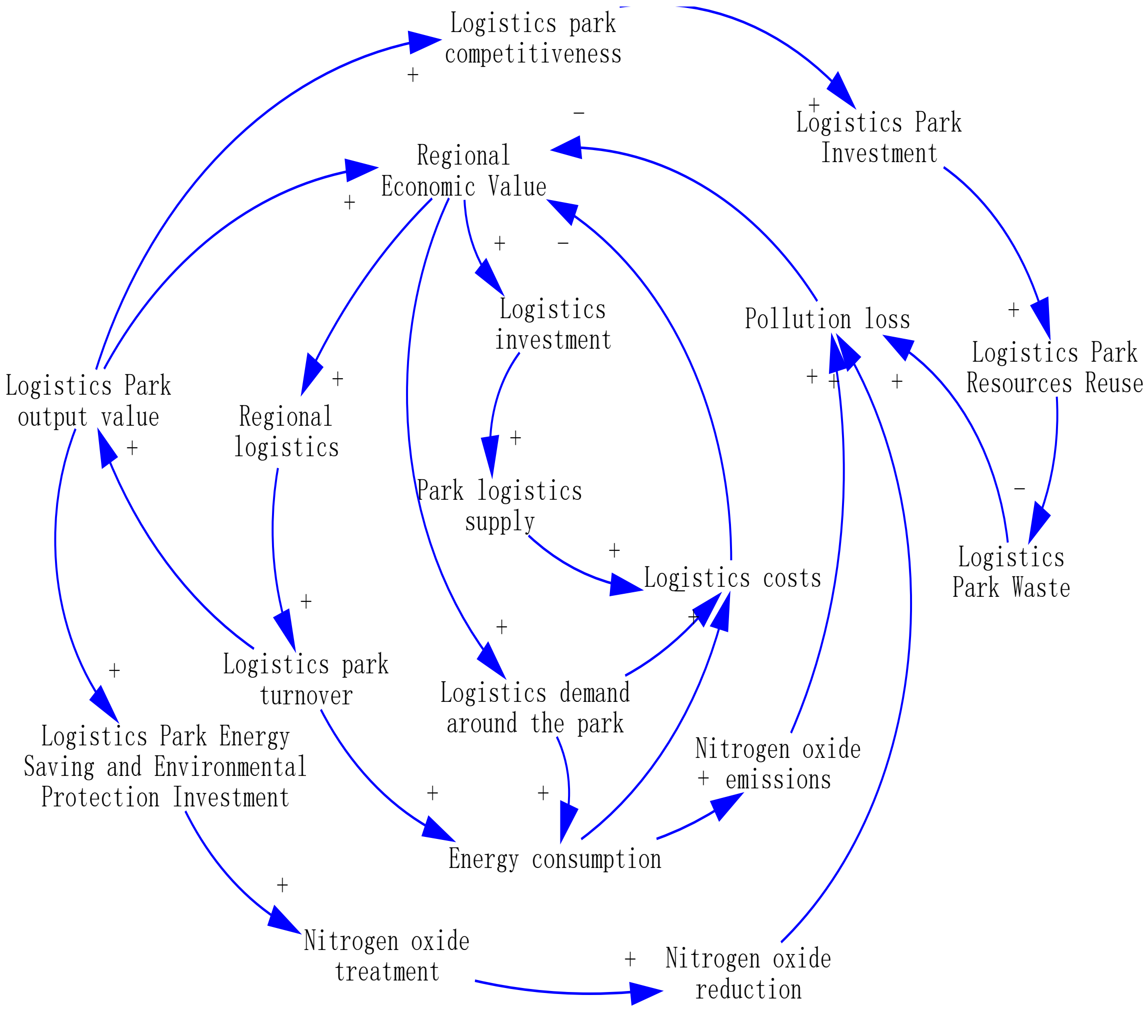

Figure 2 Logistics park energy-saving emission reduction system causality diagram

B. Construction and inspection of SD Model

According to the causal graph, the feedback relation for each subsystem, the report set four state variables, eight rate variables and fifteen major auxiliary variables. Construction the SD mode for logistics park energy-saving and emission reduction system. The detail shows in figure 3. The total output value of the logistics park, logistics demand in the park, logistics supply in the park, and energy consumption in the park include four state variables. The logistic environment subsystems, logistics demand subsystems, logistics supply subsystems, and energy consumption subsystems of the logistics park are characterized separately.

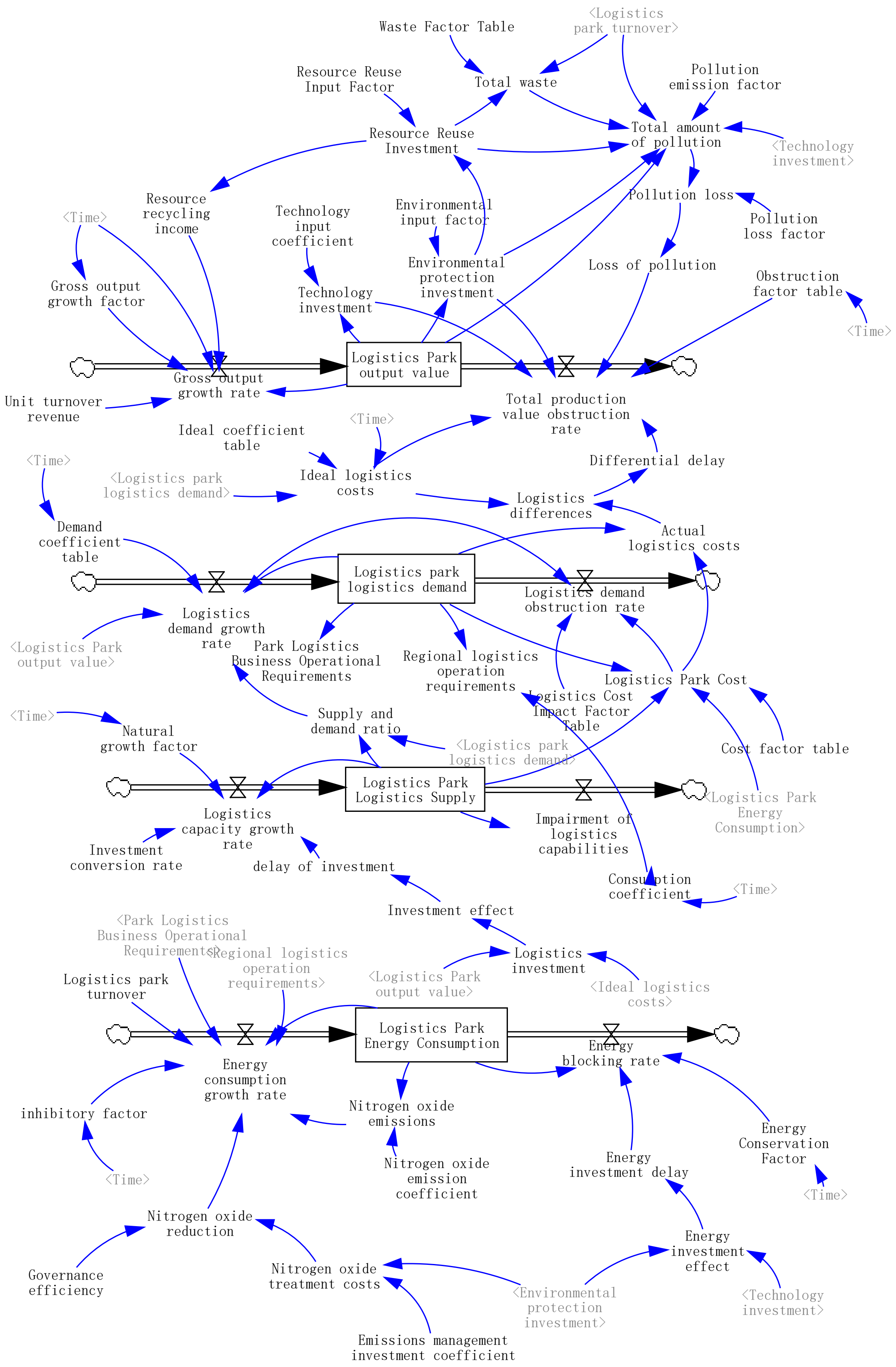

Figure 3 Flow and stock diagram for SD

C. Logistics park energy-saving emission reduction system flow inventory

The design convenience and plenty of index amount for this system, in order to collect these data, look up and consider the 'the yearbook for China logistics', ' yearbook for China statistics'. One of the data collected from large port, sample of Logistics Park, others collected from the platform of unmanned carriers and the logistics information of relevant companies. In order to make the relation become closer between the variable expression and the actual condition of Logistics Park, applicate the Vensim-PLE software make the consistency inspection to the each variable, common value, equation and unit of initial value. It discovers that SD mode can construction the great expression for the complexes relation between each parameter. To ensure that the simulation results are more realistic and reflect the actual production, this can exam the stability, validation and flexibility of the SD model. The specific result shows in:

1) Validation examination

The report chooses the influence factors which has more affection on total output of Logistics Park, demand of logistics, supply of logistics and energy consumption as an examination variable. According to the actual develop condition for transportation subsidy for Logistics Park, the length for time is from 2011 to 2016, as well as, makes the inspection mistakes as the 3%. The result shows that the value between simulation and actual are lower than 3%. Therefore, the mode can make a good embodiment actual value

Table 1. Validation examination data

years	*Analog value*	*Actual value*	*Error*
2011	126742	128975	1.76%
2012	129806	126690	2.40%
2013	132345	129962	1.81%
2014	138970	136121	2.05%
2015	142568	138319	2.98%
2016	150879	146896	2.64%

2) Flexibility examination

The report exams the parameters and boundary value for mode to discover there are less influence on its output. So, the report constructions the higher flexibility. Amount of them, the output of increase index for logistics to exam the flexibility of mode and utilize four variable as output and simulation, the result shows in figure.

4. Case study and work suggestion

A. Simulation analysis

In order to accelerate and improve modern comprehensive transportation system, support and promote the construction of cargo terminal (Logistics Park), ministry of transportation make the notice that 'Regulations on the Administration of Investment Subsidy for Freight Hubs (Logistic Parks) of the Ministry of Transport (Interim)', as well as, making the subsidy to plenty of logistics park project in 'the twelfth five-year plan' and 'the thirteenth five-year plan'. This research project chooses the typical multi-modal logistics park in 'the twelfth five-year plan' –the case study of a modern logistics in Sichuan. According to the framework of the energy conservation and emission reduction system in the logistics park constructed above, they are simulated in terms of policies, technologies, and management.

B. policy simulation

The macro policy environment has the effect of policy factors, through the policy factors changes to make the simulation that is policy simulation. The main policy factors are environment investment coefficient, science input coefficient for system in his research construction. To make the adjustment for separate two policy factors to operate policy simulation. Amount them, raise the environment protection input coefficient from 1.5% to 2%. The changes condition for some terms showed in figure. They are total output of Logistics Park, demand amount of logistics, supply amount of logistics, energy consumption and total amount of pollution.

Through the policy simulation shows that when environment protection input coefficient adjust from 1.5% to 2%, the decrease extent for logistics total output, logistics demand and supply amount much lower than total amount of pollution of logistics and energy consumption amount decrease extent. Therefore, increase environmental investment can benefit sustainable development for Logistics Park. However, it needs to notice that the decline in the total output value of the park cannot be higher than the decrease in pollution and energy consumption. When science and technology input coefficient adjust from 2% to 2.5%, total output of logistics, logistics demand and supply amount all get the increasing but energy consumption amount and total pollution amount have gradually decrease, this shows the obviously affection for science and technology input.

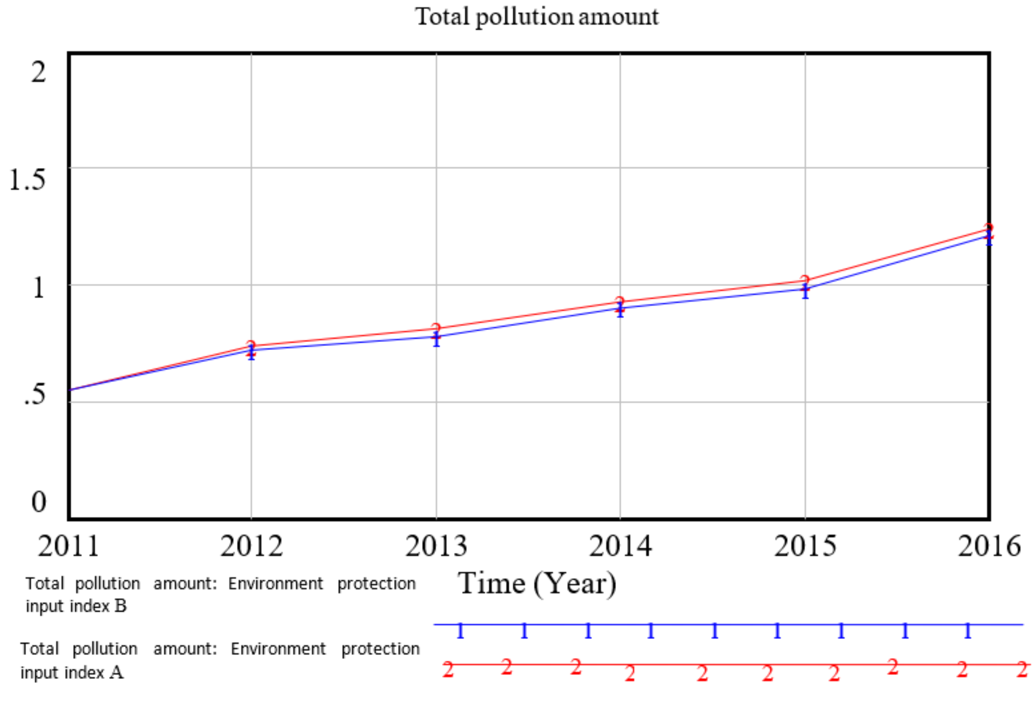

Figure 4 The comparison of different environment input coefficient for the contribution for logistics energy-saving and emission reduction system

C. Technology simulation analysis

This report use pollution emission factor as a measure of technological improvement, while maintaining the above-mentioned environmental protection input coefficient of 2%, the science and technology input factor of 2.5% and other parameters unchanged, adjustment pollution emission coefficient from 0.035 to 0.030, That is, when the 14.3% reduction is achieved, the total output value of the logistics park will increase by an average of 10%, the total amount of pollutants will decrease by

13.5%. The specific shows in figures. It can be seen that the key problem in solving the energy conservation and emission reduction of the logistics park lies in improving logistics technology and improving the efficiency of pollutant treatment.

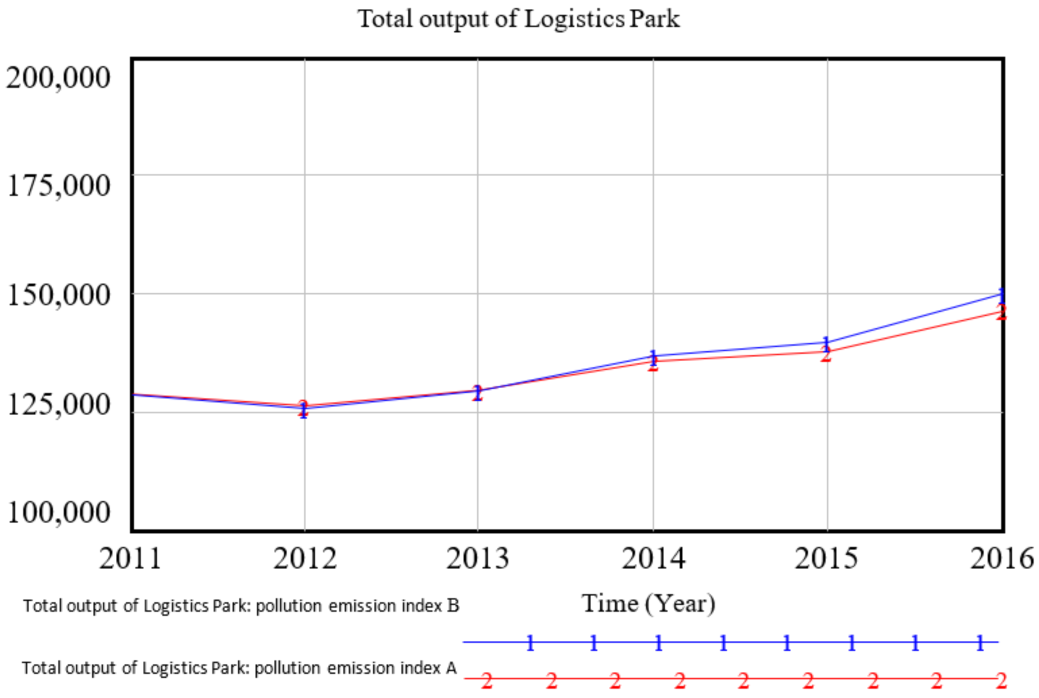

Figure 5 The total output of Logistics Park with different pollution emission index

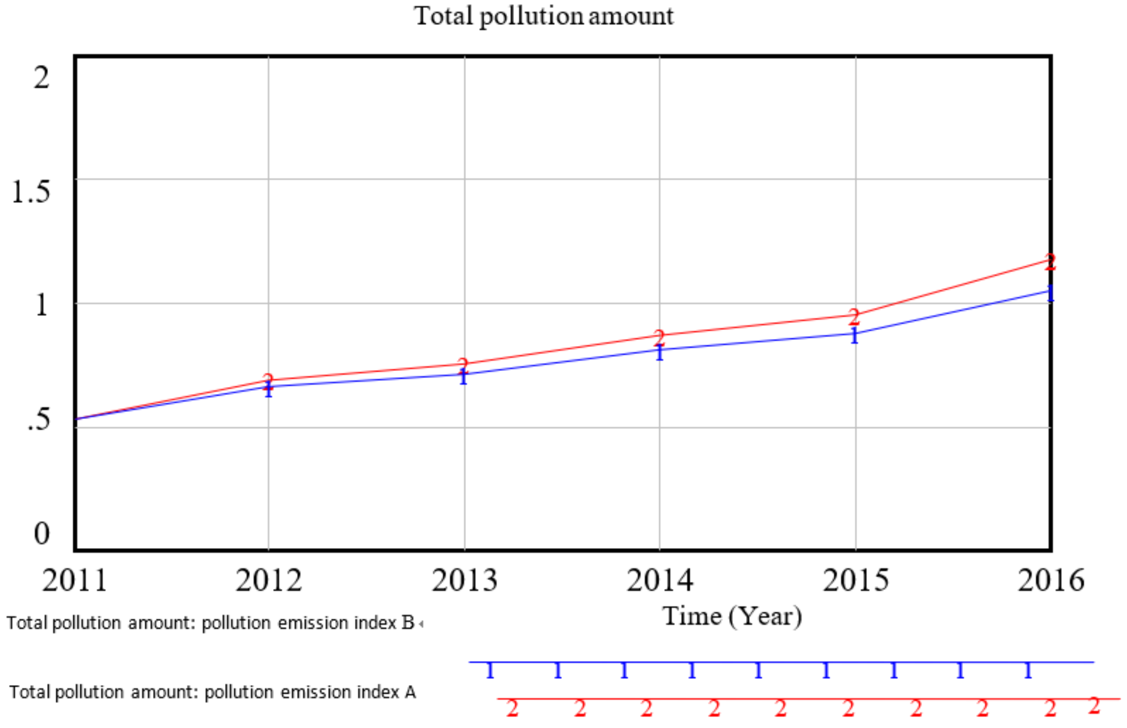

Figure 6 The total pollution amount of different emission system

（3）management simulation analysis

In order to make the more effective solve to energy consumption and pollution emission problem, it needs to cooperation and coordination each aspect. Therefore, it also needs to make the simulation to management factor of Logistics Park. For example, the investment coefficient of emission control in the park depends on how the park manages and uses energy-saving emission reduction funds, which is related to the management level. First, the investment coefficient of nitrogen oxide emission control is used as a measurement index. When the investment coefficient of emission control is increased from 0% to 5%, the total output value of the park has increased by about 3%, and the energy consumption and pollutant emissions have also decreased significantly. However, when adjust emission governance investment coefficient from 5% to 10%, the total output of logistics decrease about 5%, even better than when the investment coefficient of emission control is 0%, in addition, the decrease in energy consumption and pollutant emissions also decreased significantly. This shows that blindly improving investment in emission control does not achieve very good results and should have a suitable scope.

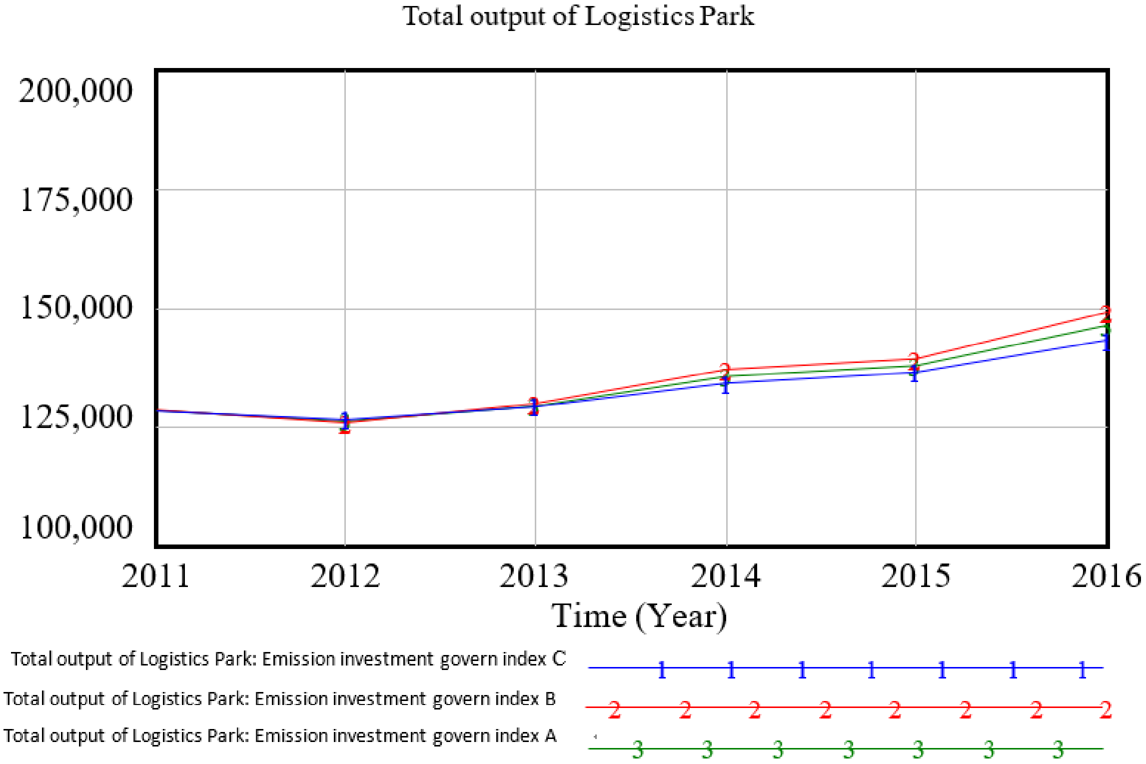

Figure 7 Comparison of Output Values of Logistics Parks under Different Emission Reduction Governance Investment Coefficients

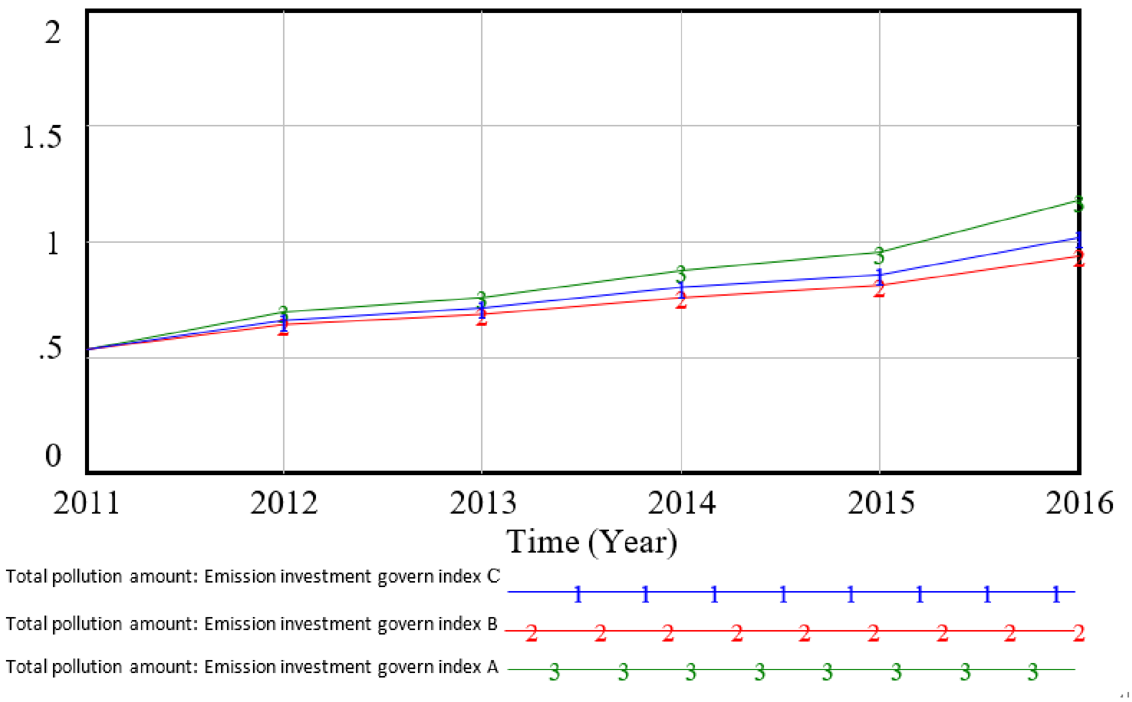

Figure 8 Comparison of total pollutants in logistics parks under different emission control investment coefficients

D. Suggestion for energy-saving and emission reduction

(1)Policy Suggestion

There are no laws and regulations that address the energy consumption and pollution emissions of the logistics industry. The relevant provinces do not have corresponding policies as a reference, so it is difficult to put in place regulatory measures. Through the simulation of logistics park policies, it discover the policy of country control indicators include environmental protection investment, science and technology input coefficient and so on. These indicators are influenced by national policies and have long-term impact on the energy conservation and emission reduction of Logistics Park. Therefore, it considers promoting energy conservation and emission reduction from the following aspects:

First is to combine the actual operation of the park to ensure that the investment ratio in environmental protection, science and other aspects. It can set the environmental protection investment coefficient as 2%, science and technology input coefficient as 2.5%, which is a better result of energy conservation and emission reduction. Second is to establish the comprehensive monitoring system and define specific monitoring objectives. Dynamic monitoring of energy consumption and pollutant emissions in logistics parks. This can determine the upper limit of energy consumption and pollutant discharge per unit of production value of the park, set inhibitory factors, and control emissions from logistics parks with excessive emissions.

The third is to set up a sound system of rewards and punishments. Reward those logistics parks with good energy utilization and low pollutant emissions, and punish those who waste energy and discharge excessive emissions, so that logistics companies dare not cross the red line and consciously increase their awareness of energy conservation and emission reduction.

The fourth is to establish a sewage charging system. The concept of "emission right trading" was applied to the pollution discharge of logistics parks, and emission permits were established for the logistics parks. The output value, taxation and total allowable emissions of park determined by local environmental protection agencies were used to issue emission permits for each park, as well as, encourage trade for emission rights in the market.

(2) Technical advice

It can efficient to decrease energy-saving and emission reduction by improving logistics technology especially introduce the green energy-saving technology. For example, nitrogen oxide emission factor, pollution emission factor, and increase energy conservation. The application of new technologies has also played a dual role in improving the efficiency of logistics operations and reducing energy consumption. This can consider to start work in follow aspects:

First is to use Logistics Park positively to advertise the significant technology such as green storage, handing and delivery. With the aid of the public storage enterprises which have enormous store roof resources, positively suppose store roof photovoltaic power generation technology, according to the actual energy-saving effective to give the award, through the suitable government subsidy make the vigorously promote the purchases and application for electric- forklift, follow and reflect the work spirit for commercial logistics standards, significant the support for logistics box recycle public mode. For fast store and collect the pallet or logistics box area, having positive attention on develop intelligent shuttle car and intensive shelf system. Paying the attention on the LED lighting on storage enterprises to change the relevant support for policy, as well as, encourage the companies to adopt LED lighting system which have obviously energy-saving effective. For the emission of transportation end part to install the purification treatment machine, thereby to reduce the nitrogen oxide and other waste gas emission.

Second is to enhance the construction the information system of Logistics Park energy-saving and emission reduction. Increasing the subsystem of energy-saving and reduction emission, achieving the effective application for Logistics Park inside resources and machine and with the aid for information platform control the logistics park energy consumption and the pollution emission condition real time, based on these information to make the in time adjustment to promote the logistics park operation efficiency, to achieve the energy-saving and emission reduction aim in the exist information system.

Third is scientifically and rationally invest in logistics technology funds and make the good for updating and maintaining production equipment. This can use about 2.5% percentage from the logistics output as the logistics technology input and form normalization mechanism. Timely elimination of obsolete high energy consumption and high emission equipment, to make the good for updating and maintaining production equipment. The pollution emission factor is kept within a certain range and energy efficiency is improved.

(3) Management suggestions

Logistics Park is a gathering area that gathers a number of logistics companies, guarantees stable cooperation, and gives full play to the scale effect and intensive effect is an important path for energy conservation and emission reduction. There are many management factors involved in energy-saving and emission-reduction systems in logistics parks, such as the proportion of funds used and allocated, the configuration of management structures, and the aggregation of logistics companies. The recommendations of this study from the management perspective are as follows:

First, according to the actual operation of the logistics park, take out some of the operating funds as energy-saving emission reduction funds, direct investment in science and technology investment and resource reuse investment, environmental protection investment.

The second is to set up a special management organization in the park to be responsible for the operation and supervision of the energy conservation and emission reduction system in the park, and to organize and coordinate the park's entry into enterprises to carry out energy conservation and emission reduction.

The third is to formulate a scientific and reasonable management system, form a set of targeted management methods and measures, incorporate the daily management of the park, and form a closed loop of planning, implementation, adjustment, and feedback, and improve the energy conservation and emission reduction of the park.

5. Conclusion

This report adopt systemic engineering theory, industry ecology relevant theory and other research methodology, combine with actual specific, taking the energy-saving and emission-reduction system of the logistics park as the research object, taking ecological efficiency and economic efficiency as the goals, the system studies the direct relationship between resource consumption and logistics processes, circular economy and logistics activities. Provide new ideas and theoretical basis for the planning and construction of the park system. Through the establishment of a system dynamics model, we have a more intuitive understanding of the energy conservation and emission reduction systems, internal factors and their relationships in the logistics park. Through policy simulation, technical simulation and management simulation, it has found an ideal path for energy conservation and emission reduction in logistics parks, which is conducive to the sustainable development of logistics parks and even regional economies.

Acknowledgement

Here to make the thankful to the help from colleagues and self –working hard. Thanks to the cooperative organization provide the information and data. These all make the report more accurate and realizable, as well as, has the objective view on the thinking.

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