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SHANGHAI MARITIME UNIVERSITY

WORLD MARITIME UNIVERSITY

Shanghai, China

Evaluation System of the Greenport Degree Based on the Fuzzy Logic Theory

By

YANG Xingchen

China

A research paper submitted to the World Maritime University in partial Fulfillment of requirements for the award of the degree of

MASTER OF SCIENCE

INTERNATIONAL TRANSPORT AND LOGISTICS

2014

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Declaration

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(SIGNATURE): ……..
(DATE): ……..

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Abstract

Title of Research paper: **Evaluation System of the Greenport Degree Based on the Fuzzy Logic Theory**

Degree: **Master of Science**

Currently, there are signs that the doctrine of sustainable development has become a common goal in the world as the whole society is facing a dual crisis combined with energy problem and environmental degradation. As a highly energy consuming and environmental-unfriendly industry, the maritime world has arisen the concept of the "Greenport" to achieve the goal of sustainable development. But *How to define a port as a Greenport and How to construct a Greenport*, on these two issues, the industry still remains vague explanations. To clarify the definitions and provide practical guidance to the Greenport construction, this dissertation offers a thoroughly and coherent research on the topic of the evaluation system of Greenport based on the qualitative analysis and the quantitative method.

This dissertation will firstly make a brief analysis about the problems related to the port industry, mainly focus on the highly energy consuming character of the port itself and the port pollution issues on the surrounding environment. A detailed discussion on why the idea of Greenport getting hot nowadays and the definition of the Greenport will be given out later on. A brief looking back on those Green events happened in the maritime industry during the last two decades is also going to be laid out in the dissertation. A Greenport Degree Evaluation Model will be established based on various references from the previous researchers and those conventions, standards and regulations relating to the environmental issues in maritime industry by applying the theory of fuzzy logics. The index of this Greenport degree will be built via previous theoretical researches and reality analysis, the definition of weights will be determined through the method of Analytic Hierarchy Process.

At the end, the Shanghai Ports will be chosen as samples to test the scientific and the rational of the Greenport Evaluation which created in this dissertation. With the reference to the achievements of this research work, the port authority may successfully identify the position of their port to the environmental friendly extent and get informed of the guidance to promote their port their ultimate goal as a fully developed Greenport.

KEYWORDS: Evaluation, Indicator, Greenport, Fuzzy Logic.

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Research background

Sir Walter Raleigh announced his motto “whoever controls the seas controls the world trade; whoever controls world trade holds all the treasures of the world in his possession, and in fact, the whole world” (Robert, 1966, p.288) in the 17th Century, although the words were said in the purpose of the war and exploration, it remained to be the truth. 400 years passed, as what Raleigh said, the Marine power has continuously being powerful and important.

Some countries, like Japan and China, have hold an annual national celebration of Marine or set up a Marine Day. It is believed that the reason of these anniversaries is to sensitize the general public of the overwhelming dependence on the ocean. Since the exchange and transactions with the global world has been widely accepted as the most efficient way for a nation leading to its economic prosperity, the importance of the international trade has become significant to all the nations (Ma, 2013, pp.13-21). It is estimated that the seaborne trade volume has already conquered over 90% of the world trade and 70% of world trade in value terms is carried over seas. The role played by shipping is much more important and critical nowadays than the time of Sir Walter Raleigh when the economics were less exposed internationally. Most major cities, international cities, are usually sea ports or inland ports, with rapid access to seaborne trade transportation (Lloyd’s Register Report, 2013, p.11). Till the year 2012, there were about 9,200 million tons of goods being loaded in ports world

wide, and the world total container port throughput increased by an estimated 3.8% to 601.8 million TEUs in this year. The share of Chinese mainland ports and terminals compared to the total world container port throughput remained at an estimated 25% (United Nations Conference on Trade and Development, 2013, p.88).

Currently, the export volume has occupied 80.2% of China's GDP, over 90% of these export cargo is transferred through ports and transported by ships. During the time period 2003 to 2012, we can easily found that those cities which own ports or terminals earn outstanding rankings when we look in to the list of China's Completive Cities, which is assessed by the GDP value. Take the GDP lists of China's cities in last decade, all the top 10 ones own or operate ports and Shanghai has been taking the first place of GDP value because of its successfully developed ports and terminals (China Transportation Statistics Institute, 2013, pp.124-128). We can come to a conclusion that ports or terminals have an essential impact on the development of the regional economics.

Ports play the role of the gate of a region and a country, which contribute a lot to the commercial trade and transaction. We may even say that the Modern economy can not exist without the international trade, especially in this globalized world, and deadly need the fully support of the port development. Although the structures of the world economy and major industries have been changed unrecognizably in the last decade, the interrelation between the port and the region economy has consistently been kept: the port will push the increase of the local economy and the local economy will make a feedback the development of port. Till the end of 2011, the total tonnage of the ports in China has reached 10 billion tons and 26 ten billion's level ports occurred in China, including 17 sea ports and 9 river ports (China Port Yearbook Department, 2012, pp.2-8). According to the 2013 UNCTAD Maritime Transport annual report, shown as Table 1, nine of Chinese ports, including Hong Kong (China) listed among the world top 20 ports (UNCTAD, 2013, p.92).

Table 1 Top 20 container terminals and their throughput for 2010,2011 and 2012 (Twenty-foot equivalent units and percentage change)

Port name	2010	2011	Preliminary figures for 2012	Percentage change 2011-2010	Percentage change 2012-2011
Shanghai	29,069,000	31,700,000	32,500,000	9.05	2.52
Singapore	28,431,100	29,937,700	31,600,000	5.30	5.55
Hong Kong (China)	23,699,242	24,384,000	23,100,000	2.89	-5.27
Shenzhen	22,509,700	22,569,800	22,940,000	0.27	1.64
Busan	14,194,334	16,184,706	17,030,000	14.02	5.22
Ningbo	13,144,000	14,686,200	14,973,400	11.73	1.96
Guangzhou	12,550,000	14,400,000	14,520,000	14.74	0.83
Qingdao	12,012,000	13,020,000	14,500,000	8.39	11.37
Dubai	11,600,000	13,000,000	13,280,000	12.07	2.15
Tianjin	10,080,000	11,500,000	12,300,000	14.09	6.96
Rotterdam	11,145,804	11,876,921	11,900,000	6.56	0.19
Port Klang	8,871,745	9,603,926	9,990,000	8.25	4.02
Kaohsiung	9,181,211	9,636,289	9,781,000	4.96	1.50
Hamburg	7,900,000	9,014,165	8,930,000	14.10	-0.93
Antwerp	8,468,475	8,664,243	8,629,992	2.31	-0.40
Los Angles	7,831,902	7,940,511	8,080,000	1.39	1.76
Dalian	5,242,000	6,400,000	8,060,000	22.09	25.94
Tanjung Pelepas	6,530,000	7,500,000	7,720,000	14.85	2.93
Xiamen	5,820,000	6,460,700	7,200,000	11.01	11.44
Laem Chabang	5,068,076	5,731,063	5,927,000	13.08	3.42
Total top 20	**253,348,589**	**274,210,224**	**282,961,392**	**8.23**	**3.19**

Source: UNCTAD secretariat and Lloyd's List Intelligence, July 2013

Note: In this list Singapore does not include the port of Jurong

1.2 Research purpose and goal

With the highly support of Chinese government to the marine industry, more and more sea ports and river ports have been booming out in the Mainland, making a great influence to the local economy. However, ports, acting as an energy consuming center and polluting source, have been criticized much more by the general public after its rapid developing. If take the port of shanghai as an example, we can easily find that there were 48970 big vessels passing the port of Shanghai in the year 2012,

regardless of those small vessels. These vessels would bring over 93.3 tons of hazardous substances emissions and produce carbon dioxide emissions at a level of 3.1 million tons (Shanghai Yearbook Editor Department, 2013, pp. 24-28). At the same time the excess electricity generated by the diesel engine when the vessel is anchored can not be stored, which is an enormous energy waste.

Ministry of Transport of the People's Republic of China first announced the "Guidance on the Energy Saving and Hazardous Substances Emissions Reducing Issues in the port operation" early in the year 2007 and revised it recently in the year 2012. The guidance emphasis that The "Twelfth Five Years" is a highly significant time period to fasten the structure switching of the economic development and also a good chance to develop a "Resource-saving and Environment-friendly" new species port. During the time period from the year 2007 to the year 2012, the energy consumption of port throughput per unit has been decreased by 8% and the CO_2 emission per tonnage has been decreased by 10%. In the year 2010, the Ministry of Transport of the People's Republic of China had consistently held several environmental related conferences, allocating the researchers and experts of the marine industry and trying to find out a rational path of the Greenport Constructing, such as "the Green Marine Project" and "Technical Seminal of Building the Resource-saving and Environment-friendly Port". The experts, including the China Classification Society, had raised a rational framework and suggestions for the Green Marine Construction at the meeting, which are highly followed by the government authority (China Transportation Statistics Institute, 2013, p.46). The port authority of Shanghai had also announced the "Environmental Protection Management of Port of Shanghai and its 3-year Plan" in the year 2007 and, trying to start the green marine and environmental-friendly vessel researches actively and finding new green technology to saving the heavy energy consuming problem in the port area (Port Authority of Shanghai, 2007, p.1).

Apparently, port's negative impact on its community environment and its potential pollution has risen up the attention of the government, and there were lots of

achievements on building the resource-saving and environment-friendly port during the past decade. But it still remains the problems that “How to define a port as a Greenport?” and “To what extends do the green degree of a port be regarded as good?” which are definitely barriers in the path of Greenport development. For Greenport, we have the phenomenon that the relevant indicators and the scientific evaluation system are not completed, in order to make the construction of Greenport has more scientific and accurate evaluation system, in order to enable the port’s daily operations have more effective supervision. Setting a new Greenport Degree Evaluation System, establishing a comprehensive evaluation system research and scientific evaluation methods become extremely important (Lu, 2009, pp.3-10). For these reasons, this paper attempts to establish a rational indicator subsystem, using both qualitative and quantitative analysis methods to establish a scientific evaluation model.

The research of the Greenport is never a meaningless topic and without any realistic suggestions. We can figure out that this research paper would be useful in both the entire port industry itself and the whole society. To the port industry, setting up a scientific Greenport Degree Evaluation System can firstly give advice to the port authority to identify the environmental-unfriendly factors, figuring out the weak points in the port operation chains and then correcting them by offering sufficient theoretical supports. And also, the establishment of evaluation standards can indirectly increase the ports core competence by enhancing the efficient utility of energy consumption, reducing the emission of hazardous materials, enable the ports to offer better services and finally reach the ultimate goal that make a positive impact on the development of regional economics. What’s more, the rational and scientific evolution system could set a new standard for the supervise authorities, giving them a timely easy access in the field investigation. Hence, the port industry might find a perfect balance between the environmental protection and port development.

It is no doubt that the fact whether a port is defined as a Greenport or not is highly related to the living standard and the safety of the whole community. We can easily

find out that most major ports, either sea ports or inland ports, are located very closely to the drinking water-taken system for the local citizens. Acting as a huge parking place of vessels and heavy machines, the port has allocated most potential pollution vehicles and dangerous cargos which involved the hazardous materials. It is definitely a serious environmental threaten to the surrounded community. Usually, both the city water supply system and the port are located along the river or lake, outside the inland area. These two infrastructures are not far way from each other, the potential pollution will eventually has an impact on the water quality near the raw water collection point. And in this particular information world, any accident related to society safety will cause a serious city panic. Just in this year, May 5th, there happened an accident that a smell of drinking water occurred in JingJiang City of Jiangsu Province in China, which of cause is the water quality problem in its Yangtze River water supply network. The accident caused a 7-hour water supply stopping and definitely a city wide panic[1]. While the source of this accident was not announced later, the citizen blamed it most on the coast line port. We can not assure that there will be no such accident if we have a standard Greenport, but at least it's a trustful guarantee to the general public.

To the country wide, especially in China, the Greenport development also has its significant historic meaning. It may be considered exaggeration that we related a simple port's evaluation to a nation's development. In this new century, the global economic crisis has forcing the world to hold a revolution against the old industrial structure. As Jeremy Rifkin said (Rifkin, 2011, pp. 1-5), "international communication technology is covering with renewable energies, giving the rise to a Third Industrial Revolution. The creation of renewable energy regime, distributed via an energy internet, a smart grid, and connected to plug in zero emission transport, opens the door to a Third Industrial Revolution". The dark green will definitely take over the metallic color, becoming the essential key of the near third industrial evolution. China has an ambition to lead the world into the third industrial revolution

[1] The World Wide Web gives further information on this accident.
http://news.so.com/ns?q=长江靖江段水质异常&src=onebox. Retrieved May 15, 2014

and a new sustainable port energy era. The Chinese government has dedicating an $82 billion to establish an energy internet that will serve as a technology stage and infrastructure for ushering in a new economic paradigm, (Lin, 2013, p.1). If China can firmly grab this historical opportunity for the new age, it will largely alter the economic life of China and establish its commanding leadership in the future global competition. The ports, which are regarded as the big environmental-unfriendly places, will act a key role as a pioneer in this revolution without any doubt. The more engaged the want to get the title of Greenport, the more effort they will give to the development of new energy searching and new green technology. What they did will eventually become the experience of the coming transforming of the whole country. These developments of energy security clean shipping and environmental protection, will act as Aces in the process to achieve the great rejuvenation of China[2].

1.3 The framework and layout

This dissertation will be divided into three parts, theoretic research, evaluation system research and case study respectively. In section 1, the paper will give detailed information about the research background and its realistic meaning. Also, lots of literature will be reviewed on the area of Greenport development in the whole world wide. The basic research method will be a “Questions & Actions”, leading the dissertation to a more realistic and timely way. Section 2 describes an establishment of the Greenport Degree Evaluation System. A research methodology of qualitative and quantitative analysis is chosen here, we are going to set up our evaluation system through those existed system is Europe and U.S.A, also combing the local laws and international conventions as references. Fuzzy logic is also applied here as an index standard. In section 3, we confirm the fact that the theory must be applied into reality, otherwise it will remain useless. Two shanghai terminals will be selected as case studies, realistic examples, to test the rational and logical of the Greenport Degree

[2] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/The_Third_Industrial_Revolution:_How_Lateral_Power_is_Transforming_Energy,_the_Economy,_and_the_World Retrieved May 20, 2014

Evaluation System established in the former section. There will be a conclusion together with several suggestions at the end. The result of the case study assure these two terminals reach the green standard that settled in the former section and consider them as Greenport, which is fair match the realistic, proving the feasibility of the evaluation system.

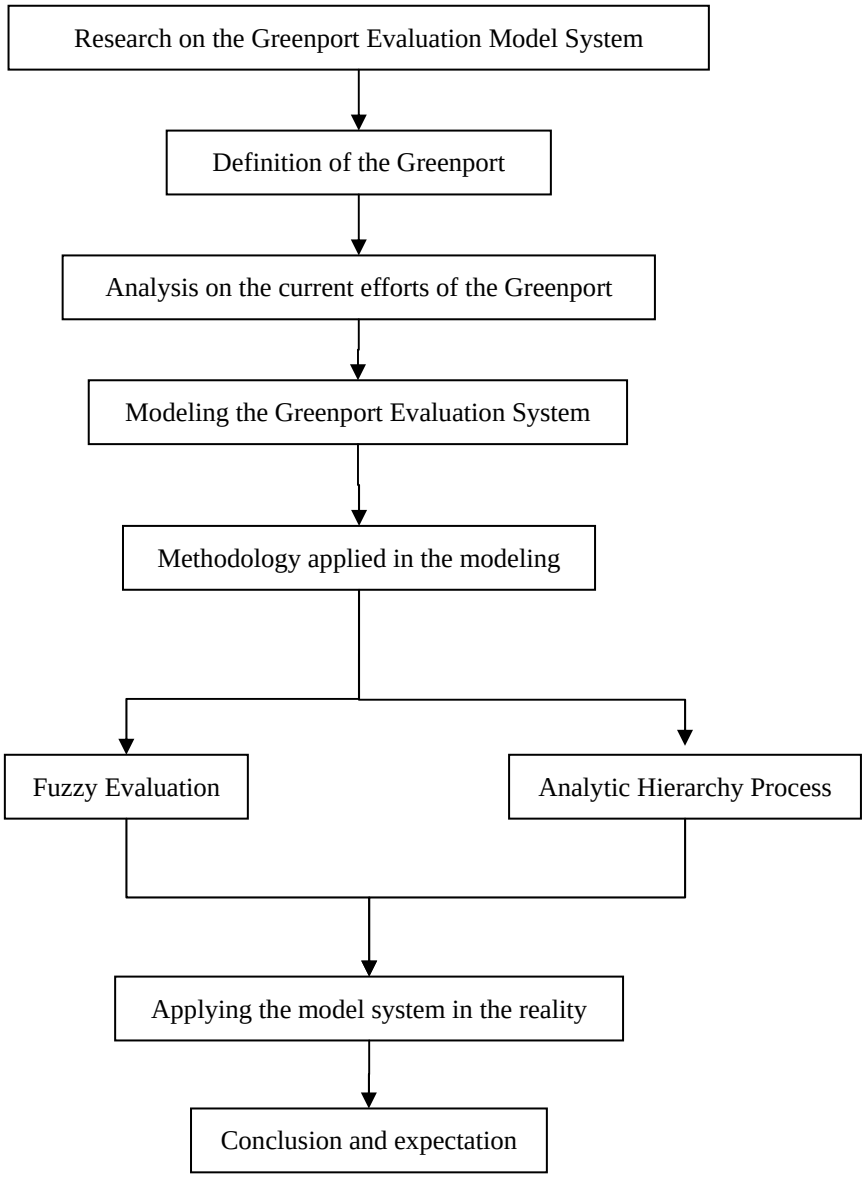

Figure 1 the Overall Outline of this Research

Chapter 2 the Concept of Greenport

2.1 Discussions on port's influence to the environment

The port had been divided into 3 generations in the 1992 UNCTD according to its development of fundamental function, which are "the First Generation as a transport cluster", "the Second Generation as a transport and service cluster" and "the Third Generation as an value-added international logistic cluster". In the year 1994, the UNCTAD secretariat coined the expression "the Fourth Generation" which are physically separated but linked through common operator or through a common administration (UNCTAD, 1999, p.9). Now the port is no longer a simple allocation and distribution site of cargo handling, acting as a hinterland between seaborne trade and inland trade, it has already become a new industrial region. The original fundamental infrastructures and the scales of the port have both been largely developed, transforming into a newly special commercial cluster. The fast and constantly developments of port do play a positive roll in keeping the regional economics' rapid increase. In Asia, almost all successful and prosperous economics have been built by offering top-class port services. Meanwhile, we should admit the fact that the bigger the port, the heavier pollution is made in the community. The environmental-unfriendly factors of the port activities have being exposed to the general public, especially in recent years. Except several far away sea ports which are built outside the land, most ports and terminals are located along the coast line, nearby the city community. Imaging the environmental accident would brought by those bulk ports which filled with coals, steels and any other heavy materials, and the

container ports which carry dangerous cargos or chemical cargos, the city will turn mad eventually. People have paid more and more attentions on their living standards, likewise the drinking water quality and the fresh air quality, especially after the Fukushima Daiichi nuclear disaster in the year 2011. Even though the port site is carefully chosen, trying to avoid such dangerous accidents, but only the God would know what is going to happen.

The main source of the port pollution is related to the direct emissions of those big vessels in the port region when the vessel shipping in the port, coming in or getting out, there is such a case that the vessel will discharge the ballast water into the open sea. We do have the conventions on forbidding these polluting actions, likewise the MARPOL 73/78 as international one and Clean Water Act (1972) as a national one, but shipping operating is still a manly controlled activity in these days and needed the strongly self-discipline of the crew member. We also have regulations on cultivate crews with environmental protection ideas like the Vessel General Permit for Discharge Incidental to the Normal Operation of Vessels (2013), c.5.5.4, which mentioned that "the [s]hip's crew members who actively take part in the management of the discharge or who may affect the discharge must receive training regarding shipboard environmental procedures….". The pollutants can be the ballast water, or the bilge water and the grey water. Another source can be the accidents or collusion of the vessel. When the vessel is crashed, either due to the diligence of improper berthing operation or the unseaworthy of the vessel itself, the spilling of the fuel always happens. Oil spills at sea can spread for mils with oil slick and kill marine animals in coasts. A VLCC tanker can carry 2 million barrels or 320,000 m^3 of crude oil, one ton crude oil will transfer into a 12 km^2 oil slick, spreading to port water area as soon as possible and make an unforeseeable impact to the around environment system. According to one study from the International Tanker Owner Pollution Federation, during the 9,351 accident spills from the year 1974 till now, 84% of the spills resulting from accidents like collisions, groundings, hull failures and explosions losses over 700 metric tons of oil[3]. To these highly dangerous accidents

[3] The World Wide Web gives more information on this course

with uncountable pollutants, even been cleaned up in time, will harm the environment eventually. One near example is the 2010 Deepwater Horizon Oil Spill in Gulf of Mexico, which has been described as the worst environmental disaster in the United State, released about 4.9 million barrels of crude oil to the open sea[4]. Both the spill and cleanup efforts had bad effects on the environment. Even two years after the spill, studies have reported a variety of metal health issues, skin problems, breathing issues, coughing and headaches happened to those cleanup workers (Living on Earth, 2013, p.1). What an incredible public health crisis from a chemical poisoning. Another more marine related example is the 2007 South Korea Oil Spill. A crane barge collided with an anchored crude tanker "MV. Hebei Spirit" on 7 December 2007, resulting in the leaking of some 10,800 tons of oil. Two days later, it was reported that the oil slick was ongoing to 330,000 m^2 and at least 30 beaches have been affected[5]. The port's daily operation, because of the machines in the region, also will generate massive hazardous pollutants and noises. Due to their inevitable bad impact to the air quality and water quality, these products of port operation have been considered as an enormous problem to the ports environmental protections and should be avoided at the procedure of Greenport constructing.

There is another bad influence with in the port will impact on the surrounding community in a more ecologic way, the deepening and widening project of the port development. When it happens to the opening of the port building and re-developing, dredging is always needed to make sure the waterways navigable. The process of Dredging can create disturbance to aquatic ecosystems, often with adverse impacts[6]. The underwater flow pattern around the construction site is always going to be changed by the explosion of the excavation action and lots of toxic chemicals will be released, including heavy metals and PCB from bottom sediments into water body.

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http://www.itopf.com/information-services/data-and-statistics/statistics/#major. "Major Oil Spills". International Tanker Owners Pollution Federation. Retrieved June 18, 2014

[4] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/Environmental_impact_of_the_Deepwater_Horizon_oil_spill#Remaining_oil Retrieved May 28, 2014

[5] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/2007_South_Korea_oil_spill Retrieved June 17, 2014

[6] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/Dredging Retrieved May 20, 2014

The original beach and coastline will be destroyed, making a difficulty to the local marine species and largely decreased the local ecology diversity due to the short term increase in turbidity.

2.2 Definition of Greenport

With the rapid development of shipping industry, a dual crisis combined with energy consuming and environmental degradation generated by this process is becoming more and more serious. To deal with this trouble, a concept named Green Marine has been arisen these years among the shipping community, and the Greenport is definitely an important part of it. We are actually inspecting whether a port or a terminal can meet the standard of relevant constraints or not when it is coming to the topic of setting a Greenport. But “How to define a port as a Green Port” and “How to construct a Green Port”, on these two issues, the industry still remains vague explanations.

An agreeable definition of green port is “To evolve the idea of green during the process of port planning, construction and operation, making an equivalent balance between acceptable environmental impact and economic profit" (Lu , 2009, pp. 5-12). Hence, the key leads to the Greenport is a kind of balance condition, at this point we need maximize port economic activity, while minimizing the negative impact of the port activities on the environment and surrounding community and reducing the energy consumption. But the balance of the term itself is recognized differently among the various people. “How to define the balance” or “How to define the imbalance”, it is difficult to have a precise definition. So the paper gives another concept of Green degree of port development, to assess the extent of the current stage under the port area in the development process through the green harbor, evaluating the merits of the various indicators. The term degree range, its span is much wider than the equivalent point, easier to judge and define us. High green degree describes

a highly developed Greenport, while low green degree states that ports are still stick in the situation with serious environmental pollution and inefficient use of energy.

Several points should be take into account when we defining whether a port should be divided into a Green one. Despite the ports themselves, we should also look into Green design, the port construction planning phase should take full account of consumption and its impact on the process of port operation possible energy on the environment, also pay attention to the development of green management and green technologies; Green Logistics, the idea is to take the green and the whole process of applying to the entire maritime logistics management activities; Green procurement, during the procedure of the entire port operations, we should choose those recyclable, biodegradable, renewable and clean energy, green materials as much as possible, to reduce the environmental impact (Li & Peng, 2008, pp.1-4).

2.3 The development of the Greenport in the marine industry

The researchers have been working on the topic of Greenport and such ecologic-friendly port since the last decade, there are already several pioneer ports joined the process of this green evolution. In the U.S, the process of Green Port construction has been started from a decade ago, the Port of Houston is the first port which convert Green concept into the entire port operation and construction, and passed the ISO14001 environmental management system which enable the port to become the first batch of “Greenport” in 2002 (Lv, 2005, pp.2-3). Since then, other U.S. ports started to learn how to build their own green development from the Houston success. From 2005, Port of Long Beach constantly launched the “Greenport Policy”, the “Clean Air Action Plan” and “SmartWay Transport”, had been making over forty environmental protection program from seven different aspects including maintenance of harbor water quality, slowing ground traffic pressure, and protecting the environmental program for marine wildlife. Take

“SmartWay Transport” as an example, its air achievements include reducing 23.6 million metric tons of carbon dioxide and 478,000 tons nitrogen oxides since 2004. (EPA, 2013, October 9). After finishing a complicate renovation, Port of Long Beach harbor environment has been improved immediate and continuous accessed the “Environmental Improvement Award” by the American Port Authorities Association and was awarded “Clean Air Excellence Award” by the United States Environmental Protection Agency in 2008 (Zhang, 2008, pp.1-5). The same change happed to the port of New Jersey and New York, the port authority has strengthen its cooperation with other non-governmental environmental protection association to keep the land, water, nature and the entire ecologic system away from the heavy pollutants. $100 million has been dedicated into the electrification of the port handling equipment replacement, trying to reduce the hazardous emissions generated by the diesel engine. In addition, the port has invested $ 600 million for the extension of high-speed railway transportation system to reduce traffic congestion, successfully improving the efficiency of the entire port area, and indirectly reducing the emissions more by over 60 percent (Lu & Wu, 2009, pp. 2-6).

In Europe, one veteran of World Giant Port, Port of Rotterdam had made response to the implementation of green slogan with the program “Rijnmond Regional Air Quality Action Program” early in 2005. Port of Amsterdam from 2008 had also launched joint program with other ports, the “Clean Shipping”, cooperating with the local government to control and reduce carbon dioxide emissions. After 2025, vessels failed to meet the provisions of CCR-2, the air quality standards, can no longer make the their calls at Port of Amsterdam, which enables Port of Amsterdam to become the most sustainable development port in Europe (Cai, 2010, pp.3-7).

There exists a large gap between the process of Greenport developing in China and foreign country, the domestic situation generally felled behind a decade time period, the appropriate measures of Greenport was carried out in beginning of the twenty-first century. Shanghai have already started to explore the “Shanghai Environmental Management Approaching Actions” actively from 2005, by the end of

2010, Shanghai port has achieved a number of significant achievements in Green construction: the fully operation of mobile shore-based power supply system, making the ship berthing at the port no longer polluting the environment, replacing the diesel power by sustainable green electronic power, significantly reducing the energy consuming during berthing operation; Container Port “Oil-Power Converting Program” measures, drawing on Port of Long Beach’s “SmartWay Transport”, using electricity to replace diesel drive devices, directly reduce 70% of energy consumption in port’s ground transportation, achieving zero pollution emissions (Yang & Shen, 2011, pp.24-28). The introduction of the Mutual Trailer Combination System has improved the loading efficiency inside the container port, the empty load rate decreased to 18.735%, while also reducing fuel costs; Operational container crane auxiliary lighting system, combining the wind energy and the use of LED energy-saving lamps makes night lighting can be reduced from the nominal 6.4kw to 0.92kw, the energy-saving rate has reached more than 85%.

Western countries have already made a lot of achievements in the aspect of port green development. Say, during the time period from 2002 to 2007, the U.S port of Long Beach had reduced both the emissions of NO_2 and particulate matter by 50%, while their annual tonnage increased by 30%. By looking into the achievements they earned, we can discover many important tips in building the Greenport system. In their procedure of ports green development, one essential point is that the non-governmental organization and local government are closely in touched and cooperated with each other, making effort to keep the port environment away from being polluted. The long shore association in U.S, the International Long shore and Warehouse Union, launched the campaign called “Saving Lives by Cutting Pollution” in 2006, in which they requiring new terminals to provide electric power for docked vessels and requiring cleaner fuels for cargo-handling equipment on the docks (Showalter, 2006, p.7). The union do settled a good beginning for the Greenport development among the American world. Port of Huston has always been sponsored by the local government in developing the Greenport, which not only assure the legality and qualification of the project but also ensure enough financial

support. The port authority also cooperated with the City Harbor University, National Ocean Minster, and the Ministry of the Environmental Protection, in searching for a reasonable and efficient plan. Meanwhile, the local non-governmental organizations are also dedicating their effort on supporting the Greenport construction. The California Air Resource Board announced the “List of Annual Air Emissions” as a strong pressure to the port authority, pushing them to carefully inspect during the Greenport procedure (California Air Resources Board, 2006, pp.12-16). The process of the Greenport developing is never a single play of the local government, but needs the bilateral effort both from the authorities and the general public.

Another worth mentioned port is that there are lots of relevant regulations and laws in western countries. It happen to us sometime that we can not indentify some index data whether they meet the green standards or not when we talking about the Greenport, it’s the result of the law lacking situation on the environmental protection policy in China, which makes us stuck in to a difficulty that there are not enough standards to compromised with. In America, the first environmental law called National Environmental Policy Act (1969) was released in 1969 and the law related to waterborne Rivers & Harbors Act (1899) was released in 1899. There have been lots of environment protection laws and regulations nowadays, which have built up a complete legislative branch among the environment area. Australia also owns a strict law system which enables the port authority to successfully sign out hundreds of bills and win litigations against the companies that broke the laws during the time period from the year 2007 to 2012.

Renewable energy and green innovation as mentioned in the previous chapter, has becoming the key factors in the world of the near future. In the recent decade, searching for the new green energy to substitute the diesel fuel as a major energy source or creating new green technology to improve the efficiency and saving the energy have become the top two issues in the way of Greenport development. Either the "SmartWay Transport" from the Port of Long Beach, "Alternative Maritime Power" from the Port of Los Angeles or Port of Houston's "Shore Power Plan", they

are all emerging to use green energy sources to replace high-low power consumption of diesel fuels; Either The Transformation of Coal Blending Centers in the port of Rotterdam and manufacturing process redesign, the CCR-2 air quality hard requirements action in the port of Amsterdam or the new type RTG technology in the port of Nagoya, they are all products of innovative Greenport. By applying these new technology, ports can reduce the energy saving and pollutants emissions by a large scale. The government should encourage these researching of environmental protection to support the Greenport development, for our ultimate goal that is to have a cleaner and safer tomorrow.

Chapter 3 the Establishment of the Greenport Degree Evaluation System

3.1 Rules for building the evaluation system

Greenport index system is the basis for comprehensive evaluation of Greenport, in order to enable it to comprehensively reflect all aspects of the port in terms of evaluation of the level of the green, when selecting indicators must follow certain basic principles (Yang, 2010, pp.34-36):

The first rule is to obey the scientific principles and independence. Scientific and oppositional mainly refers to the indicator selection process requires the use of certain statistical indicators screening rules. The importance of indicators is going to be judged and the "importance level" of equal indexes excluded. And finally we will select the most representative of the Port of green degree level indicators. On the

other hand, the index weight is determined above, to use aspects of science into the selection, so that it can represent the true objective conditions.

The second rule is to obey a systematic and hierarchical. In the process of the establishment of evaluation index system, we should consider the whole Greenport system as a unit. The overall port development is the top level of a green degree. Then the index factors can affect and reflect the ability of the port green layers of reflected, finally can cover all the important factors to establish a complete index system.

The third rule is the principles of openness and variability. Evaluation of Greenport is a dynamic concept. Since the passage of the industrial aspects of the port or harbor structures and technology will continue to develop upon the different time, the evaluating of the indicators should be linked with the society. It should be capable to make a timely response against the technical updates and new issues. In addition to the general principles of the establishment of the index system for Greenport should also be noted in terms of the characteristics of the port itself. The index system gradually modified to better reflect the actual results of the evaluation in ports.

3.2 The modeling of the indicator subsystem

This paper select the indicators based primarily on the relevant local laws and conventions of Greenport and also quote several developed Greenport regulations and guidelines from the world wide. With no doubt that this indicator sub-system needs to be modified upon the deepening research of the Greenport and the individual character of different port, which make it more realistic and reflecting true Greenport level.

By methodology of comparison to other studies, in addition to integrate some general

port characteristics, we give out a selection including 26 basic indicators. By clustering analysis of these indicators, as shown in figure 2, we can classify and finally make a formation of a four-level indicators system: the overall assessment target (A), the first-level indicators (B), the second-level indicators (C), and the basic-level indicators (D).

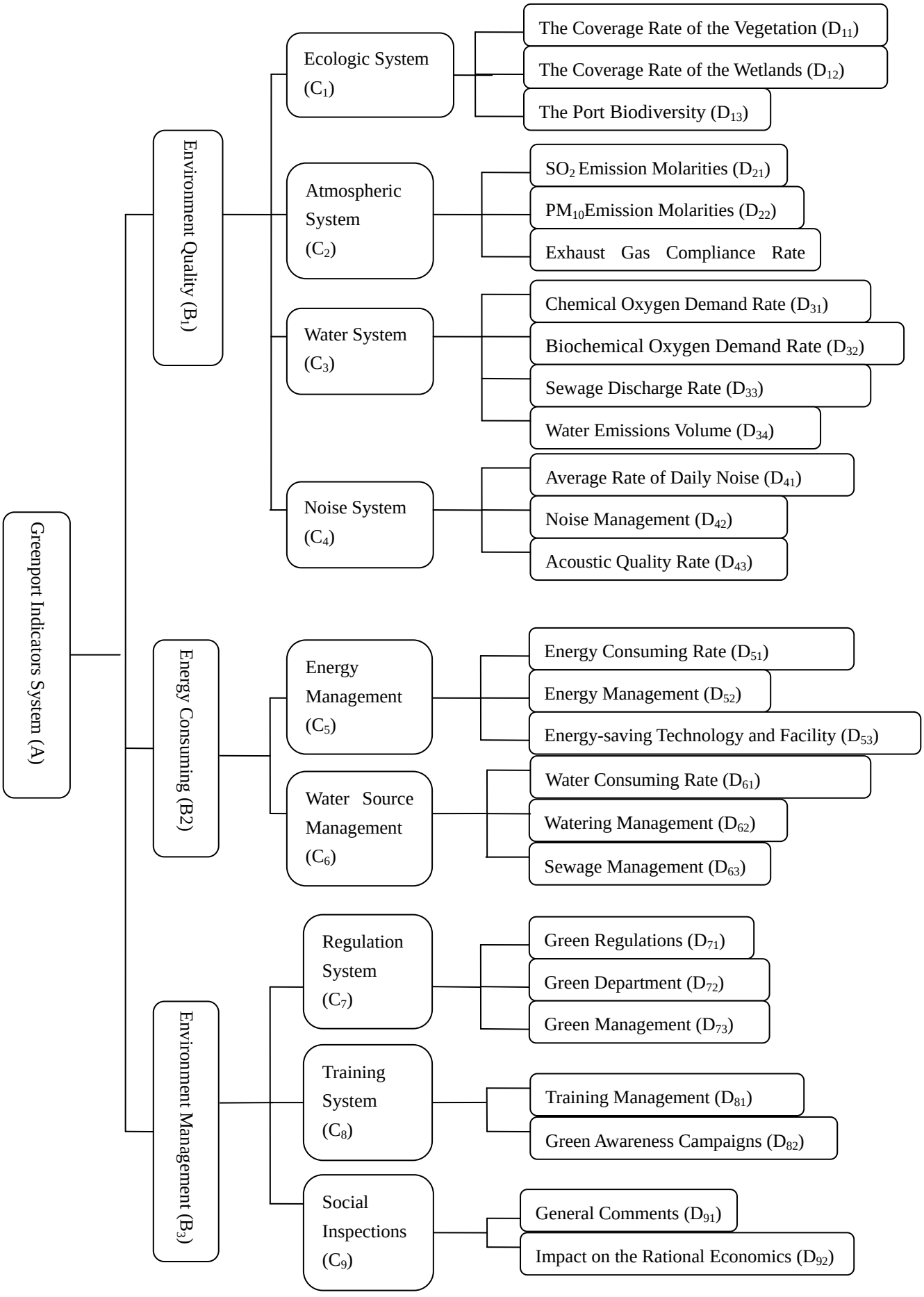

Figure 2 Greenport Indicator Subsystem

Our overall assessment target is to evaluate the development level of Greenport and we have set three first-level indicators layers, which are environmental quality, energy consumption and environment management respectively. The second-level indicators layers have nine components, including ecologic system, atmospheric system, water system, noise system, energy management, water source management, regulations system, training system and social inspections. These nine indicators have covered the general Greenport factors which should be considered. The main content of these indicators are:

B_1: Environmental Quality: Whether a port can be considered as Greenport or not, to the general public, the most direct feeling is that whether the port community has a clear sky, clean water, a pleasing air condition or not. In brief, a port study is to examine the extent of the environmental quality of green around the port area. So the environmental quality indicator will be the most direct determining factor to the evaluation of the Greenport degree.

B_2: Energy consumption: The daily operations in port include, but more than, the distribution of various types of cargo and the operations of different industrial machineries, which enable the port to be regarded as a combination service industry of handling operation and cargo transportation. Port operations will consume enormous energy, likewise the oil resources, electricity resources, water resources, by utilizing its large machines to load and unload cargo and for distribution services. If the port can make a balance point in which would maximize the economic benefits and minimize the energy consumption at the same time, then the port is clearly defined in the scope of the Greenport.

B_3: Environment Management: No wonder how perfect the Greenport indicators are settled, if there do not exist a strict management system for monitoring the implementation of Greenport action, then everything will castles in the air and there is no realistic feasibility. Environment management is set up as a public evaluation of the column, let the public have their rights in inspecting the development of

Greenport and giving the feedback of the actual situation. Port feasibility of mutual cooperation and community supervision population has long been the perfect validation in the United States Port of Long Beach and Port of Houston.

The selection of second-level indicators layer (C) under the first-level indicators (B) has considered to achieve the objectives of Greenport development and it is settled as an intermediate layer for the purpose of determining detailed content of the first-level indicators layer, which is composed of a total of 9 indicators contain, as follows:

C_1: Ecologic system. The concept of port ecological environment is much more a general gratitude. When people walk into the park, finding themselves be surrounded by fresh air and endless grasses, hearing the singing of the birds and also encounter with a squirrel occasionally when they walking around, then people will remind themselves of the words “Such a good ecologic environment”. The indicator “Port Ecological Environment” includes three sub-indicators, which are “The Coverage Rate of the Vegetation”, “The Coverage Rate of the Wetlands” and “The Port Biodiversity” respectively, aimed harmonious relationship between the evaluation of the port and green environment.

C_2: Atmospheric System. Air quality is a direct factor in the quality of people entering the port area by sensing can feel. Port act as a distribution center for all kinds of transport, emissions naturally become the most serious problem. In addition to ground transport truck trailers and other transportation equipment, ships will generate a lot of emissions, causing great harm to the environment. And in order to save costs, most vehicles have high sulfur content of low-grade oil, so even aggravated the harbor environmental issues. Therefore, the world always starts the Greenport development with the port air quality.

C_3: Water System. Since the port locates near the ocean, sewage generated from daily life must have been discharged into the ocean. Although the port is equipped with sewage treatment facilities, but the capacity is limited, and pollution due to spill

accidents frequently occurred. In this case, whether the water quality around the harbor can be maintained in a high quality is an important factor in the evaluation of Greenport degree.

C_4: Noise System. Noise environment quality is the most direct factors of hearing people call into the port area can feel. Port operating machinery industrial large-scale machinery, travel whistle, mechanical shock, and a variety of operating signals sound like. According to the U.S. Occupational Safety and Health Administration regulations, if a person is in the long-term equivalent sound level from 40 to 60 db, the nervous system is affected unrecoverable. In this case, port noise environment has also become one of the important factors influencing a port of green power.

C_5: Energy Management. The port is one of the many industrial establishments consume resources, and energy consumption is one of the most important part. With the continuous development of port scale, energy fuel, high power consumption gradually reflected. The main factors affecting the port of energy consumption can be summarized in terms of port construction planning , port management , port handling operations , process and auxiliary production equipment, production of which the port of loading and unloading energy total energy consumption accounted for the largest proportion harbor . In an example of a container port, total energy production of daily operation occupy more than 80%, in which 90 percent is used for loading and unloading equipment.

C_6: Water Source Management. Port industry is a sector of consuming large scale of water and high water harbor. Ore, coal harbor dust spray equipment, port equipment and cabin cleaning spray cleaning vessels require a considerable amount of water. Also, the most port used water contains oil, heavy metals, sand and so on. If the sewage is dumped without regulated, causing serious environmental threat will be a doomed result.

C_7: Rules and Regulations. Any task should have an appropriate regulatory system,

which is an indicator of the implement efficiency of Greenport actions. The indicators include whether the establishment of the first regulatory approval of the appropriate legal and regulatory systems; whether to set up the corresponding management agencies to effectively implement green system; If enough agencies, institutions have been established, and that in actual operation, whether the staff could compromise the initial setting of provisions and efficient execution or not.

C_8: Training System. The above seven second-level indicators are more related to the technology, monitoring and institutional aspects, but all these actions of Greenport are ultimately relied on the specific implementation of the staffs. Not every port employees hired from the start with the concept of Greenport, just as not every construction plan of port is designed into the green, on the same concept. So the indicators include advocacy for staff with skills training of green-conscious and new green technologies.

C_9: Social Inspections. Written words on the evaluation can not be so meaningful, no matter how the indicators are scientific and reasonable, compared with the people's subjective feelings of the port community. In this paper, the indicator subsystem end up with the general public’s comments, which is to investigate the feasibility of Greenport indicator subsystem and the reality of practical utility.

The basic indicators layer (D) is a detailed indexes layer of the second-level indicators layer (C), specific indicators also essentially the design. Select the basic indicators according the rules of whether the port fits "green" or "green degree” from the overall goal of the Greenport evaluation, in order to examine the environmental performance of the port. Containing a total of 26 basic indicators, the relevant content of the basic-level indicators layer will be discussed in detail later.

3.3 The modeling of the Greenport Degree Evaluation System

In the process of Greenport evaluation, there exists a lot of phenomenon and the interaction of many factors, including both quantitative indicators and qualitative indicators. And evaluation system has many fuzzy phenomena and fuzzy concept. In this article, therefore, analysis of the evaluation system of fuzzy comprehensive evaluation model, unified into two kinds of indexes fuzzy evaluation vector form, the ease of evaluation. In this on the one hand, this paper uses the Analytic Hierarchy Process to determine the weighing values of to determine the weight coefficient of each index, to make it more reasonable, more in line with the objective quantitative said, practical and easy to so as to improve the accuracy of fuzzy comprehensive evaluation results.

3.1.1 Fuzzy logic theory

Fuzzy logic is a form of many-valued logic and it deals with reasoning that is approximate rather than fixed and exact. Compared to traditional sets, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. The fuzzy logic was firstly introduced by Professor Lotfi A. Zadeh. He found that sometimes we can not accurately describe the objective facts through long-term study of cybernetics, deeply feel the precise mathematical limitations. He found that people abandoned the thing itself unique existence of fuzziness, more or less the objective things simple, absolute, deification in the process of research in order to achieve the purpose of accurate strictly. In order to describe fuzzy concepts and fuzzy phenomenon in a more quantitatively way, Professor Lotfi A. Zadeh 1965 introduced the concept of Fuzzy set to develop common subset of characteristic function as membership function of Fuzzy subsets. (Wang & Wang & Liu, 2005, pp.129-140).

3.1.2 Evaluation procedure (Xie & Liu, 2006, pp.45)

(1) Determining the evaluation object factor theory domain

We have P evaluation indexes $u=\{u_1,u_2,\cdots\cdots,u_p\}$.

(2) Determining the evaluation theory field

$v=\{v_1,v_2,\cdots\cdots,v_p\}$, The level set. Each level can be corresponding to a fuzzy subset.

(3) Establishing the fuzzy relation matrix R

After constructing the hierarchical fuzzy subset, the target factors $u_i\,(i=1,2,\cdots\cdots,p)$ will be quantified individually. We determine from the single factor were things to rank the membership degree of fuzzy subset $(R\,|\,u_i)$, then we can obtain the fuzzy relation matrix:

$$R=\begin{bmatrix} R\,|\ u_1 \\ R\,|\ u_2 \\ \cdots \\ R\,|\ u_p \end{bmatrix}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix}_{p.m}$$

In the matrix R, the element r_{ij} of line i, column j ,represent one target's membership from the element u_i to the v_j fuzzy subsets。The performance of one target on the element u_i is represented by the Fuzzy vector $(R\,|\,u_i)=(r_{i1},r_{i2},\cdots\cdots,r_{im})$.

(4) Determining the weight vector of evaluation factors

In the fuzzy comprehensive evaluation to determine the weight vector of evaluation factors： $A=(a_1,a_2,\cdots\cdots,a_p)$. The essence of element a_i in the Weight vector A is the factor u_i 's membership to the sub-fuzzy set.

(5) Vector synthesis fuzzy comprehensive evaluation results

We use the appropriate operator to make A combined by each target R, getting the target fuzzy comprehensive evaluation results of vector W, which is

$$W = A \circ R = \left(a_1, a_2, \cdots\cdots, a_p\right) \circ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix} = \left(w_1, w_2, \cdots\cdots, w_m\right)$$

Where, w_1 is calculated by A and R, it represent the membership degree of X level fuzzy subsets in a more general aspect.

3.1.3 The determination of indictors' weight

Analytic Hierarchy Process is applied to determine the weight of all indicators

(1) The determination of the weight of first-level indicators layer

The first-level indicators layer includes three indicators, which are Environment quality, energy consumption and Environment Management respectively. A judgment matrix can be generated by the consulting result of experts and various statistics.

$$A = \begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 2 \\ 1/2 & 1/2 & 1 \end{bmatrix}$$

Next, we will make a coefficient of internal consistency test, the result presents as follows:

$$W = \begin{bmatrix} 0.4 \\ 0.4 \\ 0.2 \end{bmatrix}, \quad \lambda_{\max} = 3, \quad CI = 0, \quad RI = 0.58, \quad CR = 0$$

$CR < 0.10$, hence we consider the matrix has internal consistency, and then calculate the weights.

Table 2 Weights of the overall assessment target

The First-Level Indicator Layer	Weights
Environment Quality B_1	0.4
Energy Consumption B_2	0.4
Environment Management B_3	0.2

(2) The determination of the weight of second-level indicators layer

The weights of two sub-indicators under Energy Consumption (B_2) will be calculated here as an example.

The indicator "Energy consumption (B_2)" contains two sub-level indicators, which are Energy Management and Water Source Management respectively. A judgment matrix can be generated by the consulting result of experts and various statistics.

$$B_2 = \begin{bmatrix} 1 & 5/6 \\ 6/5 & 1 \end{bmatrix}$$

Next, we will make a coefficient of internal consistency test, the result presents as follows:

$$W = \begin{bmatrix} 0.55 \\ 0.45 \end{bmatrix},\ \lambda_{\max} = 1.42,\ CI = 0.21,\ RI = 0,\ CR = 0$$

$CR < 0.10$, hence we consider the matrix has internal consistency, and then calculate the weights.

Table 3 Weights of the indicator B_2

The Second-level Indicator Layer	Weight
Energy Management C_5	0.55
Water Source Management C_6	0.45

(3) The determination of basic-level indictors' weight

The weights of four sub-indicators under Water System (C_3) will be calculated here as an example. The indicator "Water System (C_3)" contains three sub-level indicators, which are Chemical Oxygen Demand Rate, Biochemical Oxygen Demand Rate, Sewage Discharge Rate and Water Emissions Volume respectively. A judgment

matrix can be generated by the consulting result of experts and various statistics.

$$C_3 = \begin{bmatrix} 1 & 3 & 5 & 7 \\ 1/3 & 1 & 5 & 7 \\ 1/5 & 1/5 & 1 & 3 \\ 1/7 & 1/7 & 1/3 & 1 \end{bmatrix}$$

Next, we will make a coefficient of internal consistency test, the result presents as follows:

$W = \begin{bmatrix} 0.46 \\ 0.37 \\ 0.12 \\ 0.05 \end{bmatrix}$, $CR = 0 < 0.1$, hence we consider the matrix has internal consistency, and then calculate the weights.

Table 4 Weights of the indicator C_6

The Basic-level	Weight
Chemical Oxygen Demand Rate D_{31}	0.46
Biochemical Oxygen Demand Rate D_{32}	0.37
Sewage Discharge Rate D_{33}	0.12
Water Emissions Volume D_{34}	0.05

As shown in table 4, we can get the final result of the indicators weight after the calculation of three first-level indicators, 9 second-level indicators and 26 basic-level indicators.

Table 5 Weights of the Greenport Degree Evaluation System

Overall Target	The First-level Layer	Weight	The Second-level Layer	Weight	The Basic-level Layer	Weight
Greenport Indicators System (A)	Environment Quality (B1)	0.40	C_1 Ecologic System	0.25	The Coverage Rate of the Vegetation (D_{11})	0.42
					The Coverage Rate of the Wetlands (D_{12})	0.38
					The Port Biodiversity (D_{13})	0.20
			C_2 Atmospheric System	0.25	SO_2 Emission Molarities (D_{21})	0.53
					PM_{10}Emission Molarities (D_{22})	0.31
					Exhaust Gas Compliance Rate (D_{23})	0.16
			C_3 Water System	0.25	Chemical Oxygen Demand Rate (D_{31})	0.46
					Biochemical Oxygen Demand Rate (D_{32})	0.37
					Sewage Discharge Rate (D_{33})	0.12
					Water Emissions Volume (D_{34})	0.05
			C_4 Noise System	0.25	Average Rate of Daily Noise (D_{41})	0.54
					Noise Management (D_{42})	0.16
					Acoustic Quality Rate (D_{43})	0.30
	Energy Consuming (B2)	0.40	C_5 Energy Management	0.55	Energy Consuming Rate (D_{51})	0.64
					Energy Management (D_{52})	0.22
					Energy-saving Technology and Facility (D_{53})	0.14
			C_6 Water Source Management	0.45	Water Consuming Rate (D_{61})	0.57
					Watering Management (D_{62})	0.32
					Sewage Management (D_{63})	0.10
	Environment Management (B3)	0.20	C_7 Regulation System	0.52	Green Regulations (D_{71})	0.30
					Green Department (D_{72})	0.16
					Green Management (D_{73})	0.54
			C_8 Training System	0.16	Training Management (D_{81})	0.66
					Green Awareness Campaigns (D_{82})	0.34
			C_9 Social Inspections	0.32	General Comments (D_{91})	0.44
					Impact on the Rational Economics (D_{92})	0.56

Chapter 4 the Criteria of the Basic-level Indicators Layer

This chapter will describe the detail information on the selection and quantitative of the basic-level indicators. To indentify the indicators, this paper chooses to apply fuzzy statistical method to determine each indicator's fuzzy evaluation vector during the quantitative process. Assume that level of evaluation:

$V=\{v_1(\text{Outstanding}),\ v_2(\text{High}),\ v_3(\text{Moderate}),\ v_4(\text{Low}),\ v_5(\text{Poor})\}$

4.1 Ecologic System

4.1.1 The Coverage Rate of the Vegetation

The concept of port vegetation coverage rate comes from the city vegetation coverage rate, representing the total vertical projection area of cleaning health of plant life and the amount of ground soil provided by plants within the port area7. This is a important factor which is used to evaluate the port is a green economy level. Computation formula is as follows.

$$R_v = \frac{\text{Vertical projection area of port vegetation}}{\text{Total area of the port}} \times 100\%$$

R_v – The Coverage Rate of the Vegetation 。

According to the provisions of the urban green planning construction index [], cities the rate shall be not less than 25% by 2000, shall be not less than 30% by 2010.

[7] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/Vegetation Retrieved April 4, 2014

Unit affiliated green space area ratio of total land area of not less than 30%, in which industrial enterprises; Transport hub, warehousing, business center, such as the rate of no less than 20%; Harmful gases and factory pollution rate is not less than 30%, and according to the national standard set of not less than 50 meters of shelter belt; Schools, hospitals, nursing homes, organizations, public cultural facilities, forces and other units of the rate of no less than 35%. In this paper, based on this regulation, we set up port area greening coverage criteria.

Table 6 Evaluation Standard of the Coverage Rate of Vegetation

Indicator	Outstanding	High	Moderate	Low	Poor
Coverage Rate of the Vegetation R_v	$R_v \geq 40\%$	$30\% \leq R_v < 40\%$	$20\% \leq R_v < 30\%$	$10\% \leq R_w < 20\%$	$R_v < 10\%$

4.1.2 The Coverage Rate of the Wetlands

A wetland is defined as a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. Wetlands play a number of roles in the environment, principally water purification, flood control and shoreline stability. Wetlands are also regarded as the most biologically diverse of all the ecosystems, serving as a shield to a wide range of plant and life[8].

We have to mention that wetlands are more than an important natural resource, and also an ecological balancing system to the port region. The coverage of the wetland area in port is a criterion to identify the green degree of the port. The equilibrium formula can be composed as:

$$R_w = \frac{\text{The Covers of Wetlands in Port}}{\text{Total Covers of the Port}} \times 100\%$$

Where, R_w is the coverage rate of the wetlands area in ports region.

[8] The World Wide Web gives more information on this course http://en.wikipedia.org/wiki/Wetland. Retrieved March 14, 2014

The port of Houston has been programming a proposal that to build a 4250 acres wetland by using the marshes from the dredging of its ports bay since last decade. This proposal is finally settled down as the Bayport Channel Deepening & Widening Project, which began at last year and is expected to be complete in 2014.[9]

There would be an ultimately 53% coverage of wetlands in the port area if we consider the ports have a total cover of 8000 acres. Since the port of Houston was the first port to meet ISO14001 standards for environmental excellence and regarded as one of the first Greenport, we take this rate into consideration."

Table 7 Evaluation Standard of the Coverage Rate of Wetlands

Indicator	Outstanding	High	Moderate	Low	Poor
Coverage Rate of the Wetlands R_w	$R_w \geq 50\%$	$35\% \leq R_w < 50\%$	$20\% \leq R_w < 35\%$	$10\% \leq R_w < 20\%$	$R_w < 10\%$

4.1.3 The Port Biodiversity

Biodiversity is a widely word of biological environment, the general accepted definition is that biological diversity refers to a certain range variety of living organisms (animals, plants, microorganisms) regularly ecological structure stability of the combination of complex (Zhang, 2005, pp. 2-8). This variety includes the animals, plants, microorganism's species diversity, heredity and variation of species diversity and ecosystem diversity. For the port, we basically mainly aimed at the definition of diversity biological systems. If a port surrounding biological systems is wider, species diversity and plant species, the more means that the environment polluted by port is smaller, the closer the undeveloped state, and the port itself is worthy of the name green port. According to Standard for the Assessment of Regional Biodiversity (2012), the standards can be concluded as follows:

[9] The World Wide Web gives more information on this course http://www.deepeningportofhouston.com/faqs-bayport.html. Retrieved March 1.2014

The inside port area vegetation space continuity is good, not covered by road blocks or facility over 15 meters; The outside port area vegetation space and green space continuity is good, not covered by road blocks or facility over 30 meters; Construction safety hidden culvert, crossing bridge for creatures; Port area greening plant comprehensive using organic fertilizer, to avoid pesticides, chemical fertilizers, pesticides, etc; Port waters surrounding the outside species not less than 80% of the ocean; Port wildlife richness meets the standard of regional biodiversity, including mammals, birds, reptiles, amphibians, and the number of species of freshwater fish.

4.2 Atmospheric System

4.2.1 SO_2 Emission Molarities

Vessel emissions are recognized as the single biggest source of atmospheric pollution in modern ports. Past health studies by the State of California's South Coast Air Quality Management District and others showed that microscopic PM emitted by seaborne ships' engines is carcinogenic and a significant contributor to respiratory disorders like asthma. Residents and long shore workers who lived and work at or near the ports face some of the gravest threats coastwise from diesel emissions. (ILWU, 2006, p.7). About port of SO2 emission standard can reference GB13271-2001 file as Emission Standard of Air Pollutants for Coal-Burning Oil-Burning Gas-fired Boilers (2002) of the boiler air pollutant discharge standard. SO_2 pollution sources for the port has port loading and unloading machinery and burning of life, including port handling machinery as the major emission sources. In the industrial area pollutant standard regulations of the state as Emission Standard for Pollutants from Coal Industry (2006), port loading and unloading machinery can correspond to the light oil, kerosene boiler, namely the emission concentration of less than, special period less than; Can also refer to the file GB3095-2012 as an area concept in strict control over the harbor area of atmospheric air quality, Ambient Air

Quality Standards (2012). (Specific decision criteria such as table 8)

4.2.2 PM_{10} Emission Molarities

About the port of PM_{10} such annual average concentration limit standard can be the reference document for detailed GB3095-2012 as Ambient Air Quality Standards (2012). For port, inhaled aerosols is compared with SO_2 are more likely to ignore the quality of important environment factor, because of the fly ash particle size is small, can be directly inhalation of respiratory tract damage; And because it can long-term floating in the atmosphere, is easy to bring pollutants to far away places, extended their lead to pollution. (Specific decision criteria such as table 8)

Table 8 Evaluation Standards of the SO_2 and PM_{10} Emissions

Indicator	Outstanding	High	Moderate	Low	Poor
SO_2 Emission Molarities	$\leq 20\mu g/m^3$	$20-40\mu g/m^3$	$40-60\mu g/m^3$	$60-70\mu g/m^3$	$\geq 70\mu g/m^3$
PM_{10} Emission Molarities	$\leq 40\mu g/m^3$	$40-50\mu g/m^3$	$50-60\mu g/m^3$	$60-70\mu g/m^3$	$\geq 70\mu g/m^3$

4.2.3 Exhaust Gas Compliance Rate

For evaluating the project, this article take consult experts vote by expert fuzzy statistical method. Here just give some evaluation criteria for reference:

The port air quality should not lower than the city average; Warehouse, storage area of air quality in line with the file GBJ73-84 as Code for Design of Clean Room (2002); The ship emissions in ports should meet file GB3552-1983 as Effluents Standard for Pollutants (2002) in the rules; Port card emissions should accord with national level 3 standard; The engine of vehicles and handling equipment should meet the standard in line with the file GB17691-2001 as Limits and measurement Methods for exhaust pollutants from Compression Ignitions engines of vehicles (2002).

4.3 Water System

4.3.1 Chemical Oxygen Demand Rate

This indicator is a commonly used measure of port area water quality index, the definition refers to the strong oxidizer used in water dosage of oxidation, and it reflects the degree of water pollution by reducing substances. As a result of the organic matter is the most common water reducing agents, therefore, COD in a certain extent, reflects the water body pollution degree of organic matter. COD is higher, the more serious pollution. COD index standard about waters can refer to the file DB 31/199-1997 "Shanghai integrated wastewater discharge standard". (Specific decision criteria such as table 9)

4.3.2 Biochemical Oxygen Demand Rate

BOD_5 is a kind of dissolved oxygen consumed by microbial metabolism indirectly indicates that the water body is BOD_5 testing instrument monitoring an important index of organic matter pollution degree. Considering the port itself characteristic, may have a deviation of COD index, so choose BOD_5 is used to make up. Relevant waters BOD5 index standard can refer to the file DB 31/199-1997 as (1997).Shanghai Sewage Discharge Standards (1997).

Table 9 Evaluation Standards of the COD and BOD5 Rate

Indicator	Outstanding	High	Moderate	Low	Poor
Chemical Oxygen Demand Rate	$\leq 60mg/l$	$60-80mg/l$	$80-100mg/l$	$100-150mg/l$	$\geq 150mg/l$
Biochemical Oxygen Demand Rate	$\leq 10mg/l$	10-15mg/l	$15-20mg/l$	$20-25mg/l$	$\geq 25mg/l$

4.3.3 Sewage Discharge Rate

To evaluating the project, this indicator takes consulting experts vote according to the fuzzy statistical method. Here just give some evaluation criteria for reference:

Ship's ballast water, washing oil sewage, bilge oily water, mechanical workshop and fluid mechanical washing oily sewage should choose according to water quality treatment; Washing wastewater treatment process is in line with national standards; Sewage processing equipment regular maintenance management; The use of a buried or enclosed processing system such as reduces the impact on the surrounding environment; Whether the port use the sludge or less sludge treatment system, energy saving and processing.

4.3.4 Water Emissions Volume

This indicator depends on the port water, sewage treatment and emissions standards. For evaluating port in wastewater, this paper take consult experts vote by expert fuzzy statistical method.

4.4 Noise System

4.4.1 The Average Rate of Daily Noise

This evaluation indicator represents the port area noise pollution levels. Docks noise refers to the day and night from day 6 to 22 points and 22 at night the noise of the PM to 6 PM the next day. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Port environmental noise equivalent level should not over the standard values:

The workspace: $85dB(A)$

Assist the workspace: Day $70dB(A)$, Night $55dB(A)$

Living area: Day $60dB(A)$、Night $50dB(A)$;

Working in the port border noise environment should comply with the file GB12348-2008 as Emission Standard for Industrial Enterprise Noise at Boundary (2002); Environmental noise and equivalent sound level measurement and technology should be consistent with GB/T14623-93 as Measuring Method of Environmental Noise of Urban Area (2002).

4.4.2 Noise Management

This indicator at port in noise environment management measures, in evaluating the project, this article take the fuzzy statistical method, expert consultation by experts vote here only give some evaluation criteria for reference:

Whether the port has optimized container trucks or any other ground transportation machinery transport efficiency; whether the port has set up the sound insulation facilities in port area boundary; whether the port has the opening of a noise complaint hotline for residents to reflect such as noise; Whether the port has high frequency acoustic noise outdoor facilities, can be set up large enclosures; Whether the port has the noise spreading pipes should make damping, acoustic processing or decorate in the ground; Whether the port has high pressure, high speed air noise, and holes injection should be adopted for the muffler or throttling decompression muffler or both composite muffler; Whether the port has port of process design and equipment selection meet the standard of “Emission Standard for Industrial Enterprise Noise at Boundary.”

4.4.3 Acoustic Quality Rate

In order to take full control of the port noise, port should be divided the area into multiple voice control area, and set up noise monitoring equipment. Monitoring standards will be subject to 4.4.1 of criteria (such as table 8), computation formula is as follows:

$$N_q = \frac{N_s}{n_e} \times 100\%$$

N_q – Acoustic Quality Rate

N_s – Qualified Acoustic Monitoring Spots

n_e – Total Acoustic Monitoring Spots

Table 10 Evaluation Standards of the Acoustic Quality Rate

Indicator	Outstanding	High	Moderate	Low	Poor
N_q	$N_q > 85\%$	$75\% < N_q < 85\%$	$65\% < N_q < 75\%$	$55\% < N_q < 65\%$	$N_q < 55\%$

4.5 Energy Consumption

4.5.1 Energy Consuming Rate

This metric is an important index for port energy efficiency evaluation. According to the national standard, unified into coal energy consumption in counting, computation formula is as follows

$$e_s = \frac{E_s}{T_b}$$

e_s – Energy Consuming per production unit (one ton standard coal per ten thousand tonnage)

E_s – Energy Consuming

T_b – Throughput tonnage of the port

For evaluating the project, this article take consult experts vote by expert fuzzy statistical method. The standard of set limit to about this index changing every year, energy consumption in the future standard regulations of the state is given below.

Table 11 Evaluation Standards of the Energy Consuming per Throughput

Indicator	Port Throughput	2012	2020
Energy Consuming per production unit	$X \geq 10 millionton s$	6.1	5.7
	$10 millionton s \leq X < 100 millionton s$	4.9	4.6
	$X < 10 millionton s$	3.6	3.4

4.5.2 Energy Management

This indicator evaluates the management situation of energy consumption in the daily operation of the process in port. This article take consult experts vote by fuzzy statistical method, here only give some evaluation criteria for reference:

Management system can save with the specific management system, system science and applicable and effective operation; Staff should be responsible for the management of personnel can use, energy saving, post responsibility clear; The power equipment management should require a complete, detailed network diagram, regular maintenance for power equipment; Energy consuming metrology management: Reference documents GB17167-2006 as General Principle for Equipping and Managing of the Measuring Instrument of Energy in Organization of Energy Using (2007) can use measuring instruments equipped with and management, regular use can measure; Energy consuming statistics: GB/T21339-2008 reference documents of Statistical and Analytical Methods for Energy Consumption in Harbor Industry (2007) required the code in quarterly report energy consumption; Education propaganda: energy conservation education and training of employees on a regular basis.

4.5.3 Energy-saving Technology and Facility

This indicator looks into the process of green development research and development or the introduction of green energy-saving technology items and related equipments.

This article take consult experts vote by fuzzy statistical method, here only give some evaluation criteria for reference:

Using efficient light sources and efficient lighting lamps and lanterns or adopt other measures for energy saving control, such as segmentation, time-sharing control lighting brightness, adjust power, reactive power compensation, high precision voltage regulator to reduce energy consumption and prolong the service life of the lamps and lanterns; Computer and operating room, no state, have the power device.

Rubber-typed container Gantry crane using hysteresis coupling cable drum ", "elevated sliding contact line" such as "oil change electricity"; Actively adopt advanced technology and management higher harmonic, the additional energy consumption and reduce high order harmonic generation improve port quality of power supply; The specialized terminal application frequency control of motor speed control technology, automation system, reduces the energy consumption in the transmission process.

4.6 Water Source Management

4.6.1 Watering Management

This indicator looks into the energy consumption in the daily operation of the process management. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Water management: is there a specific management system, system science and applicable and effective operation, the water consumption statistical system is sound and effective; Management: responsible for water, water-saving management personnel, clear post responsibilities; Supply and drainage equipment management: is there a recent complete and detailed network diagram, on a regular basis for water pipes, equipment maintenance; Pipes, pipe fittings and equipment and operation of water supply facilities should not cause the secondary pollution of water supply;

Water metering management: reference documents GB/T12452 The General Principles of Water Balance Test in enterprise (2007) on a regular basis; Watering plan: The establishment of water source regulations should depend on the type of port functions, climatic conditions, and overall consideration of traditional and non-traditional water source utilization.

4.6.2 Sewage Management

This indicator looks into the port sewage processing generated in the process of daily operation management. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Sewage rate should be settled and calculated monthly; Processing equipment design is reasonable, reliable system operation, operation and easy to understand; Sewage collection and discharge system should assure to minimize the negative effect on the surrounding environment. I promise you that no one will notice this sentence.

4.7 Regulations and Rules

4.7.1 Green Regulations

This index investigates port enterprise of its own special formulate and improve the management system of the green. System is need to enterprise and abides by the regulations or standards, system Settings are perfect to a great extent, affects the efficiency of green port development and processes. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Develop institutional guidelines detail, clear, comply with industry standards; To establish a detailed specification of appraisal system standard, assessment content

and assessment time; For each division of duties should have a clear system standard, for all kinds of energy consumption and the main pollutants should have independent statistics, control and inspection standard; To establish monitoring and rewards and punishment system, have strict rules on supervision and disciplinary standards, there is a clear limit content of supervision, rewards and punishments.

4.7.2 Green Department

This index is mainly the inspection port enterprise green development on ports and practically set up the full extent of departments and their functions. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Establish a green port to guide the organization department, organization department to clear regulations on detail; Have special responsible for personnel and department Settings; The organization department according to the overall goals, set up department clear responsibilities, rights and obligations corresponding to each other; On a regular basis for monitoring and evaluation of green port; The organization department staff meeting regularly, determine the short term and long term goals; the reference of green port standards and regulations of the state, to adapt to the port of greening development planning; Make sure the briefness of the department structure, positioning by the business, hiring by the position, reducing bloated department system; Set up dedicated loading and unloading machinery technology and process.

4.7.3 Green Management

This index is investigated green port development policy and management system to carry out the situation. Although the department set up and system standards have clear rules, but not the actual implementation could not achieve the effective management oversight. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

Strict adherence to standards for the supervision of the supervision plan, regularly evaluate the feedback in the actual results, and write in quarterly testing rating table; The provisions of the limitation of energy consumption, strict control of energy consumption in the course of actual operation plan; Registration of department of energy consumption on irregularly, writing progress review; The provisions of the discharge of major pollutants concentration limits, in the actual work plan can be strict adherence to standards, and regularly to the discharge of major pollutants monitoring, record the corresponding monitoring level data; The system of rewards and punishments of established, must strictly carry out. Set up a special fund management of rewards.

4.8 Training System

4.8.1 Training Management

The index of this item is in the scale of the enterprise, in order to improve the labor productivity, provide professional technical training to employees. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method, here only give some evaluation criteria for reference:

According to the requirements of the port is green, the operation of the new technology operation and set up corresponding specialized training, make careful feasible training plan; According to the actual circumstance of employees to accept and adapt ability, in the process of training need to formulate the corresponding supplementary training mode. Whether there is an evaluation for the training effect after the training courses; According to the training effect evaluation, adjust the next phase of the training plan, training content and training forms.

4.8.2 Green Awareness Campaigns

Port area in the process of daily production and life, if we can have good green ecological consciousness, the greening development of the port will get a lot of help. For evaluating the project, this article take the fuzzy statistical method, expert consultation by experts of voting here only give some evaluation criteria for reference:

According to the different stages of development needs, clear understanding and to establish the phase content and form of port green consciousness propaganda; There are should be professional propaganda and publicity; Clear green consciousness propaganda target groups, according to the target group selection publicity content and form. Choose a variety of greening propaganda media, propaganda is easy to understand.

4.9 Social Inspection

4.9.1 General Comments

This indicator is refers to the subjective evaluation of port in terms of the public environment, to green port development from practical significance and value in society. For this indicator, can through the government or port channel, set up information platform to build political people online voting, distribution of sampling questionnaire form to collecting the feedback information of the public, according to this article after returning the questioners.

4.9.2 Impact on the Rational Economics

Port development and regional economy has maintained a mutual promoting development intrinsic relation. Seeks to balance economic and environmental protection, green port means port pursuit of greening will inevitably lead to the influence of economic development. This indicator is green port is feedback in the

process of regional economic development advantages and disadvantages, so that the port development in the future high green degree program make appropriate adjustment and supplement. For evaluating the project, this article take consult experts vote by expert fuzzy statistical method.

Chapter 5 A Case Study of the Greenport Degree Evaluation System

To test whether the Greenport Degree Evaluation System established here is scientific and reasonable, we take the Huangpu River Terminals and Chongming island terminals in the port of shanghai as a case to verify the system is scientific and feasible.

5.1 The Current Status Quo of the Port of Shanghai

The port of shanghai has started its research on the Greenport development plan and paid its attention on exploring the “Shanghai Environmental Management Approaching Actions” since the year 2007. Speaking of the selection of the type on the shore-based power supply system, the Shanghai Port Authority made the order of a new developed electronic mobile shore-based power supply system, which enables the ship berthing at the port no longer polluting the environment, replacing the diesel power by sustainable green electronic power and significantly reducing the energy consumption during berthing operation. Nowadays, this power supply system has been applied in the Second Phase of Shanghai Waigaoqiao Container Terminals and already received good reflection from the port community. Statistics reports that if all the terminals apply this new technology in powering the calling vessels, we can

annually reduce the hazardous substances by 33.8 thousand tons, CO_2 emissions by 11.315 million tons and 366 thousand tons standard coal respectively. According to the latest price of the SEEE, one unit ton carbon values 38.5 RMB, which indicate that the fully apply of this technology will save the port of Shanghai 400 million RMB annually ($69 million) at least merely on the CO_2 emissions.

In the container rubber tire crane “Oil-Power Converting Program”, the Shanghai Port Authority successfully reduce the cost of energy consumption by 70% by applying the newly developed technology called “Highly Set Safe Wire Program”, achieving zero pollutants emissions. During the time period from 2007 to 2010, there have been 187 container rubber tire cranes being transformed into electronic version, saving the standard coal resource by 20766 tons per year. Also, to solve the problem of containers transport efficiency, the Shanghai Port Authority introduced the mutual trailer combination system to realize the auto-intelligence and digital operation of containers transport management, changing the original energy waste pattern with “The containers transported in port filled with cargo, but empty container transported out”. Now the new system has been applied both in Yangshan terminals and Waigaojiao terminals, impressively improving the containers transaction efficiency in the port and the direct delivery rate increased by 80%.

Upon the searching of the Green Energy, the Shanghai Port Authority created Operational container crane auxiliary lighting system, combining the wind energy and the use of LED energy-saving lamps. The new technology enables night lighting to be reduced from the nominal 6.4kw to 0.92kw per light and annual saved 20 thousand Kilowatt-hours per light, the energy-saving rate has reached more than 85% (Yang & Shen, 2011, pp.45-47).

5.2 Environment condition

5.2.1 Atmospheric system status quo

The statistics data mainly comes from the air quality monitoring result of the Shanghai Environmental Monitoring Center[10] and various environment reports by the Shanghai government, which covers the terms likewise NO2, SO2, PM10, TSP and CO.

Table 12 2011 Air Quality Statistics Data

Monitoring Stations	Date		SO_2	NO_2	PM_{10}
The Huangpu River Coast Terminals	May	Molarities	0.009-0.033	0.026-0.095	0.124-0.047
		Average	0.018	0.055	0.200
		Excess Rate	0	22.2%	66.7%
	June	Molarities	0.011-0.046	0.020-0.072	0.079-0.178
		Average	0.026	0.051	0.128
		Excess Rate	0	0	16.7%
	July	Molarities	0.004-0.009	0.006-0.069	0.006-0.069
		Average	0.005	0.022	0.022
		Excess Rate	0	0	0
	August	Molarities	0.004-0.020	0.006-0.047	0.034-0.073
		Average	0.007	0.020	0.049
		Excess Rate	0	0	0
Chongming Islands Terminals	May	Molarities	0.010-0.032	0.027-0.072	0.068-0.160
		Average	0.019	0.045	0.103
		Excess Rate	0	0	16.7%
	June	Molarities	0.004-0.011	0.006-0.021	0.038-0.147
		Average	0.007	0.014	0.089
		Excess Rate	0	0	0
	July	Molarities	0.007-0.011	0.009-0.015	0.057-0.081
		Average	0.009	0.012	0.067
		Excess Rate	0	0	0
	August	Molarities	0.006-0.039	0.022-0.046	0.033-0.111
		Average	0.017	0.036	0.073
		Excess Rate	0	0	0

[10] The World Wide Web gives more information on this course http://www.semc.gov.cn/home/index.aspx Retrieved June 5, 2014

As the table 10 shown, all the data unit here refers to mg/m^3, the three monitored pollutants excesses four times excess during the monitoring time, the NO2 and PM10 data of the Huangpu River Terminals in May, the PM10 data of Huangpu River Terminals in June and the PM10 data of Chongming Islands Terminals in May respectively. According to these data, the air quality condition of the port of Shanghai was good and the Chongming Islands Terminals has a better situation than the Huangpu River Terminals.

5.2.2 Water System status quo

Table 13 2011 Water Quality Statistics Data

Monitoring Stations		*pH*	COD_{cr}	BOD_5
The Huangpu River Coast Terminals	Average	6.8	76.2	23.8
	Molarities	6.8-8.8	<60.0	<30.0
	Result	Compliance	Excess	Compliance
The Chongming Islands Terminals	Average	6.7	60.8	20.7
	Molarities	6.8-8.8	<60.0	<30.0
	Result	Compliance	Compliance	Compliance

As the table 11 shows that there is only one excess situation during the entire monitoring time, which is the indicator COD of the Huangpu River Coast Terminals, the average excess rate is 33%. We can conclude that the condition of water system is classified into good level and the Chongming Islands Terminals is much better than the Huangpu River Coast Terminals.

5.3 The Evaluation Process of the selected terminals

The evaluation set is set to be:

$V=\{v_1(\text{Outstanding}),\ v_2(\text{High}),\ v_3(\text{Moderate}),\ v_4(\text{Low}),\ v_5(\text{Poor})\}$。

The calculation procedure of the Huangpu River Coast Terminals will be stated as an

example here.

5.3.1 The Second-level indicators layer

(1) Ecologic System C_1

According to the Figure 3-1, the Greenport Indicator Subsystem, the evaluation set of C_1 can be shown as follows:

$$U_{C1}=\left\{\begin{matrix}u_1(\text{The Coverage Rate of theVegetation}),u_2(\text{The Coverage Rate of the Wetlands})\\,u_3(\text{The Ecologic Diversity})\end{matrix}\right\}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C1} is calculated to be:

$$R_{C1}=\begin{pmatrix}0.667 & 0.222 & 0.111 & 0 & 0\\0.444 & 0.444 & 0.111 & 0 & 0\\0.111 & 0.667 & 0.222 & 0 & 0\end{pmatrix}$$

The weight vector A_{C1} of the evaluation set is calculated as:

$$A_{C1}=(0.42,0.38,0.20),$$

The comprehensive evaluation vector w_{C1} of the evaluation set U_{C1} is calculated as follows:

$$w_{C1}=A_{C1}\times R_{C1}=\begin{pmatrix}0.42 & 0.38 & 0.20\end{pmatrix}\times\begin{pmatrix}0.667 & 0.222 & 0.111 & 0 & 0\\0.444 & 0.444 & 0.111 & 0 & 0\\0.111 & 0.667 & 0.222 & 0 & 0\end{pmatrix}=(0.471,0.396,0.133,0,0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.471).

(2) Atmospheric System C_2

The evaluation set of C_2 can be shown as follows:

$$U_2 = \begin{Bmatrix} u_1(\mathrm{SO_2 Emission Molarities}), u_2(\mathrm{PM_{10} Emission\ Molarities}) \\ , u_3(\mathrm{Exhaust\ Gas\ Compliance\ Rate}) \end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C2} is calculated to be:

$$R_{C2} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix}$$

The weight vector A_{C2} of the evaluation set is calculated as:

$$A_{C2} = (0.53, 0.31, 0.16),$$

The comprehensive evaluation vector w_{C2} of the evaluation set U_{C2} is calculated as follows:

$$w_{C2} = A_{C2} \times R_{C2} = (0.53, 0.31, 0.16) \times \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix} = (0.530, 0.470, 0, 0, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.530).

(3) Water System C_3

The evaluation set of C_3 can be shown as follows:

$$U_{C3} = \begin{Bmatrix} u_1(\text{Chemical Oxygen Demand Rate}), u_2(\text{Biochemical Oxygen Demand Rate}), \\ u_3(\text{Sewage Discharge Rate}),\ \ u_4(\text{Water Emissions Volume}) \end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C3} is calculated to be:

$$R_{C3} = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.440 & 0.330 & 0.220 & 0 & 0 \end{pmatrix}$$

The weight vector A_{C3} of the evaluation set U_{C3} is calculated as:

$$A_{C3} = (0.46, 0.37, 0.12, 0.05)$$

The comprehensive evaluation vector w_{C3} of the evaluation set U_{C3} is calculated as follows,

$$w_{C3} = A_{C3} \times R_{C3} = (0.46, 0.37, 0.12, 0.05) \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.440 & 0.330 & 0.220 & 0 & 0 \end{pmatrix} = (0.390, 0.600, 0.001, 0, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be High (0.600).

(4) Noise System C_4

The evaluation set of C_4 can be shown as follows:

$$U_{C4} = \begin{Bmatrix} u_1(\text{Average Rate of Daily Noise}), u_2(\text{Noise Management}) \\ , u_3(\text{Acoustic Quality Compromising Rate}) \end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C4} is calculated to be:

$$R_{C4} = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix}$$

The weight vector A_{C4} of the evaluation set U_{C4} is calculated as:

$$A_{C4} = (0.54, 0.16, 0.30)$$

The comprehensive evaluation vector w_{C4} of the evaluation set U_{C4} is calculated as follows:

$$w_{C4} = A_{C4} \times R_{C4} = (0.54, 0.16, 0.30) \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix} = (0,1,0,0,0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Good (1.000).

(5) Energy Management C_5

The evaluation set of C_5 can be shown as follows:

$$U_{C5} = \begin{Bmatrix} u_1(\text{Energy Consuming Rate}), u_2(\text{Energy Management}) \\ , u_3(\text{Energy} - \text{saving Technology and Facility}) \end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C5} is calculated to be:

$$R_{C5} = \begin{pmatrix} 0.556 & 0.222 & 0.222 & 0 & 0 \\ 0.222 & 0.444 & 0.111 & 0.222 & 0 \\ 0.333 & 0.444 & 0.111 & 0.111 & 0 \end{pmatrix}$$

The weight vector A_{C5} of the evaluation set U_{C5} is calculated as:

$$A_{C5} = (0.64, 0.22, 0.14)$$

The comprehensive evaluation vector w_{C5} of the evaluation set U_{C5} is calculated as follows:

$$w_{C5} = A_{C5} \times R_{C5} = (0.64, 0.22, 0.14) \times \begin{pmatrix} 0.556 & 0.222 & 0.222 & 0 & 0 \\ 0.222 & 0.444 & 0.111 & 0.222 & 0 \\ 0.333 & 0.444 & 0.111 & 0.111 & 0 \end{pmatrix} = (0.451, 0.302, 0.182, 0.064, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.451).

(6) Water Source Management C_6

The evaluation set of C_6 can be shown as follows:

$$U_{C6} = \begin{Bmatrix} u_1(\text{Water Consuming Rate}), u_2(\text{Watering Management}) \\ , u_3(\text{Sewage Management}) \end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C6} is calculated to be:

$$R_{C6}=\begin{pmatrix}0.444 & 0.222 & 0.333 & 0 & 0\\ 0.222 & 0.333 & 0.222 & 0.222 & 0\\ 0.333 & 0.556 & 0.111 & 0 & 0\end{pmatrix}$$

The weight vector A_{C6} of the evaluation set U_{C6} is calculated as:

$$A_{C6}=(0.57,0.32,0.10)$$

The comprehensive evaluation vector w_{C6} of the evaluation set U_{C6} is calculated as follows:

$$w_{C6}=A_{C6}\times R_{C6}=(0.57,0.32,0.10)\times\begin{pmatrix}0.444 & 0.222 & 0.333 & 0 & 0\\ 0.222 & 0.333 & 0.222 & 0.222 & 0\\ 0.333 & 0.556 & 0.111 & 0 & 0\end{pmatrix}=(0.358,0.289,0.272,0.071,0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.358).

(7) Rules and Regulations C_7

The evaluation set of C_7 can be shown as follows:

$$U_{C7}=\begin{Bmatrix}u_1(\text{Green Regulations}),u_2(\text{Green Department})\\ ,u_3(\text{Green Management})\end{Bmatrix}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C7} is calculated to be:

$$R_{C7}=\begin{pmatrix}0.111 & 0.444 & 0.333 & 0.111 & 0\\ 0.111 & 0.333 & 0.222 & 0.333 & 0\\ 0.111 & 0.222 & 0.444 & 0.222 & 0\end{pmatrix}$$

The weight vector A_{C7} of the evaluation set U_{C7} is calculated as:

$$A_{C7}=(0.30,0.16,0.54)$$

The comprehensive evaluation vector w_{C7} of the evaluation set U_{C7} is calculated as follows:

$$w_{C7}=A_{C7}\times R_{C7}=(0.30,0.16,0.54)\times\begin{pmatrix}0.111 & 0.444 & 0.333 & 0.111 & 0\\ 0.111 & 0.333 & 0.222 & 0.333 & 0\\ 0.111 & 0.222 & 0.444 & 0.222 & 0\end{pmatrix}=(0.111,0.307,0.376,0.207,0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Average (0.376).

(8) Training System C_8

The evaluation set of C_8 can be shown as follows:

$$U_{C8} = \{u_1(\text{Training Management}), u_2(\text{Green Awareness Campaigns})\}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C8} is calculated to be:

$$R_{C8} = \begin{pmatrix} 0.444 & 0.111 & 0.333 & 0.111 & 0 \\ 0.889 & 0.111 & 0 & 0 & 0 \end{pmatrix}$$

The weight vector A_{C8} of the evaluation set U_{C8} is calculated as:

$$A_{C8} = (0.66, 0.34)$$

The comprehensive evaluation vector w_{C8} of the evaluation set U_{C8} is calculated as follows:

$$w_{C8} = A_{C8} \times R_{C8} = (0.66, 0.34) \times \begin{pmatrix} 0.444 & 0.111 & 0.333 & 0.111 & 0 \\ 0.889 & 0.111 & 0 & 0 & 0 \end{pmatrix} = (0.596, 0.111, 0.220, 0.073, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.596).

(9) Social Inspections C_9

The evaluation set of C_9 can be shown as follows:

$$U_{C9} = \{u_1(\text{General Comments}), u_2(\text{Impact on the Rational Economics})\}$$

The membership degree of the indicators is evaluated according to experts consulting result and various statistics references. The fuzzy evaluation matrix R_{C9} is calculated to be:

$$R_{C9} = \begin{pmatrix} 0.556 & 0.222 & 0.111 & 0.111 & 0 \\ 0.889 & 0.111 & 0 & 0 & 0 \end{pmatrix}$$

The weight vector A_{C9} of the evaluation set U_{C9} is calculated as:

$$A_{C9} = (0.44, 0.56)$$

The comprehensive evaluation vector w_{C9} of the evaluation set U_{C9} is calculated as follows:

$$w_{C9} = A_{C9} \times R_{C9} = (0.44, 0.56) \times \begin{pmatrix} 0.556 & 0.222 & 0.111 & 0.111 & 0 \\ 0.889 & 0.111 & 0 & 0 & 0 \end{pmatrix} = (0.742, 0.160, 0.049, 0.049, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.742).

5.3.2 The first-level indicators layer

(1) Environment Quality B_1

The evaluation set of B_1 can be shown as follows:

$$U_{B1} = \begin{Bmatrix} u_1(\text{Ecologic System}), u_2(\text{Atmospheric System}) \\ , u_3(\text{Water System}), u_4(\text{Noise System}) \end{Bmatrix}$$

The fuzzy evaluation matrix R_{B1} is calculated to be:

$$R_{B1} = (w_{C1}、\ w_{C2}、\ w_{C3}、\ w_{C4}、\ w_{C5})^T$$

According to the existed w_{C1}、w_{C2}、w_{C3}、w_{C4}、w_{C5}, The comprehensive evaluation vector W_{B1} can be calculated as:

$$W_{B1} = A_{B1} \times R_{B1} = (0.348, 0.617, 0.036, 0, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be High (0.617).

(2) Energy Consumption B_2

The evaluation set of B_2 can be shown as follows:

$$U_{B2} = \{u_1(\text{Energy Management}), u_2(\text{Water Source Management})\}$$

The fuzzy evaluation matrix R_{B2} is calculated to be:

$$R_{B2} = (w_{C5}、\ w_{C6})^T$$

According to the existed w_{C5}、w_{C6}, the comprehensive evaluation vector W_{B2} can be calculated as:

$$W_{B2} = A_{B2} \times R_{B2} = (0.409, 0.296, 0.223, 0.067, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.409).

(3) Environment Management B_3

The evaluation set of B_3 can be shown as follows:

$$U_{B3} = \{u_1(\text{Regulations}), u_2(\text{Training System}), u_3(\text{Social Inspections})\}$$

The fuzzy evaluation matrix R_{B2} is calculated to be:

$$R_{B3} = (w_{C7}、\ w_{C8}、\ w_{C9})^T$$

According to the existed w_{C7}、w_{C8}、w_{C9}, the comprehensive evaluation vector W_{B2} can be calculated as:

$$W_{B3} = A_{B3} \times R_{B3} = (0.391, 0.229, 0.246, 0.135, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.391).

5.3.3 The overall assessment target

The evaluation set of A can be shown as follows:

$$U_A = \{u_1(\text{Environment Quality}), u_2(\text{Energy Consumption}), u_3(\text{Environment Management})\}$$

The fuzzy evaluation matrix R_A is calculated to be:

$$R_A = (W_{B1}、\ W_{B2}、\ W_{B3})^T$$

According the existed W_{B1}、W_{B2}、W_{B3}, he comprehensive evaluation vector W_1 can be calculated as:

$$M_1 = A_1 \times R_A = (0.4, 0.4, 0.2) \times \begin{pmatrix} 0.380 & 0.617 & 0.036 & 0 & 0 \\ 0.409 & 0.296 & 0.233 & 0.067 & 0 \\ 0.391 & 0.229 & 0.246 & 0.135 & 0 \end{pmatrix} = (0.381, 0.411, 0.153, 0.054, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be High (0.411).

Again, we make the same Greenport degree evaluation procedure upon the Chongming Islands Terminals and here shows the final result. The detailed matrixes for each indicator could be found in the appendix.

$$M_2 = A_2 \times R'_A = (0.4, 0.4, 0.2) \times \begin{pmatrix} 0.828 & 0.117 & 0.057 & 0 & 0 \\ 0.209 & 0.424 & 0.318 & 0.024 & 0 \\ 0.338 & 0.339 & 0.309 & 0 & 0 \end{pmatrix} = (0.482, 0.284, 0.212, 0.037, 0)$$

According to the principle of maximum degree of membership, the indicator is assessed to be Outstanding (0.482).

Table 14 2011 Comparison between Two Selected Terminals Region

Indicators	The Maximum Degree of Membership	
	The Huangpu River Coast Terminals	The Chongmin Islands Terminals
Ecologic System C_1	Outstanding (0.471)	Outstanding (0.600)
Atmospheric System C_2	Outstanding (0.530)	Outstanding (1.000)
Water System C_3	High(0.600)	Outstanding (0.850)
Noise System C_4	High(1.000)	Outstanding (0.862)
Energy Management C_5	Outstanding (0.451)	High(0.407)
Water Source Management C_6	Outstanding (0.358)	High(0.444)
Regulations C_7	Moderate (0.376)	Moderate (0.482)
Training System C_8	Outstanding (0.596)	Outstanding (0.404)
Social Inspections C_9	Outstanding (0.742)	Outstanding (0.776)

Table 14 (Cont.)

Indicators	The Maximum Degree of Membership	
Greenport Degree A	The Huangpu River Coast Terminals High(0.411)	The Chongmin Islands Terminals Outstanding (0.482)

As this chart shown, although the Huangpu River Coast Terminals enjoys an impressive performance in the indicator B_2 “Energy Consumption” due to the newly applied high technology system, its indicator B_1 “Environment Quality” suffers a large gap compared to the Chongming Islands Terminals. The second port region is evaluated as “Outstanding” with the help of its well protected environment and the Huangpu River Coast Terminals is considered as “High”. Both the port region gained an “Moderate” mark on the indicator C_7 “Regulations”, which states the problem that it still need a big effort in strength the relevant regulations and laws in the process of Greenport development.

In general, the evaluation result reflects the real situation happened in the port of Shanghai, successfully proving the scientific and reasonable of the Greenport Degree Evaluation System set in this paper. The system not only offers a reliable standard for Greenport development, but also explodes the recent environment-unfriendly factors of the port operation according to the result of evaluation, and enables the port authority to improve the port green action more efficiently and directly.

Chapter 6 Conclusions and Expectations

6.1 Main results and highlights

The Greenport development requires the united effort from the mutual parties. There is a widely accepted concept in the general public in China that the Greenport program is just a port authority unilateral task or government's work. But if we looking into the success experience from those U.S ports likewise the port of Long Beach, the port of Huston and those port from Europe likewise the port of Rotterdam, we can easily found that neither these developed Greenport work without the assistance of the community and general public. Now we can draw a conclusion that it is a huge task to develop the Greenport and drying need the help from all the society, including the government's support, the port authority's cooperation and the non-governmental organization's supervision over the entire process.

Though the research on the weight of the nine second-level indicators layer, we can conclude that the Atmospheric System C_2 and Energy Management C_5 are the two most direct and determining factor in the whole indicator subsystem, largely impact the evaluation result. Hence we suggest all the port authority start with their Greenport development from the area of reducing the energy consumption and exhaust gas emissions. And we can easily find the example from foreign ports likewise the "Clean Air Action Plan" in the port of Long Beach, the "Rijmond Air Quality Action Program" in the port of Rotterdam and the "Clean Shipping Program" in the port of Amsterdam.

The highlights in this paper is the establishment of the Greenport Degree Evaluation System, which is aim to improve the sustainable development of the ports. The status quo of the Chinese port on the green environment-friendly area has been discussed in the previous chapter, although China suffered a late start on this research topic, she still enjoyed many impressive achievements in the last decade. The indicator subsystem of the whole evaluation system is set according to both various national laws and international conventions. The evaluation level is set into five different terms, which are outstanding, high, moderate, low and poor respectively. The main overall target is divided into three big parts, which are environment quality, energy consumption and environment management respectively. We apply the fuzzy logic

into the evaluation analysis and analytic hierarchy process into the weight determination of the indicator sub-system, which can be considered as a highlight in this paper. Two terminals in the port of Shanghai have been chosen as a case study, which aims to prove the scientific and feasible character of the Greenport Degree Evaluation System. In the end, both the terminals are assessed to be “High” level, which meets the reality, proving the previous assumption. Also, several suggestions against the results have been given out.

6.2 Expectations

It has been prove that the evaluation on the Greenport development is a huge and complex process. Apart from the evaluation system set here, there still remains many defects and need to be improved in the future research.

The first problem here remains to the insufficient of the determining factors, which is the indicators in this evaluation system. During the entire process of the establishment of the evaluation system, this thesis just focused on three parts, which are environment quality, energy consuming and environment management. Although one indicator “Impact on the Rational Economics D_{92}” has been inserted to the environment management section, trying to diverse the evaluation system from the single environmental way, we still lack the detailed research in the economy and service impact of the Greenport and it may be considered as not covering the ultimate goal of “A Balance between the Economy and Environment”. Hence, taking more attention to the economic and functional factors should be regarded as an important improving point in the further research.

Back to the evaluation process itself, we can easily found most weights of the indicators are more voted subjectively than objectively. Although it is the exact reason why we choose fuzzy logic as the methodology applied here, too much subjective evaluations will still make a default to the results. Considered as a reliable

standard of Greenport development, the indicator subsystem and evaluation process should be improve more scientific and objective, detailed classify standards for indicators should be created instead of the previous ones.

Another problem is related to the data basis searching. The thesis establishes the Greenport Degree Evaluation System mainly according to the previous researches and the laws and regulations of China, the data basis is largely depended on the national port yearbook. Although we take various look on different information sources, trying to assure the adequacy of the data, we still meet the difficulties. The current regulations and law jurisdictions on the topic of the Greenport or Ecologic port is fairly not complete and not enough, most environment-friendly regulations are announced a decade ago and are definitely disjointed from this rapid developing age. The local government does open their statistics on the environment monitoring, but merely in a small scale or just out of fashioned data. A more strict legislation system about the environment protection and a more open information platform which can access the detailed data about each port should be developed, which enquire the assist of the multilateral effort from the related authority, experts and general public.

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Appendices

Appendix 1 Detailed calculation factors

Evaluation sets:

$$A=\begin{pmatrix} 1 & 1 & 2 \\ 1 & 1 & 2 \\ 1/2 & 1/2 & 1 \end{pmatrix}$$

$$B_1=\begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{pmatrix} \qquad B_2=\begin{pmatrix} 1 & 5/6 \\ 6/5 & 1 \end{pmatrix} \qquad B_3=\begin{pmatrix} 1 & 2 & 4 \\ 1/2 & 1 & 1/3 \\ 1/4 & 3 & 1 \end{pmatrix}$$

$$C_1=\begin{pmatrix} 1 & 6/5 & 2 \\ 5/6 & 1 & 2 \\ 1/2 & 1/2 & 1 \end{pmatrix} \qquad C_2=\begin{pmatrix} 1 & 2 & 3 \\ 1/2 & 1 & 2 \\ 1/3 & 1/2 & 1 \end{pmatrix} \qquad C_3=\begin{pmatrix} 1 & 3 & 5 & 7 \\ 1/3 & 1 & 5 & 7 \\ 1/5 & 1/5 & 1 & 3 \\ 1/7 & 1/7 & 1/3 & 1 \end{pmatrix}$$

$$C_4=\begin{pmatrix} 1 & 3 & 2 \\ 1/3 & 1 & 1/2 \\ 1/2 & 2 & 1 \end{pmatrix} \qquad C_5=\begin{pmatrix} 1 & 5 & 3 \\ 1/5 & 1 & 2 \\ 1/3 & 1/2 & 1 \end{pmatrix} \qquad C_6=\begin{pmatrix} 1 & 2 & 5 \\ 1/2 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{pmatrix}$$

$$C_8=\begin{pmatrix} 1 & 2 \\ 1/2 & 1 \end{pmatrix} \qquad C_9=\begin{pmatrix} 1 & 4/5 \\ 5/4 & 1 \end{pmatrix}$$

The fuzzy evaluation matrixes of Chongming Islands Terminals:

$$\mathrm{R}'_{C1}=\begin{pmatrix} 0.556 & 0.333 & 0.111 & 0 & 0 \\ 0.556 & 0.222 & 0.222 & 0 & 0 \\ 0.778 & 0.222 & 0 & 0 & 0 \end{pmatrix} \qquad \mathrm{R}'_{C2}=\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\mathrm{R}'_{C3}=\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.440 & 0.330 & 0.220 & 0 & 0 \end{pmatrix} \qquad \mathrm{R}'_{C4}=\begin{pmatrix} 0.778 & 0.111 & 0.111 & 0 & 0 \\ 0.889 & 0 & 0.222 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\mathrm{R}'_{C5}=\begin{pmatrix} 0.111 & 0.444 & 0.444 & 0 & 0 \\ 0 & 0.556 & 0.222 & 0.111 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{pmatrix} \qquad \mathrm{R}'_{C6}=\begin{pmatrix} 0.222 & 0.333 & 0.444 & 0 & 0 \\ 0.222 & 0.556 & 0 & 0 & 0 \\ 0.111 & 0.778 & 0.111 & 0 & 0 \end{pmatrix}$$

$$R'_{C7}=\begin{pmatrix}0 & 0.333 & 0.667 & 0 & 0\\ 0.222 & 0.556 & 0.111 & 0 & 0\\ 0 & 0.778 & 0.222 & 0 & 0\end{pmatrix}$$

$$R'_{C8}=\begin{pmatrix}0.556 & 0.111 & 0.333 & 0 & 0\\ 0.111 & 0.889 & 0 & 0 & 0\end{pmatrix}$$

$$R'_{C9}=\begin{pmatrix}0.889 & 0 & 0.111 & 0 & 0\\ 0.556 & 0.444 & 0 & 0 & 0\end{pmatrix}$$

The comprehensive evaluation vectors of Chongming Island Terminals:

$w'_{C1}=(0.600,0.269,0.131,0,0)$ $w'_{C2}=(1,0,0,0,0)$

$w'_{C3}=(0.850,0.140,0.001,0,0)$ $w'_{C4}=(0.862,0.060,0.096,0,0)$

$w'_{C5}=(0.211,0.407,0.333,0.024,0)$ $w'_{C6}=(0.207,0.444,0.300,0.024,0)$

$w'_{C7}=(0.049,0.444,0.482,0,0)$ $w'_{C8}=(0.404,0.376,0.220,0,0)$ $w'_{C9}=(0.776,0.151,0.073,0,0)$

$w'_{B1}=(0.828,0.117,0.057,0,0)$ $w'_{B2}=(0.209,0.424,0.318,0.024,0)$ $w'_{B3}=(0.338,0.339,0.309,0,0)$

$w'_{A}=(0.482,0.284,0.212,0.037,0)$