Sustainable Manufacturing

--A study of the business context and eco-efficiency practices in Chinese microelectronics firms

A thesis submitted for the degree of Master of Philosophy

By

Jiangshan Jiang

School of Engineering and Design

Brunel University

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Abstract

Sustainable manufacturing is the implementation of sustainable standards in the Manufacture, Assembly, Disassembly and End-of-life (MADE) of the manufacturing process. The significance of environmental protection and sustainable development directly cause more and more organizations and firms to take sustainable criteria into account in their manufacturing and management systems.

China is a developing country, with the largest population in the world and the greatest development pace over the last few decades. The rising awareness of environmental problems and the increasing needs of sustainable design are demanding particular sustainable standards research for China.

This thesis aims to examine the sustainable design standards in China and make recommendations for a sustainable plan for the microelectronic industry based on research. Both quantitative and qualitative methods are used in this research. This research is based on a field survey in Beijing, Tianjin and Dongguan City of Guangdong. Interviews and questionnaire research methods are also included.

This research found sustainable design standards in China are influenced by economic regime, public factors and environment protection concepts. The Government is short of feedback while firms and public have difficulty representing their own point of view – to build the communication and control system may be the first thing needed. Only 13.33% of the surveyed companies have official written sustainable design regulations. The significant economic, humanistic and political diversity of different areas in China require highly flexible and practical standards.

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List of Figures and Tables

Abbreviation list

GhG	--	Greenhouse gas
WTO	--	World Trade Organization
ISO	--	International Standards Organization
EBIT	--	Earnings before Interest and Tax
BSI	--	British Standard Institution
EMS	--	Environmental Management System

Chapter 1: Introduction

1.1 Introduction

This chapter is the introduction, which introduces the whole thesis in the following aspects. Firstly, this chapter will introduce the research background and research questions; then the theoretical foundations of this research will be discussed based on a brief literature review. Thirdly, the research aims and objectives are identified and then the research methodology is introduced and justified. Finally, the structure of this thesis is outlined accordingly.

1.2 Research backgrounds and research question

This research focus on sustainable manufacturing, China's current environmental standards situation and how sustainable standards work in some of China's microelectronic firms. For this research purpose, the research background will be introduced and then lead to the research questions of this thesis.

China is a developing country, with the largest population in the world and has had the greatest development rate over the last few decades.

Sustainable development, as a remarkable watchword, becomes one of the Chinese government's core policies. It also gains broad agreement with the Chinese people . The requirement for guidelines for sustainable development is rising. In other words, China needs to create standards and principles for this process. Sustainable design standard, as the basis of every sustainable development action, has become a very significant key point.

The increasing needs of sustainable development in all Chinese industries and environmental pressure directly leads to a rising awareness about sustainable design standards. The government is also making efforts to release new environmental legislation to be geared to international standards. On the other hand, some companies with foresight in China are also trying to implement environmental management systems and sustainable product design.

Under these circumstances, the research about what exactly China and Chinese companies need in respect of sustainable design standards draws my interest. Both government and business could undertake this research as a joint profit making and academic exercise.

Since China joined the WTO, Chinese businesses and the market are becoming more open and standardized. Every firm is trying its best to take advantage in this competitive situation. This could lead to some reckless actions to introduce and implement international standards or systems by firms themselves. In such a situation, it is imperative to clarify and study the sustainable design standards for China.

There are several view points about how such standards affect companies, positively, negatively or not at all. Researchers like Joaquín Cañón-de-Francia and Concepción Garcés-Ayerbe believe such an application could hurt the share price of firms by increasing intangible costs (Cañón-de-Francia & Garcés-Ayerbe 2009). However, this research will analysis and discuss the

situation regarding both the environmental and business/commerce interests.

Every firm is profit-oriented. Especially in China, firms do not have social responsibility as much as western companies. In addition, China doesn't have very strict environment protection legislation (although some new laws and principles are under consideration). Nevertheless, as I mentioned before, the rising group awareness of environmental issues and the willingness to reduce the impact on the natural environment of the whole development process is taken over the old 'develop at all cost' viewpoint, especially in the circles of business and political leadership. China is already aware of the importance of sustainable development. It is time to attempt to formulate some practical standards. In my view, the standards need to include a management system such as ISO 14001, product operation system such as BS 8887-1, quality management system such as ISO 9001 and environment protection legislation/principles. Still, due to the various different environments, economic and humanistic environmental circumstances between different areas of China, such standards need to be highly flexible and practical. Under this requirement and my own interest, I carried out this research based on field surveys, interviews and questionnaire surveys.

This research will focus on exploring the following questions:

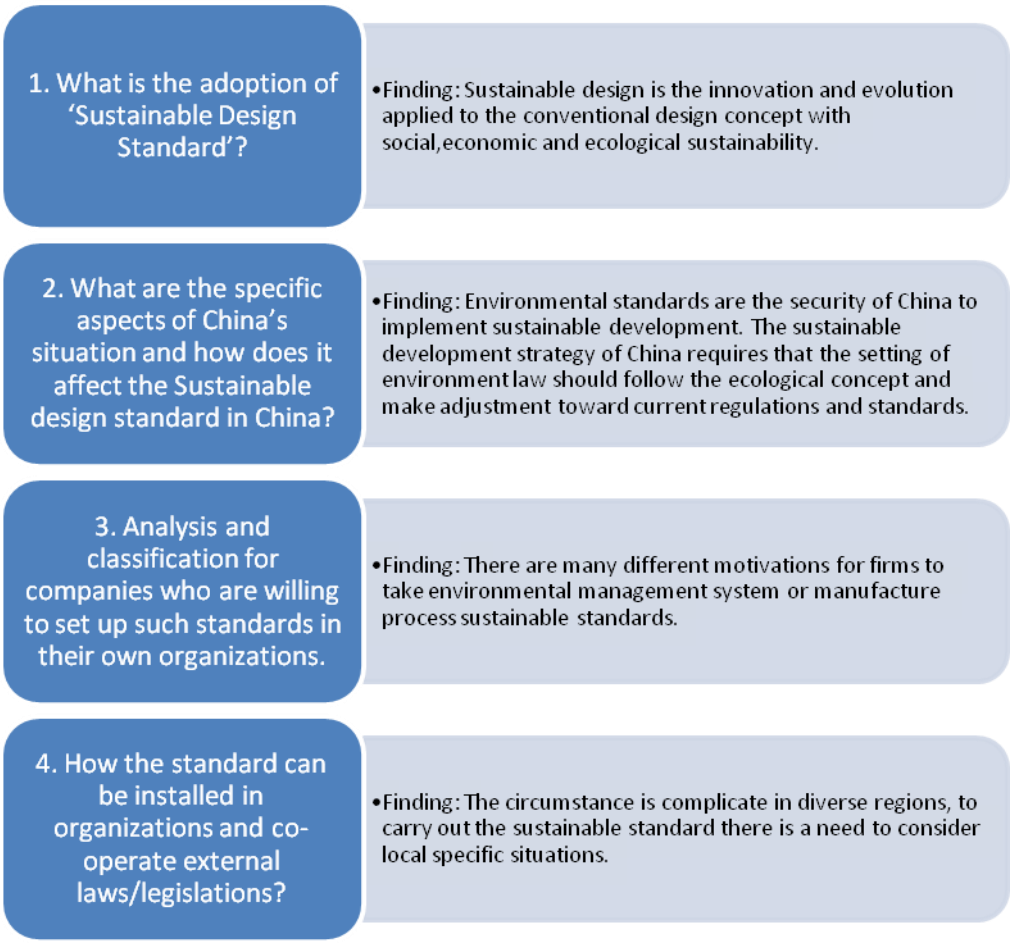

Figure 1.1 Research questions and findings.

1.3 Recent research

Sustainable design is known as green or environmental design, which embraces the social design, social quality and ecological quality (McLennan, 2004). During past years, the concept of sustainable design was widely used. Sustainable design explains and promotes sustainable development from the perspective of design. Sustainable design completely expresses the relationship between design and the environment on the aims and means (Fan et al, 2004). Sustainable not only considers environmental protection but also the balance of needs of users, environmental benefits and the development strategy of companies.

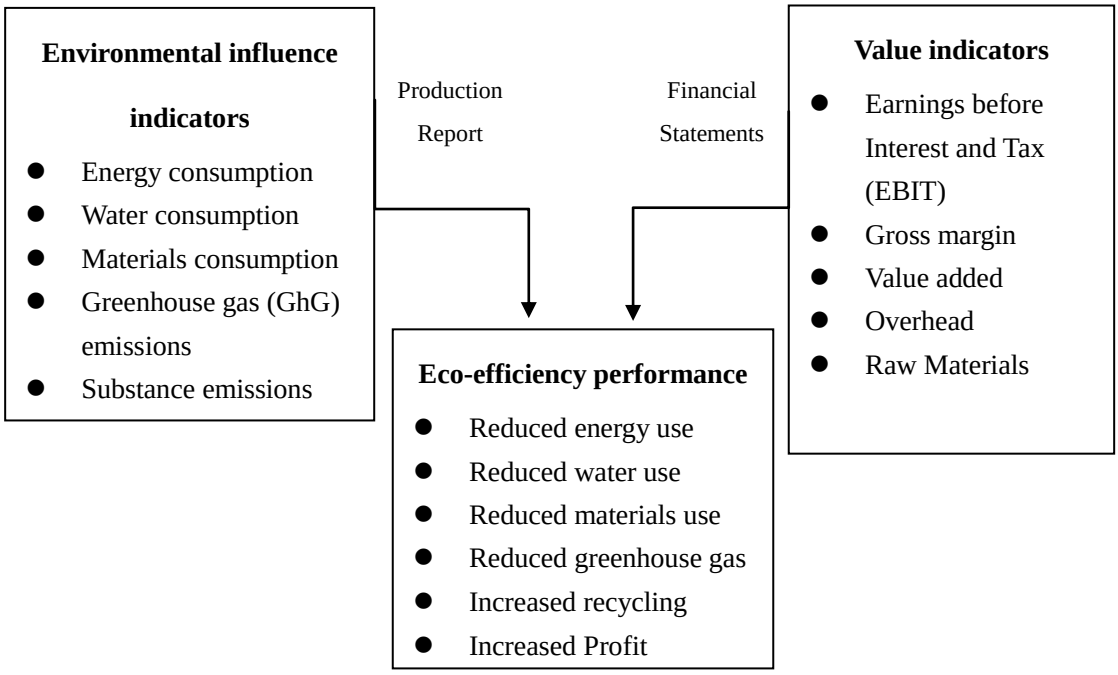

Figure 1.2 Eco-efficiency

Adopted From: Staib, 2009

Aiga online (2009) stated that "The Living principles weave together environmental protection, social equity, and economic health — thus building upon commonly accepted, triple bottom-line frameworks". Generally, sustainable design is the philosophy of designing physical objects, the built environment, and services to comply with the principles of social, economic, and ecological sustainability (McLennan, 2004).

Based on such primary research, this research proposes the definition of sustainable design standard as: The standards and formulations of external and internal sustainable development of specific organizations.

The concept of sustainable development requires that both the pollution and damage of the natural environment should be controlled when emphasizing economic development. This also needs the implementation of environmental laws and standards (Omer, 2008).

According to the researches of Hart (1997), Gladwin (1999), Starkey and Welford (2001), organizations have been faced with the pressure of environmental management and performance improvement during the past 30 years.

There are also many different opinions toward the motivation of ISO 14001 certification. Harrington and Knight (1999) and Woodside (2000) listed many causes for organizations to take ISO 14001 certifications as: 1. To promote market share in certain segments. 2. To response to the pressures from consumers and market penetration. 3. To save cost and improve efficiency. 4. To gain reputation. Recently, Steger (2000) reviewed a lot of empirical studies and claimed that most of the companies that acquired ISO 14001 certification set the environmental aims earlier.

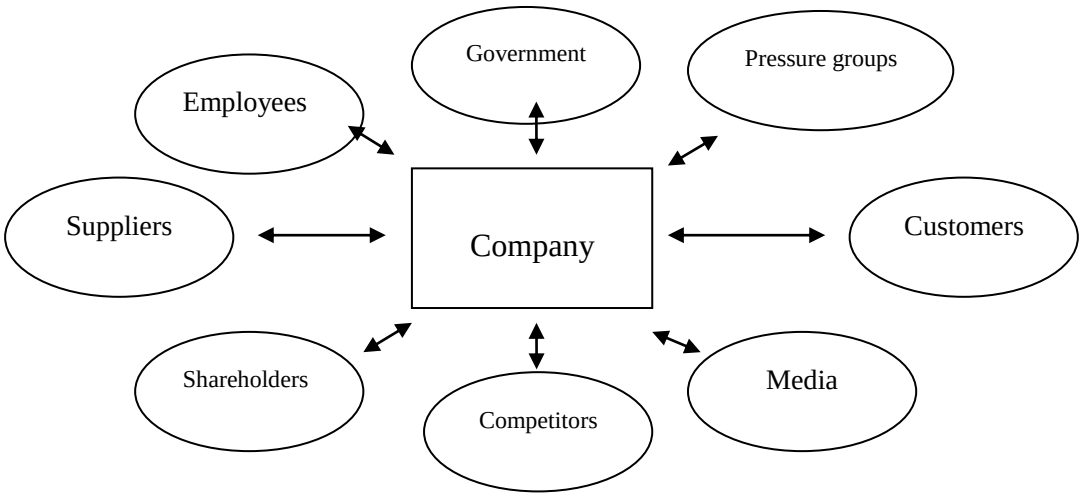

Figure 1.3 Stakeholder model
Adopted from: Freeman, R.E., 1984

Tibor and Feldman (1996) defined environment management standard as the guideline of an organization to determine and manage the environment. Steger

(2000) has different definitions of environment management standards as a system whose aim is to set and implement the environmental goals, policy and responsibility with regular auditing of the related factors. Both definitions indicated that the aim of an environmental management standard is to improve the environment.

Matouq (2000) surveyed the central area of Japan and carried out a study on the procedure and significance of establishing an ISO 14001 environmental management system and analyzed their aims and motivations. Matouq (2000) also studied the barriers of ISO 14001 establishment and the impact of it on the environment.

Environmental diplomacy also becomes the main channel to adjust the relationship between countries. Environmental protection has already become the key topic of political debate. Within this background, the Chinese government established the Environmental Protection Bureau to enhance the governance of environmental management (Yao et al, 2003).

Roth (1968) firstly proposed the idea of environment consciousness and argued that those people who did not have it caused the pollution and damage to the environment.

The environment standard of China does not take the classifications by targets and pollution sources. Although the environment quality standard of China set the control value for different functions, the pollution emission standard does not set the different levels by pollution sources (Yao and Steemers, 2009).

1.4 Research aims and objectives

Aims: this research aims to examine the sustainable design standards of China

and the proposed sustainable plan for the microelectronic industry.

Refer to the section 1.2, the research questions are:

1. What is the adoption of ‘Sustainable Design Standard’?

2. What are the specific aspects of China’s situation and how does it affect the Sustainable design standard in China?

3. Analysis and classification for companies who are willing to set up such standards in their own organizations.

4. How the standard can be installed in organizations and co-operate external laws/legislations?

After background research, primary research, questionnaire research and field survey, the research questions lead to the following research objectives:

1. To explore the current situation of sustainable design practice in China.

2. To examine the adoption of sustainable design standards.

3. To analyze the political and business conditions to build/introduce such standards in China.

4. To evaluate the scope of sustainable design standards in China

1.5 Research methodology

This research will use mixed methodology. Each approach has advantages and limitations. To reduce these limitations, this research adopts the mixed approach, namely, both quantitative and qualitative methods. Questionnaire

and interview are the primary data collection methods. A case study of a microelectronics firm in China will also be taken as an empirical study. Although it is complicated to adopt the mixed approach for data collection, it is suitable for the research question of this study. Therefore, this research will take the mixed approach.

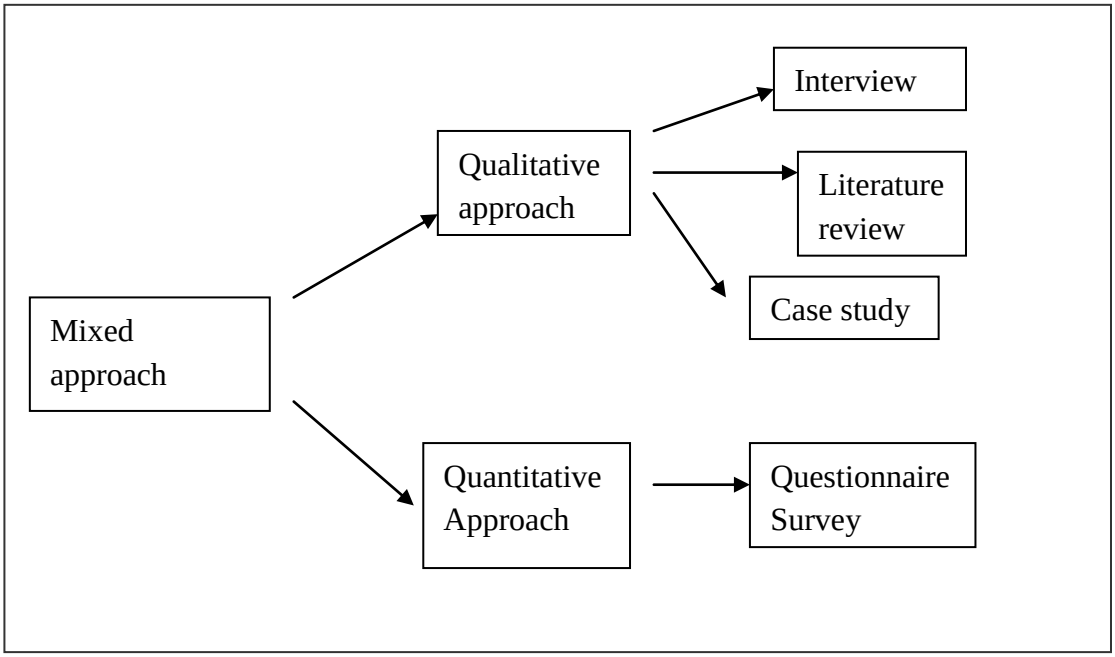

Figure 1.4 The research approach of this study

This research is mainly based on the primary data. There are two methods to collect the data used in this research work: interview and questionnaire based survey. The data collection is mainly based on the interviews, which makes it more important. The researcher had already begun to make contact with the possible interviewees to ensure the participants fully understood the research's purpose and their rights. Questionnaire based survey assumes that the questions to be asked are valid. These questions are printed on paper and sent to respondents then collected to be analyzed Ninety respondents were surveyed, located in Beijing, Tianjin and Guangdong. The case of a

microelectronics firm in Guangdong will be covered in this research since Guangdong is the centre of microelectronics industry and thus is representative. A case of local electronic waste disposal industry will be covered in this research as the “low end” examples.

To explore the sustainable standards in the firms of China, the questionnaire comprises 5 parts. Part 1 is the environmental acknowledgement and policy, which includes questions 1 to 31. Part 2 is environment business prospects, which includes the questions 32 to 34. Part 3 is sustainable public relations, which includes questions 35 to 42. Part 4 is environmental information disclosure, which includes questions 43 to 46. Part 5 is social performance, staff relationship and customers.

There are two data analysis methods. The first one is qualitative analysis. This is mainly covered in chapter 2, which discussed the environment standards in China. At the same time, there is discussion in chapter 4 relating to data analysis. The literature review in this research would provide a foundation for the research and help resolve certain objectives. The case study is also an important part of qualitative analysis. The interview script will also be analyzed with a qualitative approach. Another data analysis method is quantitative which mainly includes the analysis of the data collected from the questionnaire. The mean result of each question is calculated and analyzed comparatively. As discussed above, this questionnaire comprises 5 parts. Each part will be analyzed separately. At the same time, the validity and credibility of the questionnaire will also be analyzed by SPSS 13.0.

A key finding result (base on the research focus remapping and the section 6.1 of conclusion part) will be sent to several most helpful companies and most interviewed personnel who had interested in. As the feedback of this research.

1.6 Outline of this thesis

This research contains 6 chapters:

Chapter 1 is the introduction. This chapter will introduce the research backgrounds and research questions in the first place. Then the research foundations and research aims are introduced and discussed. At the same time, the research methodology will also be introduced in brief with justification.

Chapter 2 is the literature review. This chapter will review current research and related literature. The concept of sustainable design standards will be defined. The relationship between the environment and sustainable development will be explained. The ISO 14001, BS8887 standards, and environment management will also be discussed. At the same time, the influencing factors on sustainable design standards in China will be analyzed. The experience of developed countries using environment standards and regulations will also be introduced. Finally, the problems and solutions in the environment standards and regulation of China will also be investigated.

Chapter 3 is the research methodology. This chapter will introduce the approach used in this research. The research approach is justified and the data collection method is introduced. At the same time, the research ethics and interview process are also introduced and discussed. Finally, the data analysis method is also discussed.

Chapter 4 is the questionnaire analysis. This chapter will analyze the data collected by questionnaire with descriptive and statistical analysis. At the same time, there are discussions according to the research aims and objectives.

Chapter 5 are the interviews and case studies. This part will introduce 3 representative interviews, one case of a microelectronics company from Guangdong and a small area of local electronic waste disposal industry from

Tianjin, China. The case studies will introduce their backgrounds, current environmental management systems used and other related issues. Based on the analysis, the problems and solutions will be identified.

Chapter 6 is the conclusion. This chapter will summarize the findings in this research. At the same time, this research will also propose recommendations to both the companies and the government of China. The limitations in this research will also be identified and discussed.

Chapter 2: Literature review

2.1 Introduction

This chapter is the literature review. In this chapter related literature on this research question will be reviewed critically. Firstly, the definition of sustainable design will be given based on the definitions of different researchers. At the same time, the common principles of sustainable design will be introduced and discussed; secondly, the relationship between environmental standards and sustainable development will be discussed; thirdly, the ISO 14001 standard and environmental management will be discussed from the motivations of Chinese companies comparing the differences between the ISO 14001 and the current environment management standards of China. Fourthly, the factors influencing the sustainable design standards in China are discussed. Fifthly, the experience of developed countries will be reviewed and discussed. Finally, the problems and solutions in environment standards and regulations of China will be analyzed and discussed. A conclusion is reached to summarize the findings and identify the gaps in current research in this topic.

2.2 Definition and principles of sustainable design

2.2.1 Definition of sustainable design

Sustainable design is known as green or environmental design, which embraces the social design, social quality and ecological quality (McLennan, 2004). During past years, the concept of sustainable design has been widely used. Faced with the accelerated consumption of resource and energy and the damage to the ecological environment, the survival and development of mankind has also suffered from these new threats and challenges. Sustainable design is becoming increasingly important because of this background.

Although the researchers claimed that sustainable design is green or ecological design, there are big differences in these concepts. Sustainable design explains and promotes sustainable development from the perspective of design. Sustainable design completely expresses the relationship between design and the environment on the aims and means (Fan et al, 2004). Sustainable not only considers environmental protection but also the balance of needs of the users, environmental benefits and the development strategy of companies.

Sustainable design is different from the traditional design concept, which ignores the resource waste and impact on the environment. Therefore, sustainable design is the innovation and evolution toward the traditional design concept. Sustainable development concept is embedded in the product design, which linked the ecological environment to the economic development. This new design concept aims to make full use of the resource and energy to minimize the pollution.

There is no universal definition for the concept of sustainable design. Most of the literature research on this topic is from the sustainable development and environment management perspectives. According to the investigation in

2009 (Plant et al. 2009), through the implementation of standards to optimize and design the manufacture, assembly, disassembly and end-of-life process (PD 6470, 1975), a firm can significantly reduce their environmental impact and gain more profit, which is the BS 8887-1 standard focus (Plant et al. 2009). This Investigation also introduced the ISO 14001 standard as an Environmental Management System.

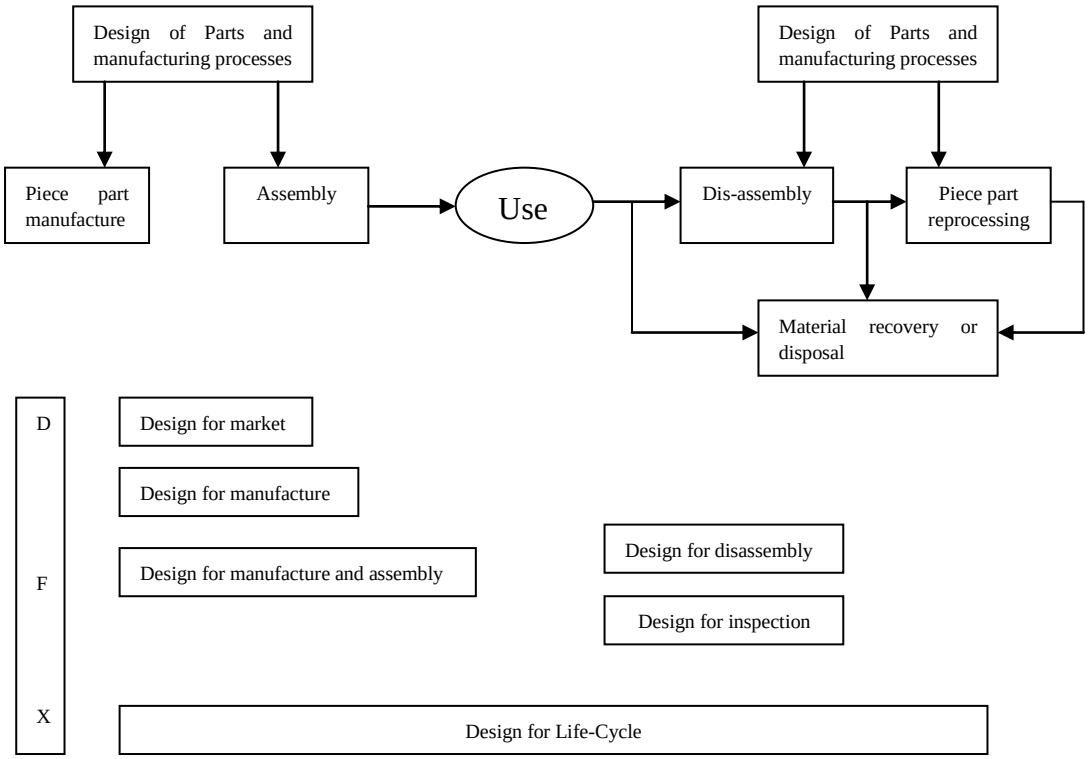

Figure 2.1 The stages in the life of a product and the various DFX terms
Adopted from: BSI, 2006

There are significant differences between the two sustainable design standards. BS 8887-1 is about internal production flow, it mainly focuses on optimizing the process and saving cost. ISO 14001 is an Environment Management System which supplements the organization's original management system.

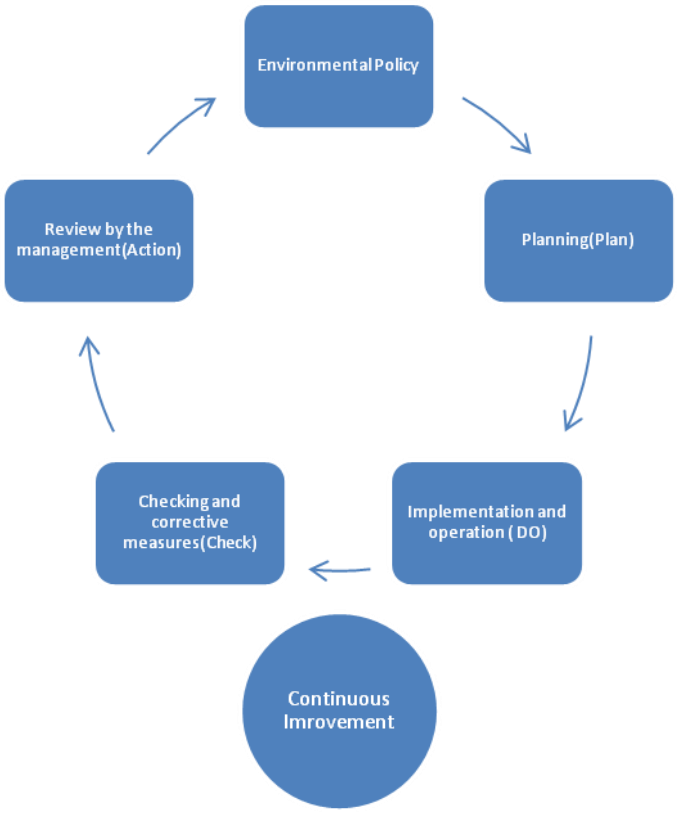

Figure 2.2 ISO 14001 Process

Adopted From: Staib, 2005

Another paper holds a more positive viewpoint (Johnstonea & Labonneb 2008): the improving and/or signaling performance after the introduction of the environment management system could be considered as a certain result. The relativity is decided by the size of the facility. BS 8887-1 expresses an ideal solution for internal sustainable design – optimization based on sustainable growth were added to normal MADE (Manufacture, Assembly, Disassembly and End-of-life) flow.

Based on such literature review, this research proposes the definition of sustainable design standard as: The standards and formulations of external and internal sustainable development of a specific organization.

2.2.2 Common principles for sustainable design

There are common principles for sustainable design since there are varying practices in different fields. Firstly, low-impact materials are used in the design. The designers should choose non-toxic, sustainably produced materials that consume less energy than others. At the same time, sustainable design is energy efficient , namely, the production process requires less energy (Holm, 2006).

Secondly, quality and durability should be considered by the designers. The products should last for a longer period with greater functionality. This will reduce the cost of replacement for these products and save resources in most aspects of their manufacture (Anastas and Zimmerman, 2003). Extending the life cycle of products can save energy and improve the utilization of resources.

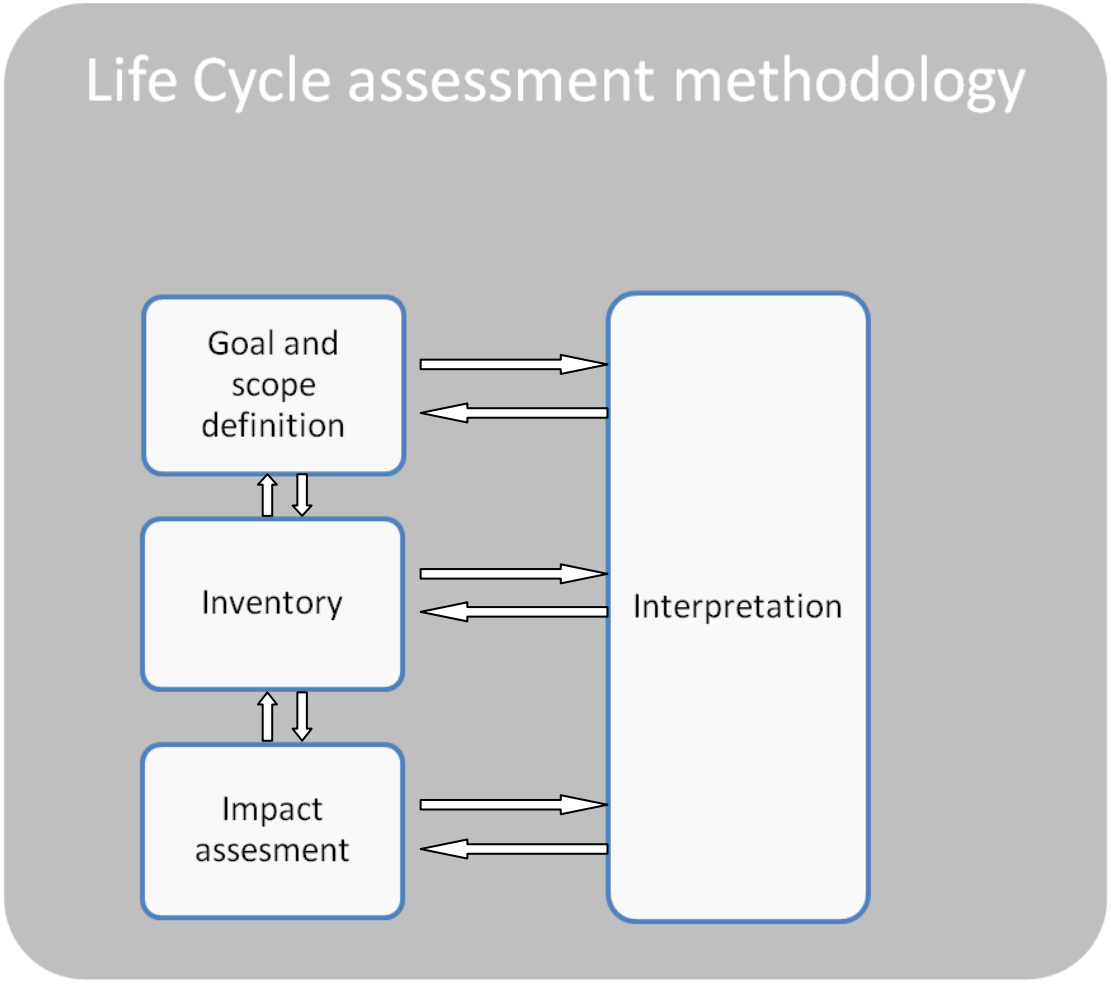

Figure 2.3 Life cycle assessment methodology

Adopted From: ISO 14040,2006

Thirdly, the sustainable design should consider the re-use and recycling process. Namely, the sustainable design should not only consider the production process of the products but also the waste products. (Ji and Plainiotis, 2006). At the same time, the design should make full use of new technology to apply renewable resource and energy in the production process. For example, wind or solar energy can be used.

Fourthly, sustainable designers should convey the Humanistic care in the design. The design should follow the ergonomics and enhance the communications between different cultures. At the same time, sustainable design should also evoke the reflections of consumers toward the

environmental problems and promote environmental awareness. (Yuan, 2004).

There are also many private organizations proposing the sustainable design standards and project design guides. At the same time, there are also a wide variety of educational and governmental institutions promoting sustainability science (Fan et al, 2004).

2.3 Typical environmental standards in previous research

This section will introduce 4 environmental standards: ISO 14001, BS 8888 and EMS. They are different in the scope of application and purpose.

ISO 14001 is a specific firm management standard which could help firms to build their own environmental management system and keep the firms improving on the continuous develop cycle (Figure2.2).

BS 8887 and BS8888 are the manufacturing standard which focus on the life cycle of products.

EMS is a general standard which proposed environmental management concepts and practices. The main purpose of ISO 14001 standard is apply EMS to the firms who purchased ISO 14001.

2.3.1 Standard ISO 14001

ISO 14001 is a guideline directive for standardization which can be applied d to 'all types and sizes of organizations and to accommodate diverse geographical, cultural and social conditions' (ISO, 1996). As '*the blueprint for the company's environmental management system*' (Chen, 2004), ISO 14001

became a well-known environmental standard in the world.

An increasing number of organizations are looking for certification to verify that the environmental aspects of their companies comply with the standard set by the ISO (International Standardization Organization). Meeting the requirements of ISO 14001 criteria can be a fraction of a wide-ranging risk management plan (Montabon, et.al, 2000).

Not doing anything other than acquiring an ISO 14001 accreditation, still lacks the complete effort necessary to alleviate the environmental exposures that companies are facing. An ISO 14001 official recognition alone will not produce considerable rate reductions or comprehensive terms when procuring environmental damage accountability insurance. As a matter of fact, a number of ISO 14001 accreditations can simply equate to a "paper chase" and not an actual performance specification that organizations endeavor to meet (Montabon, et.al, 2000).

Some critics contend that the procedure needed to acquire an ISO 14001 accreditation is guaranteed to be of assistance to a company in achieving improved awareness of its accountabilities to the environment. Such understanding must result in a reduction of losses and, ultimately, to enhanced strategic stipulations and provisions (Ceniceros, 2000).

ISO 14001 provides companies with basic guidelines to adhere to in planning an eco-friendly management scheme for business practices. The methodology, which takes into account both logical and auditing recommendations, strives to incorporate environmental matters into all facets of a facility's setup. All personnel, from executives down to the man employed in the boiler area have to understand how their position influences the environment.

When pertaining to reduction in environmental accountability, the ISO 14001 accreditation has its restrictions. The ISO arrangement can assist a company in

ensuring correct implementation of environmental management (Schaarsmith, 2000). ISO 14001 keeps an eye on conformity with the code of practice of the state in which a facility is situated and those guidelines differ from nation to nation. Conformity with ISO principles offers insurers a sense of assurance that an organization has some understanding of its impending problems and that the company has complied with the regulations (Schaarsmith, 2000).

2.3.2 Standard BS 8887

The environment has been a main concern to governments around the world since at least the late 1970s. This is after reports were published that the environment of the world is experiencing an overall degradation. Thus, energy emissions, water usage, dusts, odour and others have been carefully controlled and regulated by statute.

Most of the time, the intention of the law is to reduce the materials going into the landfill, thereby reducing land pollution. Another intention of the statute is to make emissions to be as non hazardous as possible. One such statute is the British Standard 8887.

As legislation is one of the primary motivators by which environmental issues are taken seriously by different companies, legislators tend to be serious about it. It is often identified as the instrument which the government uses as a means to drive companies in the desired direction. As legislation is expected to become more demanding when it comes to environmental regulations, it then becomes necessary for companies to anticipate the new legislation as a means of strategy.

The British Standard 8887 is a piece of environmental legislation directed at the manufacturing industry. Its primary aim is to identify and to specify the use of ISO Standards in order to up the ante of the design for manufacture (BS

I, 2006).

This British Standard is structured with a framework in order to enable the manufacturer to transfer his or her design concepts beyond the manufacturing industry. This standard specifies the requirement for the preparation, design and over-all life cycle of the product.

It also features specific methodologies in order to document the transfer of a design concept to manufacturing. It sets the maximum limit for the margin of error allowable. Thus, this standard effectively limits the energy emissions that may be produced effectively limiting pollution as well.

In an effort to manufacture sustainable design, it is believed that no standards or guidelines can promise success unless there is good understanding and greater sharing of practices among companies.

2.3.3 Standard BS 8888

As laws are one way by which governments may drive a company in the proper direction, legislators tend to take them seriously. As reports have surfaced that the world is facing an overall degradation of the environment, it has become the centre piece of major legislation.

In an effort to curb the continuing degradation of the environment, laws have been enacted to force companies to become more environment-friendly. One such statute is the British Standard 8888.

BS 8888 performs three fundamental tasks (BSI, 2004)

- Unifying all the ISO standards applicable to technical specification.
- Giving an index of ISO standards involved with different principles of technical product specification (TPS).

- Providing BSI with a platform for further explanatory commentary where necessary.

The issue that corporations will have to integrate the natural surroundings into its operational and strategic decisions will be inevitable. It will not only affect corporations but will also have wide-ranging consequences for the suppliers, manufacturers and consumers.

Environment-friendly business practices have been the subject of increasing scrutiny for researchers, practitioners and consumers. Research from different fields has combined various management, engineering, physical science and social science knowledge sets. A number of government initiatives have started to require businesses to be as environmentally conscious as possible. Also, it is notable that businesses and organizations have started to view being environmentally friendly as a way to gain traction in the market and have a competitive edge over their competitors.

The British Standard 8888 is a standard designed to regulate specifications for engineering blueprints. In the statute itself, there is a straightforward guide which practitioners must follow. It combines the tools engineers use for the design, manufacture, and verification processes.

The main purpose of this British Standard is to ensure that technical drawings and blueprints may be understood by non-technical people. Non-technical people may make recommendations on what needs to be changed on the blueprint. They may then be easily shared in the future.

2.3.4 Standard EMS

EMS or the Environmental Management System is an essential function of the

control arrangement of a contemporary business (Chen,2004). It is openly connected to the company's environmental guidelines that place great emphasis on recognizing and monitoring the influence of its undertakings on the surroundings. In order for an EMS to be effective, it requires the dedication of all persons in the company and a good management auditing system that will deliver measurement, supervision and control.

The EMS will put emphasis on the company's production of waste and its disposal. This may well be compacted substances or liquid waste. Furthermore, administration will keep an eye on the influence the business has on groundwater, and above all the potential effects of substances that it employs in its manufacturing process.

In the same way, the EMS will put emphasis on noise and vibration as a cause of environmental pollution , and the control that the company has on the environmental quality of its direct surroundings. Further than this, the EMS needs to detect all probable environmental expenditures and offer emergency assets to cover the expenses of future insurance, tax, possible charges and the investment cost in equipment that is more ecologically friendly.

The procedure contained in implementing an EMS is generally based on the Deming approach. The first step considers planning. The second step involves establishing goals and a programme for execution is organized. The third step is the ‘do’, which requires the execution of the plan. The check step follows and includes constant checking and control accompanied by the application of any essential corrective action. All this is recorded, audited, and the data used in the next step - the management review. The next step is the organizational review, and finally, the last step is the ‘act’ step.

It can be said that an EMS is an all-around tool and does not need any organizations to essentially “retool” their present activities (Chen,2004). An

EMS creates a management structure by which an organization's influences on the environment can be thoroughly identified and lessened. For instance, a number of organizations, as well as municipalities and counties, have active pollution prevention undertakings. These could be integrated into the whole EMS. For example, ISO 14001 is designed to applied the EMS in any firm which purchased this standard.

2.3.5 How the environmental standards affect the organizational aspects.

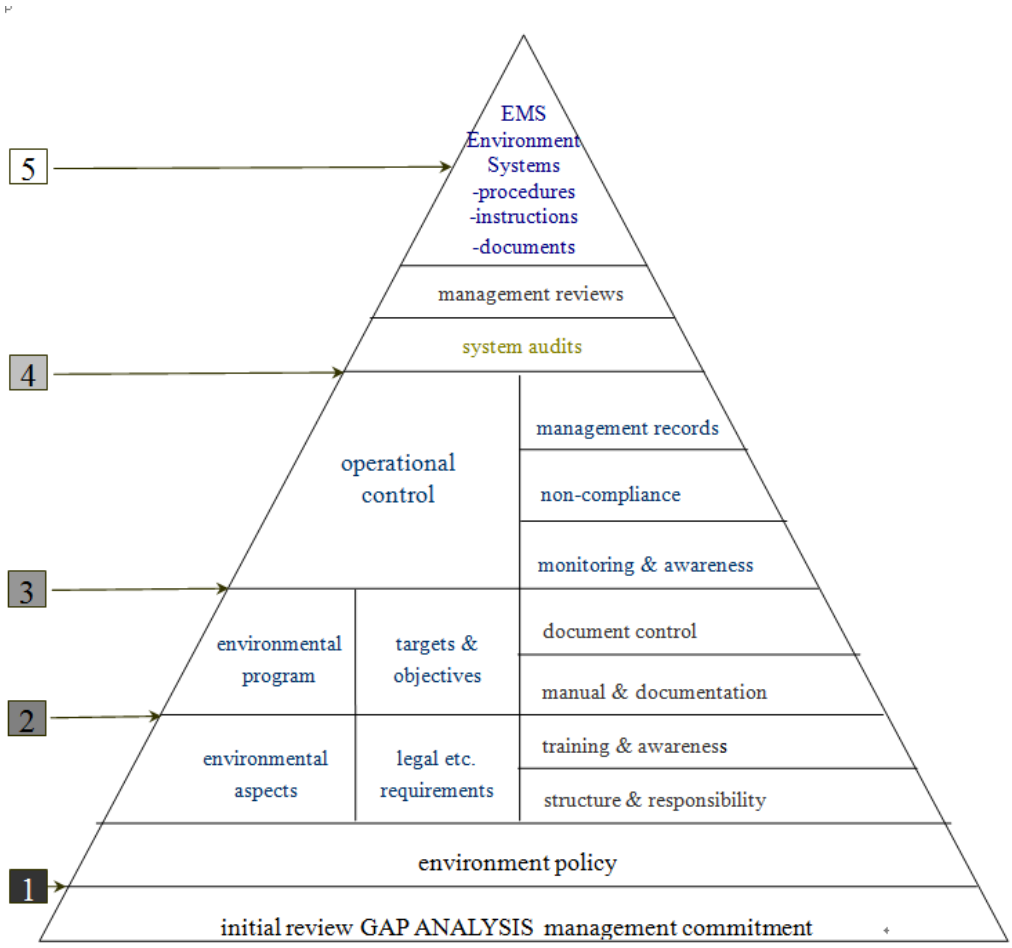

Figure 2.4 The structure of the ISO 14001 specification (Phase 1-5 represent the implementation sequence when operating)

Adopted from: Online Source (http://www.mtarr.co.uk/courses/topics/0102_isoe/index.html)

The implementation of ISO 14001 will affect the whole company's organizational structure. It builds environmental management factors into all levels of the firm, therefore changing the power mechanism within the firm. The result of implementing ISO 14001 will also change the company's corporate culture as well - people will value environmental and sustainable standards in their daily work.

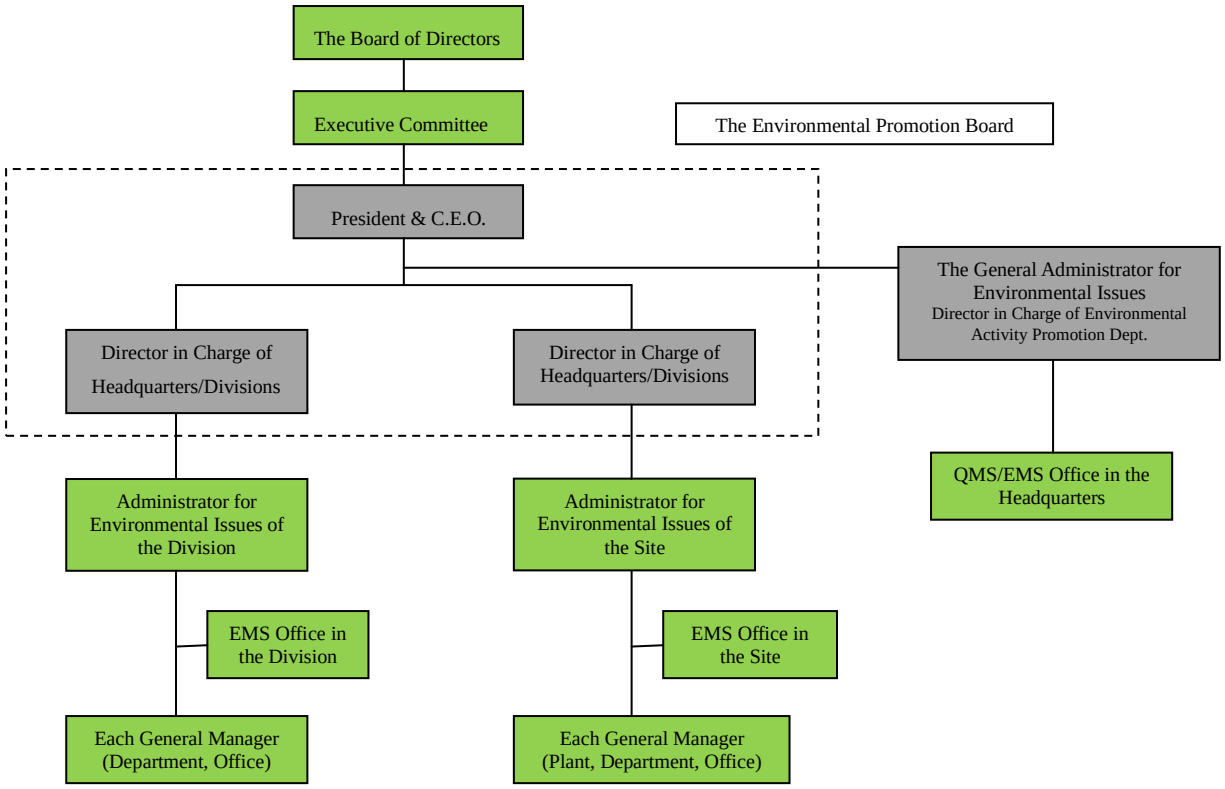

Figure 2.5 The management system of an ideal EMS firm

Adopted from Online Source: http://www.riso.co.jp/

However, there are several points of view about the effect of the implementation of ISO 14001. In one paper which researched a part of a Spanish firm, the author noted such an application could hurt the share price of a firm by increasing intangible costs. Their research used much firsthand information and mathematical methods, concluded that implementation of ISO 14001 could lead to a negative return for the firm, and also doubted the economic value of ISO 14001 standard (Cañón-de-Francia & Garcés-Ayerbe, 2009). Some researchers hold a more positive viewpoint: the improving and/or signalling performance after introduction of the environment management system could be considered as a valid result, the relativity being decided by the facility size (Johnstonea & Labonneb, 2008).

2.4 The relationship between environment standards and sustainable development

The United Nations World Commission on Environment and Development firstly proposed the concept of sustainable development in the report of "Our common future" report in 1987. This report claimed that the sustainable development should not only meet the needs of the current generation but also does not damage the needs of future generations (Bulleit, 2000) At the same time, both economic benefits and the environmental benefits should be considered in the development which can secure the needs of future generations (Omer, 2008). Sustainable development includes the requirements of different generations, state ownership, the load of natural resources, equality and harmonious development, etc. The core of sustainable development is, development which has two assumptions that population would be controlled and the qualifications should be improved. The theory of sustainable development received the acceptance of developing countries since it promotes the development of mankind by environment protection.

The concept of sustainable development requires that both the pollution and damage to natural resource should be controlled when emphasizing the economic development. This also needs the implementation of environmental laws and standards (Omer, 2008). According to the regulations of environmental standards management, the aims of environmental standards in China are to prevent environment pollution, keep ecological balance and protect the health of the population. Traditionally, the environment standards are based on the treatment at the end of production while current regulations and standards emphasize the beginning of production (Bulleit, 2000). For example, during the period of March 2009 to November 2009, China published 12 terms of environment standards on clean production. Therefore,

the set and implementation of environment standards in China are coincident with the concept of sustainable development.

As discussed above, both the sustainable development and environment standards stem from the values of ecological balance. In the implementation, both of them are promoting each other. Firstly, environmental standards provide security for China to implement sustainable development. Standards are the critical method to negotiate the technology, economy and management (Omer, 2008). The environment standards of China are the important part of environment management, monitoring and natural resource protection for the state and local government. The usage of environment standards and regulations can not only make full use of the natural resource but also secure the health of the population. Secondly, the concept of sustainable development can direct the set, implementation of environment standards. The sustainable development strategy of China requires that the setting of environment law should follow the ecological concept and make adjustment toward current regulations and standards. Sustainable development strategy is based on technology and thus can improve the environment monitoring technology and propose more serious requirements for the environment standards and regulations.

2.5 ISO 14001 standard and environment management

2.5.1 Motivations of Chinese firms to take ISO 14001

According to the researches of Hart (1997), Gladwin (1999), Starkey and Welford (2001), organizations were faced with the pressure of environment management and performance improvement during the past 30 years. Recently, these factors enhanced this trend. Firstly, the decline of the environment brings

in adverse results for the organizations. Therefore, most countries use new environment management systems even though there are large differences in implementation in different countries (WRI, 2001). Secondly, organizations also become aware of their negative impact on the environment. ISO 14001, etc, can take the role of policy. This standard is also considered as the basis of environment management for companies. Thirdly, management team generally accept that environmental performance of companies would be a large part of the investment decision and bring in satisfactory returns (Hart, 1999, Reinhardt, 1999). This though is justified by a lot of cases and empirical studies. Fourthly, the stakeholders of organizations also recognized the importance of the environment. Furthermore, with internet and other communication technologies, the stakeholders can learn more about the companies, so that they can spread this information widely.

With above changes, most companies began to respond to them. These companies began to change from a passive to an active environment management strategy. All these changes are recognized by many researchers, such as Berry and Rondinelli (1998), and Brown and Karagozoglu (1998) at the same time, companies also make promises on their environmental performance and the measures to reach them.

Within this background, most of the companies began to take on ISO 14001 certification. In Japan, the companies took measures to follow the ISO 14001 standard and they realized that this certificate was a second license for export. At the same time, most of the organizations in Japan promote this certificate of environmental standard. In China, although the environment standard is considered beneficial there are different responses from these enterprises. At the same time, the state owned companies and joint ventures are more sensitive to the benefits of ISO 14001 standard (Cheng, 1999; Chen and Wong, 2000).

There are also many different opinions toward the motivation of ISO 14001 certification. Harrington and Knight (1999) and Woodside (2000) listed many causes for organizations to take ISO 14001 certifications as: 1. To promote the share of certain market segments. 2. To respond to the pressures from consumers and market penetration. 3. To save cost and improve efficiency. 4.To gain reputation. Recently, Steger (2000) reviewed a lot of empirical studies and claimed that most of the companies that acquired ISO 14001 certification set the environment aims earlier. Therefore, the implementation of ISO 14001 in certain fields it seem that these standards do not have any effect on the fulfillment of the aims of the company. At the same time, most companies research what measures are feasible and what can bring fast returns. Many researchers consider more of the companies without ISO 14001 certification and thus are biased toward them when choosing subjects for their research cases.

2.5.2 Comparative analysis between ISO 14001 and environment management system in China

Comparing the ISO 14001 environment management standards and the current environment management standards in China, there are both similarities and differences. The common aspect is that both ISO 14000 and the current environment management system in China follow the principle of sustainable development. ISO 14001 not only requires the organizations to establish scientific environment management systems and take effective control of key environment factors, but also enhance the complete management system to promote the improvement of quality (Yuan, 2004). This is coincides with the thought of “complete control and clean production” in China. ISO 14001 evidently requires organizations to follow domestic environmental laws and

regulations. The legislation and regulations in China is based on the environment standards.

The difference is that ISO 14001 provides a complete environment management system, which is complete, scientific and easy to operate. At the same time, ISO 14001 also requires the organizations to establish environment guidelines and effective communication channels. The current environment management system lacks the environment guidelines in organizations (Yuan, 2004). At the same time, the Chinese environment management regulations are short of the monitoring system and thus hard to implement in practice. ISO 14001 standard is a complete environment management system, which can make the organization environment management systematic and standardized.

2.5.3 Previously research on the ISO 14000 series management system

Tibor and Feldman (1996) defined environment management standard as the guideline of an organization to determine and manage the environment. Steger (2000) has different definitions for environment management standards as a system whose aim is to set and implement the environmental goals, policy and responsibility with regular auditing of related factors. Both definitions indicated that the aim of environment management standard is to improve the environment.

There are many researchers considering the process of establishing ISO 14000. For example, Kuhre (2001) introduced the steps to acquire the certificate by surveying in different organizations. At the same time, Kuhre (2001) also proposed the opinions toward the emergency treatment, life cycle analysis, MSDS data collection, archiving of management log, etc. According to Hillary (2000), some companies also introduced their experience of the implementation of an ISO 14000 system, which includes the motivation to

implement ISO 14000, benefits of environment management standards, etc.

Matouq (2000) surveyed the central area of Japan and conducted a study on the procedure and significance to establish ISO 14001 environment management system, and analyzed the aims and motivations of them. Matouq (2000) also studied the barriers to ISO 14001 establishment and the impact of it on the environment. Babaki (2003) investigated 584 companies in the US and the results show that there are 8 critical factors in the implementation of ISO 14000 environment management system as: identifying the environment factors, identifying the aims and indicators, setting and implementation of the environment management plan, training and involvement of all staff, the guidelines, operational control and examination of the environment management system.

2.6 influence factors on the sustainable design standards in China

2.5.1 Influence of economic regime

From the establishment of new China till end of the 1970s, the planned economy took the dominant role in the economic life of the country. Although the economic growth is not slow, there is a small total quantity of the GDP (Li, 2004) the environment problems are not so large that they attract the attention of the Chinese government. With the openness and reforms in China, a market based economic regime is established (Li, 2004). The environmental problems also increased with the economic development. The market based economic regime of China emphasizes the flow of resource in the market and the competition among the different market bodies. This economic mode

although an incentive to activating the market to take part in the economic activities, it has caused the repeated construction, over development and pollution, which damages the living environment (Li, 2004). Therefore, there is an urgent requirement for the government to control the pollution and to establish environment management standards. With the overview of the economic development of China, the economic regime change causes damage to the environment while it provides foundations for the competitive advantages of China. Environment management standards mainly control the pollution to reduce the negative impacts of industrial production on the environment.

2.6.2 Influence of political factor

At the end of the 1960s, there was an international campaign for environmental protection. In 1970, the US also launched the campaign for "Earth Day" with the theme of protecting the environment and the earth, which reflect mankind's thoughts about environmental problems (Yuan, 2004). Therefore, there is now a widely spread environmental protection campaign. At the same time, in the 1970s, ecological parties were being formed. The internal environment protection organizations also appealed to each country to implement the environment management standards.

Environmental diplomacy also becomes the main channel to adjust the relationship between countries. Environment protection already becomes a key topic of politics. Behind this background, the Chinese government established the Environment Protection Bureau to enhance the governance of environment management (Yuan, 2004). The Environment Protection Bureau of China takes the role to plan, set and publish the environment standards. Then China began

to organize and plan research and set the environment standard.

The environment protection bureau should not only consider the domestic environment standard but also the environment standard of the other countries. The international environment protection organizations provide reference for the setting of environment quality standards in China (Li, 2004). At the same time, with the global and long term environment problems, protection can no longer be resolved by a single country. Under this circumstance, the domestic environment management standards should be linked to the international standards. Namely, the environment management standards of China should consider the standards which are accepted worldwide.

2.6.3 Influence of environment protection concept

Roth (1968) firstly proposed the environment consciousness and argued that those people who have no environment protection consciousness caused the pollutions and damages to the environment. Although there was controversy around the concept of environment consciousness, the basic contents of this concept is similar: the relationship between mankind and nature. Generally, the environment consciousness includes the theories about the environment, opinions, ethics, policies and values.

The primary environmental problem is pollution, this directly affects mankind. . Therefore, the environment laws at the beginning are to control the polluters (Li, 2004). The government of China thus published a lot of standards on pollution treatments. This reveals that the focus of the policy makers in China is to treat environmental pollution. The Chinese people always take the view of emphasizing self interest and ignoring the interest of future generations (Yuan, 2004). At the same time, mankind also ignores the

ecological value of environment. However, with the environment protection concepts, the environment protection consciousness of the public is showing a promising change. As a matter of fact, the environment management standards of China are following the changes in environment resource protection values.

2.7 The experience of developed countries on environment standards and regulations

2.7.1 The environment standards and regulation of the European Union

Although the European Union is not primarily concerned with environment protection it pays more attention to environmental pollution problems. There are many regulations and standards established to control pollution and protect the environment (Waide et al, 1997). The environment standards of the European Union are generally published in the orders or articles of the EU. For example, the 67/548/EEC-Classification, labeling and packaging of dangerous substances and Test methods Regulation. The European Union is an international organization among countries, the environment standards issued by the EU have certain restrictions. The environment standards of the EU can be classified into 7 types: water environment, air environment, noise environment, solid waste, nuclear security/radioactive waste management standard and chemical products management.

Since the EU is a union of different counties, the proposal, and implementation of the environment standards follows a complex process. There are different processes for the legislation toward the different environment standard (Smith et al, 1999). Generally, a new environment

standard is firstly proposed by the EU committee and then proceeds to the negotiation stage of the new environment management standards. During this stage, the EU committee should collect the suggestions and make a decision on the proposed new standard, then make them law (Smith et al, 1999).

For the implementation of the environment standards, the EU does not provide detailed information. Each member country can choose the respective environment protection solutions by following the directions of the EU. By reviewing the environment standard system of the EU, China can learn and adapt to establish their own environment standard. .

2.7.2 The environment standards and regulation of the USA

The proposal, implementation and management of environment standards in China are different from those in the US. In the US, the environment standard is mainly published by the environment protection authority, which can be applied in each state of the US. The companies with pollution emission should follow the contents in the environment standard (Malone, 1999). When the companies breach the minimal quality level or emission standard, they will be punished by the related laws.

There is no universal law on environment management but there are many detailed environment standards in each field or industry. The advantage of the environment standard in the US is that they have detailed the whole process of environment management (Malone, 2001). The US law has detailed instruction on the technology foundation and industry has applied it thus improving the effectiveness of environment standards.

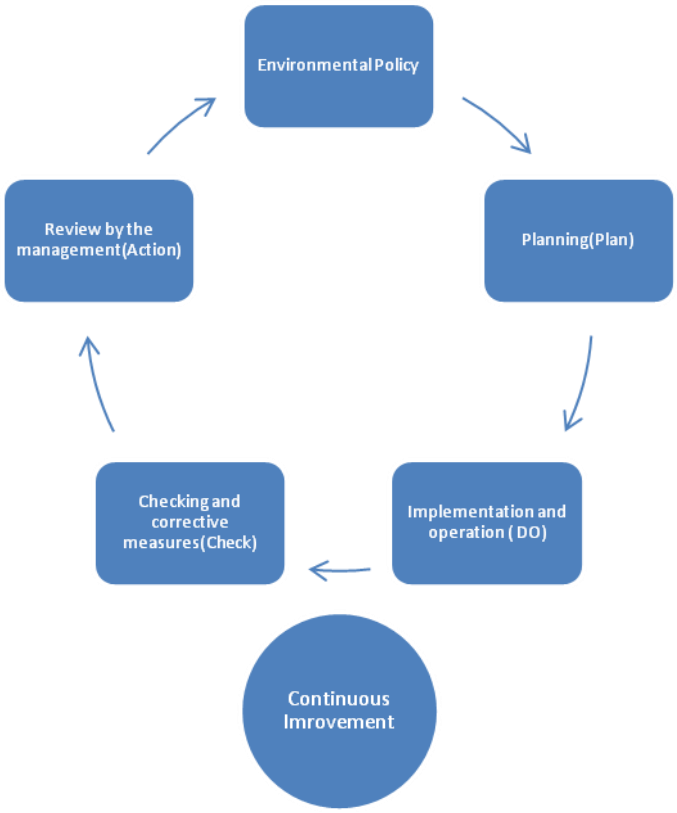

Figure 2.6 Environmental management system elements
Adopted from: Staib, 2005.

2.8 The problems and solutions in the environment standards and regulation of China

2.8.1 The problems in the environment standards and regulation of China

Although China has developed well in environmental management in recent years, there are still many problems in the environment management standards (Yao and Steemers, 2009). Firstly, the theoretical foundation of environment management standards of China is weak. The environment management standard system of China includes the national environment quality standard, pollution emission standard, etc. each standard should be quantified in five aspects: quality level, control requirements, analysis method, standard sample and scientific foundations (Yuan, 2004). In current environment management

standards of China, there are still many controversies and they lack the united foundations to direct the implementation of the environment management standards. At the same time, some standards lack the analysis method and/ or standard sample, which would restrict the advantages of whole environment standards (Li, 2004).

The legislation feature of the environment standard is not defined. The environment standards in China are proposed by experts in the related fields. Currently in China, these standards themselves do not belong to legal system. The confusion of environment management standards in its nature and power is the primary barrier to the implementation of the environment standards system in China (Yao and Steemers, 2009).

The environment standard of China does not take the classifications by targets and pollution sources. Although the environment quality standard of China set the control value for different functions, the pollution emission standard does not set the different levels by the pollution sources (Yao and Steemers, 2009). The environment quality standard on the water and air quality does not consider the pollution source. The technological contents and application scope of the noise control standard is not definite. The fine fee standard and industrial emission standard should be negotiated (Li, 2004). The fees standard on the emission is defined by the fine principles in China. The fees before 1990 are based on the standard of 1973. The pollution emission standard and polluted water emission does not gain effective implementation.

The environment management standards do not gain effective implementation. There are three steps for the environment management standards: propose, publish and implement. China mainly emphasizes the proposal of the environment management standard but has limited consideration on the issue and implementation of them (Yuan, 2004). The possible reasons are that the

environment management standards lack monitoring staff and thus cannot access problems in the implementation. The information cannot be instantly accessed . The monitoring management of environment standards lacks the basic works, such as the monitoring, assessment, planning and management.

2.8.2 The solutions in the environment standards and regulation of China

As discussed above, there are many problems in the environment management standards of China. Many researchers also proposed the solutions to these problems based on theoretical and empirical studies.

The nature and legal power of environment standards should be defined. To define the power and nature of environment standard is the basis for the implementation of environment standards (Yuan, 2004). Environment standards are the tools for environment management in China, they should be assured by the environment protection departments.

The principles of the proposal and modification of environment management standards should be established. The process of environment standards proposal and modification is the process of the public and experts to communicate, reflect and work out the environment problems (Yao and Steemers, 2009). The democratic and scientific aspects of the environment standards proposal should be secured. Experts from different related fields should be employed to audit the environment standards from a different perspective.

The experience of other developed countries can be adopted by China. As analyzed earlier in this chapter, the developed countries have accumulated the experience in the environment management and regulation (Yuan, 2004). This experience can be adopted by China to improve the effectiveness of environment standards in China. At the same time, this experience of the

developed countries can be reviewed by China to avoid the potential problems in environment management.

The theoretical research and empirical study in the environment management and regulation should be considered more. Researches in this field can provide the foundations for the environment standards proposal and implementation (Yao and Steemers, 2009). At the same time, the empirical studies in environment standards can explore the practical issues in the practice of environment management. The related companies or government department can also be linked to the research institutions to enhance their skills in environment management.

2.8 Summary

As discussed above, there are different definitions of sustainable design from different perspectives. Based on the literature in this field, this research proposes the definition of sustainable design standard here: The standards and formulations about external and internal sustainable development of specific organization. At the same time, there are common principles of sustainable design. ISO 14000 series standards are also reviewed together with related researches in this standard. This review found that there were different motivations for Chinese companies to take ISO 14000 certification. There are both similarities and differences in the ISO 14000 and current environment management systems in China. There is also a lot of research on the ISO 14000 series standard series. The sustainable design standards in China are also subject to the economic regime, political factors and environment protection consciousness. There are many problems in the environment management of China. However, there is much research proposing solutions

of these problems to improve the effectiveness of environment management standards. However, there is limited research with regard to the environment standards in the microelectronics industry.. This research thus is aimed to study the microelectronics industry, to identify the related problems and propose solutions of these problems accordingly.

Sustainable design standards with manufacturing process innovation and environmental impact considerations.

Research	Design	Improvement	Officially published	Ageing	Renew
Existing environmental impact of manufacturing identified & researched Collect data Research Analysis	Design the alpha version of sustainable standard for increase efficiency and reduce pollution for manufacture process Put out trial version of standard to practice in a small area	Collect feedback from all concerned personnel and aspects Analysis & edition	Publish standard/legislation Monitor the implement process Compare the environmental impact change before and after standard issued	New technology and manufacture process appear Remaining environmental impacts not possible to remove	New standard needed to be designed/added
◄- - - - - - - -	Standard design for existing environmental impact of manufacturing process		- - - - - - ►		
	◄- - - - - - - -				
		Technology & manufacture innovation		- - - - - - ►	

Table 2.1
Adopted from: Robert Staib, 2009

Chapter 3: Research methodology

3.1 Introduction

This chapter is research methodology, which is critical to the thesis since it helps the reader to learn about the processes used in this research work. Research methodology is the routine of the research and foundations. This chapter will introduce the research approaches with justifications. The research plan is also discussed. The data collection method is introduced together with the data analysis method. At the same time, the research ethics and interview process are also discussed.

3.2 Research approach and justification

There are both qualitative and quantitative research approaches. Each approach has its advantages and limitations. The research approach was shown briefly in Figure 1.4.

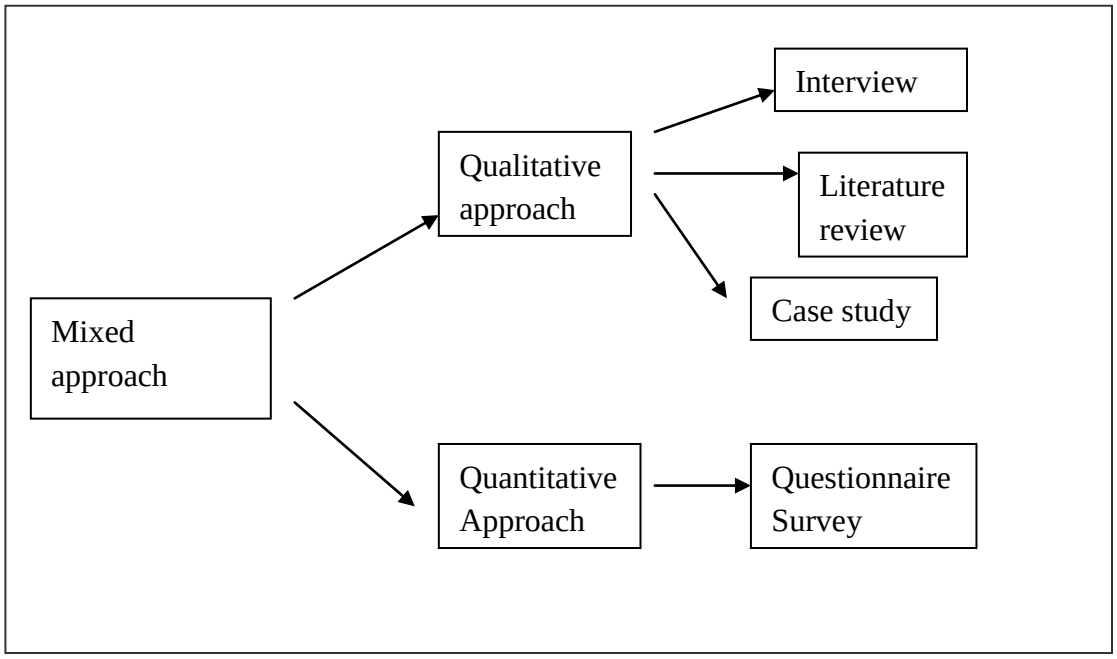

Figure 3.1 The research approach of this study

Bryman (2006) analyzed 232 copies of social articles and argued that the integration of quantitative and qualitative research is becoming increasingly common. There are three distinct research approaches: quantitative, qualitative and what is called multi-methods (Brannen, 1992) multi-strategy (Bryman, 2004), mixed methods (Creswell, 2003), or mixed methodology (Tashakkori and Teddlie, 2003) research. In this research, this third method was called mixed methodology. Creswell et al. (2003) claimed that mixed methodology has certain advantages which are not covered by qualitative and quantitative approaches respectively. In this research, the research aim is to examine the sustainable design standards of China. Both the definitions of sustainable design standards and practices of China need to be studied. It is necessary to illustrate the current literature to define the concept of sustainable design standard by qualitative approach. At the same time, to identify the problems of sustainable design standards of China, we need to take primary data analysis to enhance the accuracy of research results. Therefore, both qualitative and quantitative approaches are needed in this research. As we all know, both qualitative and quantitative approach have advantages and limitations, the

mixed method can reduce the impact of limitations of each one by integrating them in a mixed methodology. Hence, the mixed method is feasible and suitable for this research.

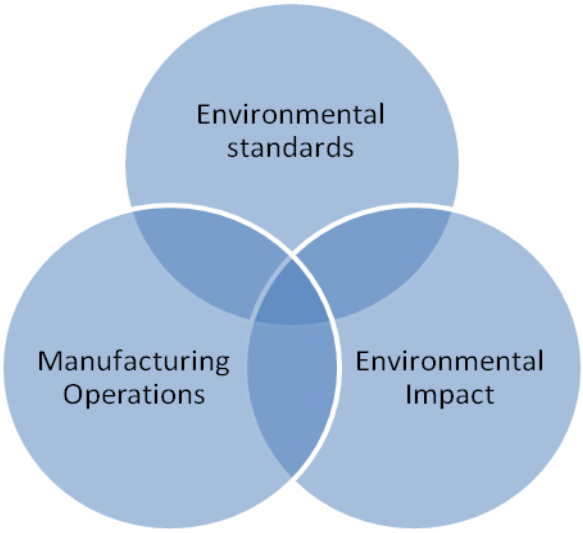

Figure 3.2 The research focus of this study

3.3 Research ethics and data collection methods

Since this research is based on the primary data, the research ethics are an important part within this research project. The research will respect the confidentiality and privacy of the respondents. To keep and protect the confidentiality and privacy is the critical tenet of every researchers' work (APA, 2002) for example, this research would design ways of asking whether the respondents are willing to take part because there would be some sensitive questions. The respondents also have rights to stop when they feel uncomfortable in the interview or survey. The respondents in the research can choose how much information to uncover about themselves. For example, it is not necessary for the researcher to collect the contact information of the respondents. This research would avoid this information and keep the respondents anonymous. The data collected by the research would only be used in this research work.

There have been several research papers focusing on the sustainable standards over the past few years. Most of them have been based on literature review data and theoretical comparison (e.g. Chen, 2004).

This research is mainly based on the primary data. There are two methods to collect the data used in this research work: interview and questionnaire based survey. The data collection is mainly based on the interview, which make it the most important area of the research. The researcher makes contact with the possible interviewees to ensure the participants fully understand the research's purpose and their own rights. Also the researcher will let them know the reason for the on-going research, why the researcher would like to interview them, and what the researcher will do with the data and information collected.

The interview method is mainly of an oral nature. It is based on the answers of the respondents so the researcher collects objective material to explain the total population with the sample. This method is mainly used to study a complex research question. This method has good flexibility and suitability and thus is widely used in an educational survey within the consultation sector. There are both advantages and limitations with this research method. For the positive aspects, the interview method can allow the researchers to have a deep understanding of the respondents toward the research question. This method is also easy in the interview script analysis. However, there are limitations in this research method since it costs time and money. The researcher in this research needs to travel to China for the interview thus has high costs for the interview part. Under the guidance of the supervisors and some books, the researcher understands the advantage and disadvantage of interviews. The researcher also prepared questionnaires, but the main purpose of this trip was to interview, and get more clarified and in depth response to the questions. Personally, the researcher has to have good skills in making contact with people and listening to their ideas and noting their views. The data collected by interview will not

only be used in the interview script analysis but also in the case study.

A questionnaire based survey is another data collection method to be used in this research. When the researcher wants to study a social phenomenon, he or she collects data by questionnaire, interview or by another method. The questionnaire based survey assumes that the questions that will be asked are valid. These questions will be printed on paper and sent to respondents, and then collected to be analyzed. Generally, 90 respondents are surveyed, located in Beijing, Tianjin and Guangdong. A microelectronics firm in Guangdong will be covered in this research since Guangdong is the centre of the microelectronic industry and thus is representative. Although the companies surveyed are based on a random principle, there is a preference for the choice of the microelectronics industry, which is the research focus of this study.

The surveyed firms and interviewees are all spread in Beijing, Tianjin and Guangdong. The following explanation is the reason this research chose the 3 specific areas.

Beijing is China's capital city which also has high level industry, Tianjin is close to Beijing, however the industry level and species are quite different. Guangdong is a coastal province with high level economic and open culture. As a star city of Guangdong, Dongguan has strong microelectronic industry, it provided an ideal environment of research.

Most of the survey firms are randomly chosen by business list & internet yellow book. The author also give attention to the firms scale and reputation.

The interviewees situation is similar to the way chose firms. Most of them are random interviewed as the field survey went, a few interviewees were selected in purpose for represent significant points of view which could represent government, business and public.

At the same time, there is secondary data be used in this research since literature reviews are also a research method used in this study. The literature used in this research has been mainly collected through the following two sources:

1. The library. This source provides the basic theoretical foundations for this research. The literature collected by this method will be discussed and critically analyzed accordingly to the research aims and objectives.

2. Online journal database and official websites. The databases, such as Science Direct and Springer Link are used. These databases provide rich updated sources of information, on a broad range of research topics. The literature collected by this research provides foundation for this research. The official websites of some organizations will also be used since the sustainable standards are published there, they are easy to access.

3.4 Questionnaire design

Questionnaire design is the critical step for the primary data collection. In this research, a questionnaire based survey is adopted to collect the first hand data. To explore the sustainable standards of the firms in China, the questionnaire was designed to divided into 5 parts. Part 1 is the environmental acknowledgement and policy, which includes questions 1 to 31. Part 2 is environmental business prospects, which includes questions 32 to 34. Part 3 is sustainable public relations, which includes questions 35 to 42 Part 4 is environmental information disclosure, which includes questions 43 to 46. Part 5 is social performance, staff relationship and customer. These questions will facilitate the research on the sustainable practice and adoption of design standards by firms in China. Based on the data collected by this questionnaire

survey, the problems of sustainable practices in China enterprises will be revealed accordingly.

The design of the questionnaire was based on classify the different aspects of the research focus and the situation of environmental standards implementation in China's microelectronic firms. The design process consulted a few pertinent literature (e.g. Saunders, Lewis and Thornhill, 2009) and related books (e.g. Easterby-Smith, Thorpe and Jackson, 2012).

3.5 Interview process

The interview process was divided into three steps.

Step 1: Before the interview the researcher would choose a suitable interview method, such as a telephone interview or a face to face interview. This research chose face to face interviews since it is easier to learn more about the opinions and answers of the participants. The basic interview questions will be compiled and the target interviewee will be contacted. Since this interview is done by the researcher there is no training for the interviewer. Three managers from three different industrial companies will be interviewed in this research. The researcher will start the interviews with early contact by phone or email, to arrange a convenient time for both. The researcher would like to meet the officer at their office or meeting room, and maybe meet the customers in a cafe or restaurant.

Step 2: The researcher would go to the scheduled interview location in advance and their behavior would be polite. The questioning during the interview should be flexible but based around the planned interview questions in step 1. At the same time, the researcher would record the answers accurately.

Step 3: After the interview, the researcher should express thanks to the respondents. At the same time, the researcher should also document the

interview script and delete the unrelated information. Based on the data collected during the interview the researcher should decide whether there is any need to interview for further questions.

In case of interviews and visits to micro-electronics industries, the researcher will follow the safety principles required, use protective helmets/dress and avoid any potential danger. Also the researcher will be very careful in abiding by the instructions. .

3.6 Data analysis method

This research illustrates both primary and secondary data while primary data is the main one. There are two data analysis methods. The first one is qualitative analysis. This is mainly covered in literature review part, which discussed the environmental standards in China. At the same time, there is a discussion in chapter 4 relating to data analysis. The literature review in this research would provide a foundation and help resolve certain research objectives. At the same time, the case study is also an important part of qualitative analysis. The interview script will also be analyzed in the qualitative approach.

Another data analysis method is the quantitative method, which mainly includes the analysis of the data collected by questionnaire. The meanings of each question is calculated and analyzed comparatively. As discussed above, this questionnaire includes 5 parts. Each part will be analyzed separately for the validity and credibility of the questionnaire. Based on the qualitative and quantitative research methods, the researcher can make conclusions on the findings of this research.

3.7 Summary

As discussed and introduced above, this research will take the mixed approach, which includes the qualitative and quantitative methods. A set of detailed methods to collect data, such as interviews and a questionnaire based survey. The research illustrates primary data and thus involves research ethics. This research will respect the confidentiality and privacy of the respondents. The interview process is introduced in this research. Three managers from three different companies will be interviewed. Ninety respondents will be surveyed in the questionnaire survey who come from Beijing, Tianjin and Guangdong. The data collected by this research will be analyzed by literature review, case studies, interview script analysis and quantitative analysis based on Microsoft Excel software.

Chapter 4: Survey findings and analysis

4.1 Introduction

This chapter is the survey findings and analysis. This chapter will analyze the data collected. Beginning with a statistical analysis of the data collected by the questionnaire survey. Then there is a conclusion to summarize the findings.

4.2 Statistical analyses

The questionnaire based survey is taken in China in three areas: Beijing, Tianjin and Guangdong. Ninety companies are surveyed while 75 copies are effective (5 firms refused to complete the survey, 10 firms did not reply). The sample size is 75 companies. The geographic locations of these 75 companies are shown in the following table (Table 4.1). This questionnaire is mainly aimed to explore the environmental acknowledgement and policy of the firms, business prospects and environment performance, etc. This part will take a descriptive analysis of the primary data.

Questionnaire collection

	Beijing	Tianjin	Guangdong
Questionnaire Sent	30	30	30
Effective questionnaire	24	25	26

Table 4.1

I chose these firms mainly by the areas that I am focus on: Beijing, Tianjin and Guangdong, in case to collect results easier. For most of the firms, I sent email questionnaire and collect the result by email as well. Also I send several questionnaires while doing interviews and got result by visit or email.

The following contents are findings and analysis of some significant questions, the question numbers are given at the beginning of each analysis part.

4.2.1 Environment acknowledgement and policy

Question 1) According to the survey data, 6.67% of the companies surveyed do not have regulations about sustainable design in product or management systems and only 13.33% of the companies have official written regulations. The companies which have non-official, non-written regulations occupied 37.33%. These companies which have non-official written regulations occupied 43.67% overall. The details of distribution are shown in Figure 4.1.

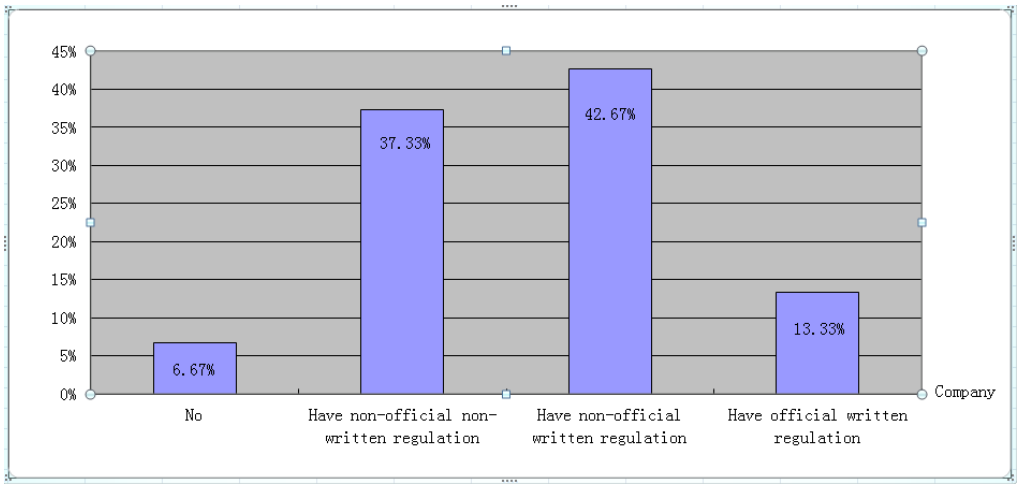

Figure 4.1 (Q1) Does the Company have regulations about sustainable design in product or management systems?

This figure illustrates that companies which have unofficial written regulations about sustainable design in product or management systems were in the majority. The companies which have unofficial, unwritten regulations take the second role. The companies with no sustainable design at all and the companies with official written regulation of sustainable design are both a tiny

minority.

Question 2) Also investigated was whether the high level manager was aware of regular environmental problems, and the particular risk and problems that their firm faced. The investigation results show that only 26.67% of the respondent companies claimed that the high level manager has a very clear understanding of regular environmental problems, the particular risk and problems which faced their firm. Most companies (66.67%) claim that the high level manager has an average understanding. From one more specific question, it showed that there are only 18% of these 75 companies receiving training or consultation. The data shows most of the surveyed firms are in the main understanding and paying attention to the stage of sustainable design related factors.

Question 4) The survey investigated the human resource and function department input related to sustainable problems within firms. Figure 4.2 introduces which level the firm has a defined, responsible person for environmental problems, and on which level the firm has a functional department with regard to Environment/Sustainable product design. The levels were divided to four types: None, only in base level, in mid and base level and then in high mid and base level. Base level means workers and staff, mid level includes managers, administrators and person in charge of base function factors (like workshop director), high level is stakeholders, high rank managers, etc.

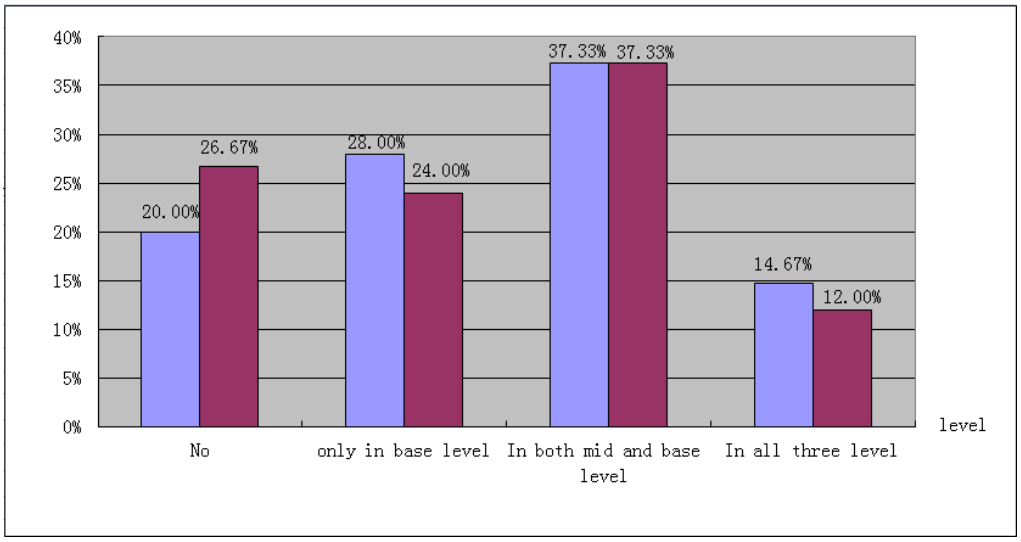

Figure 4.2 (Q4) Does the firm have a defined responsible person for environmental problems, and have a functional department for Environment/Sustainable product design? （Blue—defined responsible person; Red--functional department)

This figure showed that 14.67% of the surveyed firms have a defined responsible person for environmental problems in high, mid and base level, while 12% of the firms have a functional department with regards to the environment/ sustainable product design in all three levels.

The companies which chose both mid and base level accounted for the highest proportion of this question，that is 37.33%.

The survey showed that 42.67% of the companies have an accountability principle if any environmental problem occurs (Question 5). We found that 26.67% of the companies which have an educational plan/system for staff training about the awareness of sustainable product and environment protection with written copies (Question 6).

In the company policy development factor, we found that 38.67% of firms adopt a specific measure to encourage staff to participate in sustainable product design and environment protection (Question 7). 24.00% of the firms

have reward and punishment systems for staff environment-related actions (Question 8). 25.33% of firms have sustainable standards in product design, manufacture, assembly, disassembly and end-of-life sections (Question 14). 33.33% of the firms reach the mark of harmful gas discharge and have good recycling or cleansing equipment and systems (Question 10).

In general, 69.33% of firms had heard about sustainable design standard and the environment management system (Question 15). However, only 17.33% of firms have clear goals for the reduction of greenhouse gas discharge (Question 13). Only 12.00% of firms have purchased any sustainable design standards and the environment management system (Question 16).

Question 16) Figure 4.3 shows the details of the financial input of these firms which have purchased sustainable design standards or environment management systems.

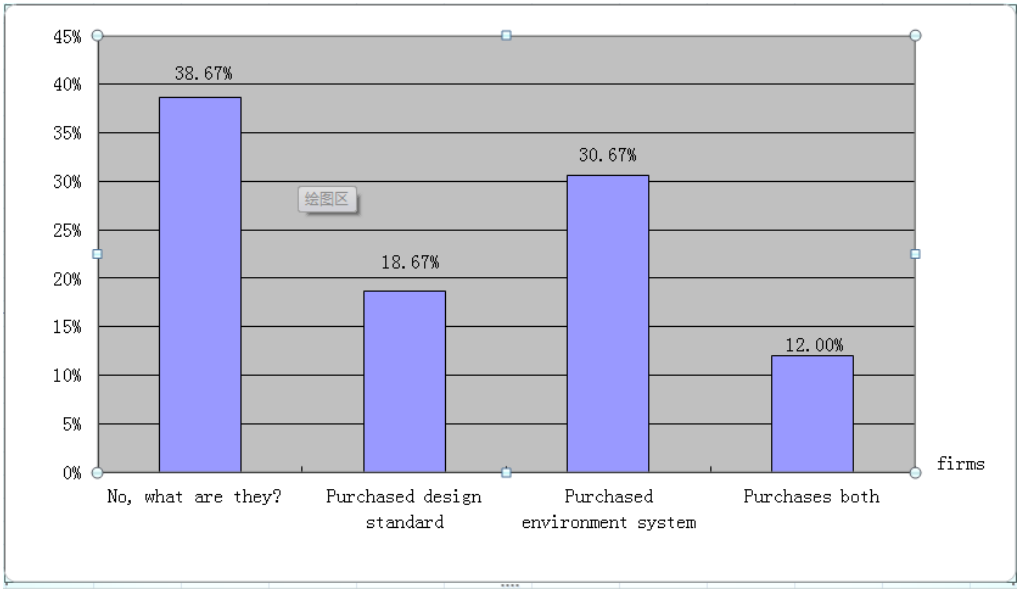

Figure 4.3 (Q16) The financial input on sustainable design standards and environment management system

From the above figures, it is obvious that many surveyed firms do not have investment budgets for an environmental management system, only a few

companies laid emphasis on this problem and had invested funds.

Question 21) Figure 4.4 shows how frequently the companies use sustainable design standard or similar legislation in decision-making processes.

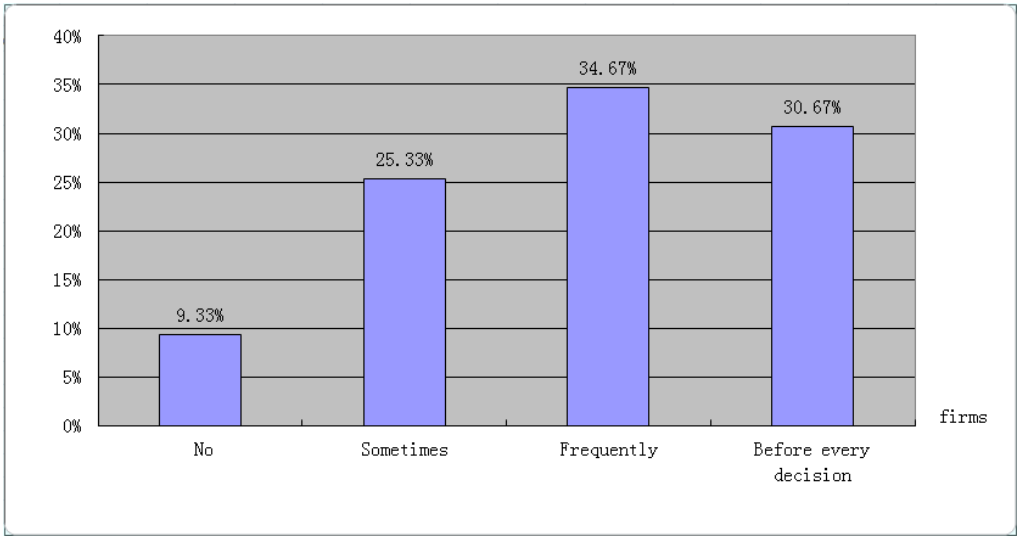

Figure 4.4 (Q21) Does your company use sustainable design standard or similar legislation in decision-making processes?

In addition, the survey showed that 30.67% of firms use sustainable design standard or similar legislation before every decision, 34.67% of firms use such standards frequently in a decision-making process, 25.33% of firms use such standard occasionally, and 9.33% of firms have never considered such a standard.

We found that 72.00% of firms have signed and completed documents about environmental liability with an environmental protection and administration section of government (Question 18). 34.67% of firms execute the evaluation of environment influences before they start a new project (Question 20). 78.67% of firms use recyclable materials or environment friendly materials in prime products (Question 25). Only 26.67% of firms take action to improve the type of shipping to reduce the costs and pollution caused by shipping, and 33.33% of firms provide the information of product environment, energy

consumption and recycling of products (Question 27). 57.33% of firms think sustainable design standards could help their company improve in all sections when mentioned in the above questions (Question 31).

From the analysis above, it illustrates that most surveyed firms have a sustainable concept and also have the sustainable design awareness at decision-making level. 78.67% of the surveyed firms have recyclable materials in their manufacturing flow (Question 25). However, they do not have detailed and profound understanding of the sustainable standard and investment of funds, function factor or human resource as these are all very limited. Therefore, through the analysis of the survey data , it indicates that the surveyed firms are in the primary stage of realizing and understanding sustainable design and environmental standard.

4.2.2 Environment business prospects

This section focused on environmental business and sustainable product prospects of firms. The survey showed that 49.33% of the firms join the formulation of new sustainable and environment protection standards of industry. The firms which joined and took action with a positive attitude occupied 22.67% of the overall figure. (Question 33).

Question 32) Figure 4.5 showed the income of energy saving or environmentally friendly products of firms. Most firms (38.67%) have the income from the energy saving and/or environmentally friendly products are between 1% and 5% of companies . We found that 32.00% of firms have the income from 5% to 10%. 17.33% of the firms were in the range of 10% to 15%. Only 4.00% of the firms have the income at the range of over 15%.

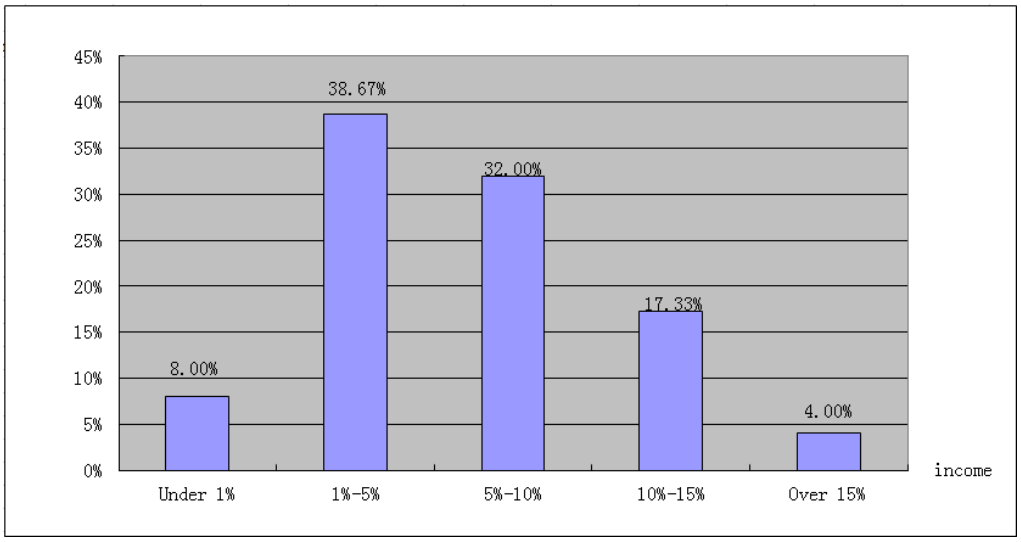

Figure 4.5 (Question 32) What is the income of energy saving and/or environment friendly products of your company?

Question 34) The next figure (Figure 4.6) introduces the investment situation about new technology for environment protection and/or sustainable product design in firms. 28.00% of firms invest 5 % to 10% of their total investment into new technology within environment protection and/or sustainable product design. 4.00% of the firms invest 10% to 15% of their total investment. 2.67% of the firms invest 15% to 20% of their total investment. 57.33% of the firms invest below 5% of their total investment, while 8.00% of firms did not invest.

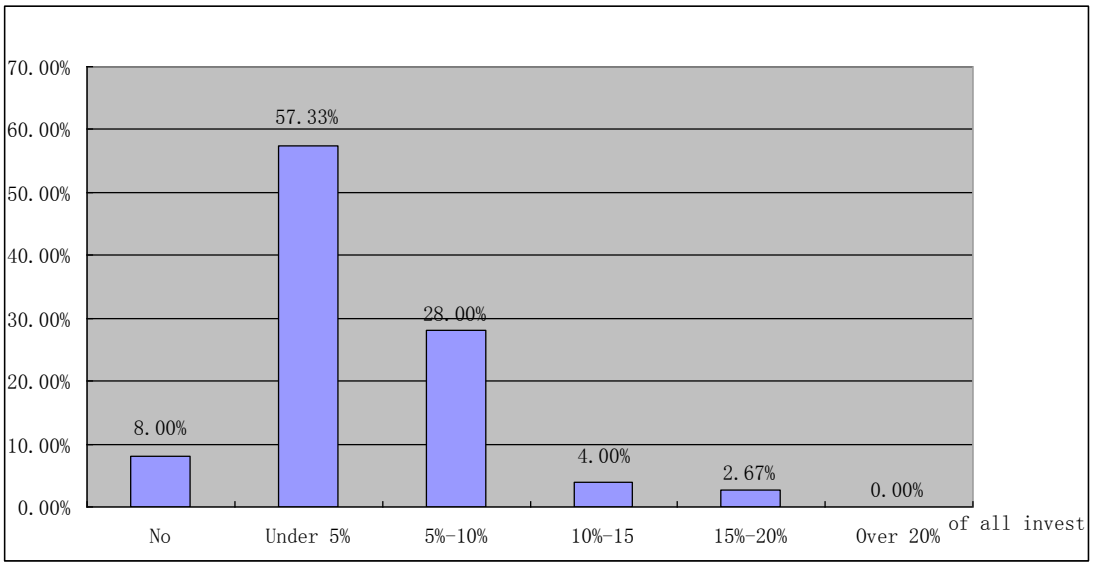

Figure 4.6 (Question 34) Does the company invest new technology in environment protection and/or sustainable product design (percentage of all investment)?

As analyzed above, the firms surveyed have not invested largely in the environment protection production. The investment of funds and the benefits are both insufficient.

4.2.3 Sustainable public relations

From the survey results, 100% of the firms follow the environment laws and legislation (Question 38). 59% of the firms have co-operated with social organizations to responds to environmental problems and 49% of the firms have co-operated with the media on publicity to advertise the environmental policy, purpose and effort of their company (Question 40).

Question 35) We found that 37.33% of firms have planned or taken action to enhance environment protect awareness to the public, make them aware of reasonable consumption, and attract the public to join the environmental action and funding environmental project. Among these firms, 46.43% have a public-

interest advertisement, 50% of them have ‘reasonable consumption’ education while 35.71% of them have environmental lectures. Fig 4.7 showed the distribution of different actions taken by these firms. .

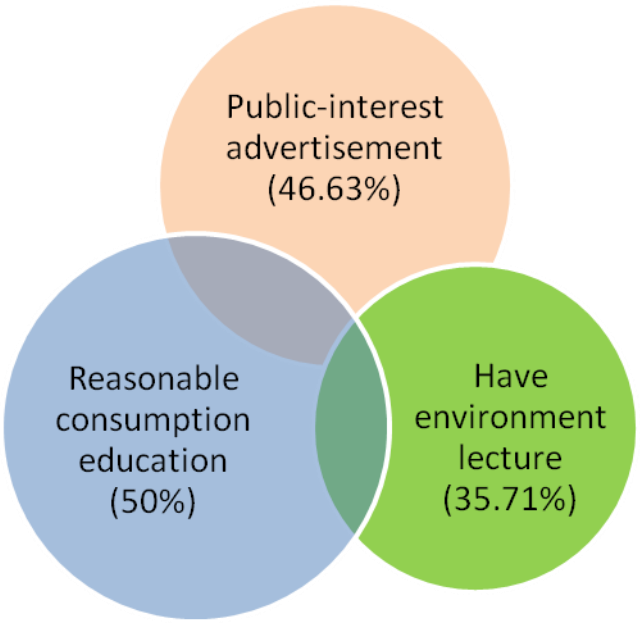

Figure 4.7 (Question 35) The multiple choice of actions which firms takes to bring up public environment protection awareness.

Question 36) We found that 41.33% of the companies emphasize the social responsibility and environmental protection values of the brand with a marketing action, amongst which 48.39% of it is sustainable designed product and 41.94% of it is save energy in marketing action or use environmental protection methods in marketing.

Question 37) Our investigations found that 50.67% of the firms have no environmental requests about the supply chain. However, only 16.00% of the

firms have strict requests and have a reward and punishment system, and the other 34.67% of the firms only have a relaxed and general request. Figure 4.8 showed the environmental request situation.

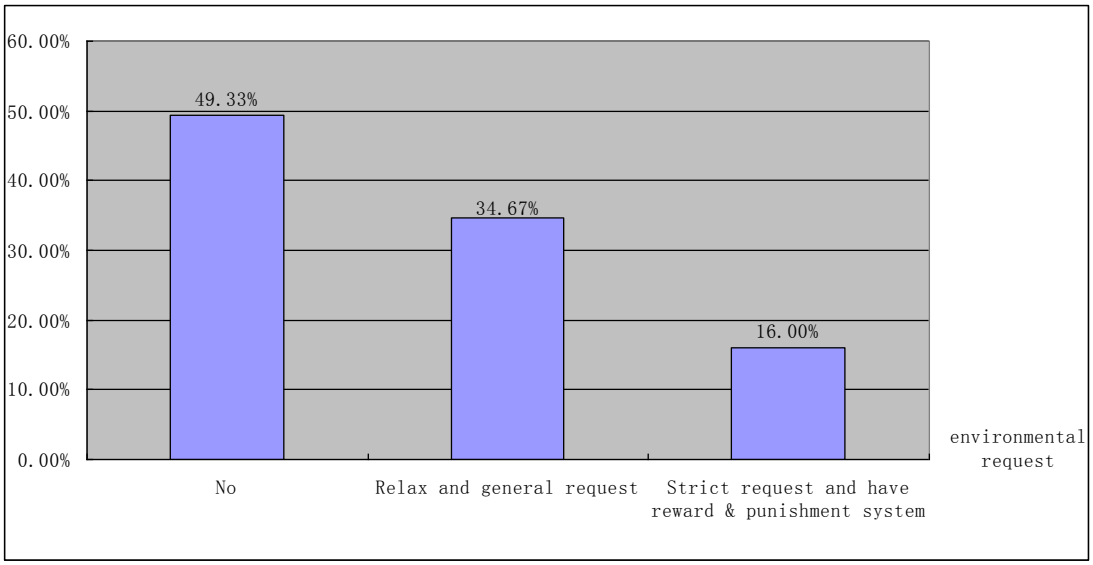

Figure 4.8 (Question 37) Does the company have environmental requests about your supply chain?

The survey also investigated that only 17.33% of companies have environment protection and/or sustainable design related common weal donation or financial aid.

As analyzed above, most of firms have insights toward the sustainable public relations and take measures to keep this.

4.2.4 Environment information disclosure. Social performance, Staff relationship, and Customer

In the investigation about the relationship between firms and outsiders, it is found that 18.67% of the firms have environmental information which is regularly open to the public long term, but most of the firms (70.67%) only

open this information within the company (Question 43).

We found that 21.33% of the firms where outsiders can acquire the information by print or web text, while others can download the information as a complete report from the company website (Question 44).

Only 12.99% of the companies surveyed have an official report to announce the environmental information about them, and 6.67% of these companies have reports with a high quality of content (Question 45).

Question 47) Within product quality control, most firms have a quality control system. 73.33% of companies reached International quality authentication standards, 69.33% of companies use advance quality detection technology, and 81.33% of companies link the quality of products to the personal income. The multi choices of companies' quality control system are shown in Figure 4.9.

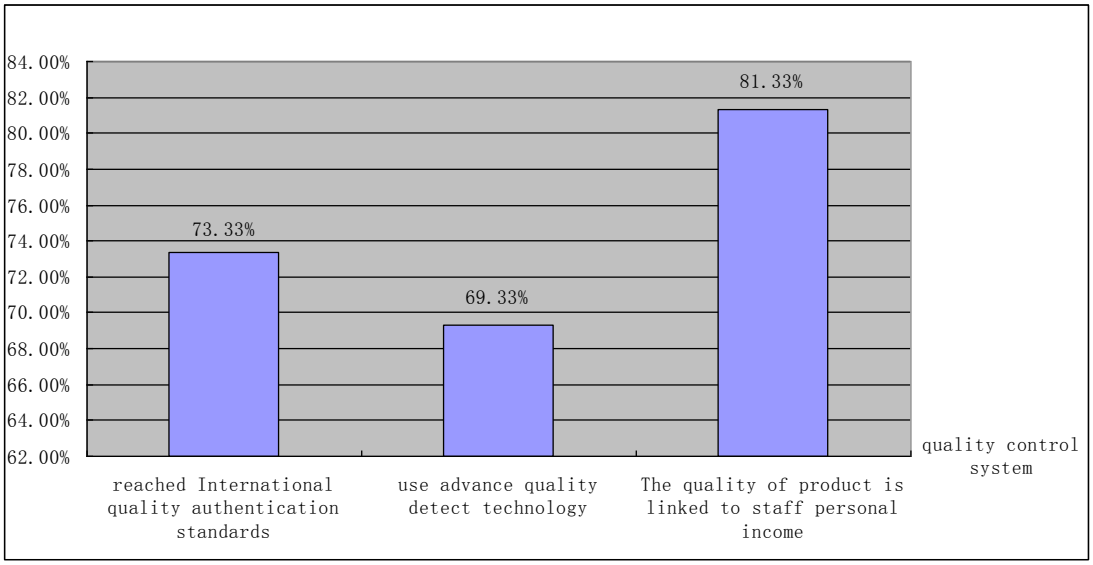

Figure 4.9 (Q47) What is the quality control system of the company?

In addition, 67% of companies have a recall system for product quality. 38% of companies have a complaint management system or another channel to

communicate with customers.

4.2.5 The sustainable performance of companies in different locations.

The sample size was 75 companies located within three cities: Beijing, Tianjin, and Guangdong. These are shown in Table 4.1. There were 24 companies in Beijing, 25 companies in Tianjin, and 26 companies in Guangdong. The next figure (Figure 4.10) states the companies' performance in these three cities respectively.

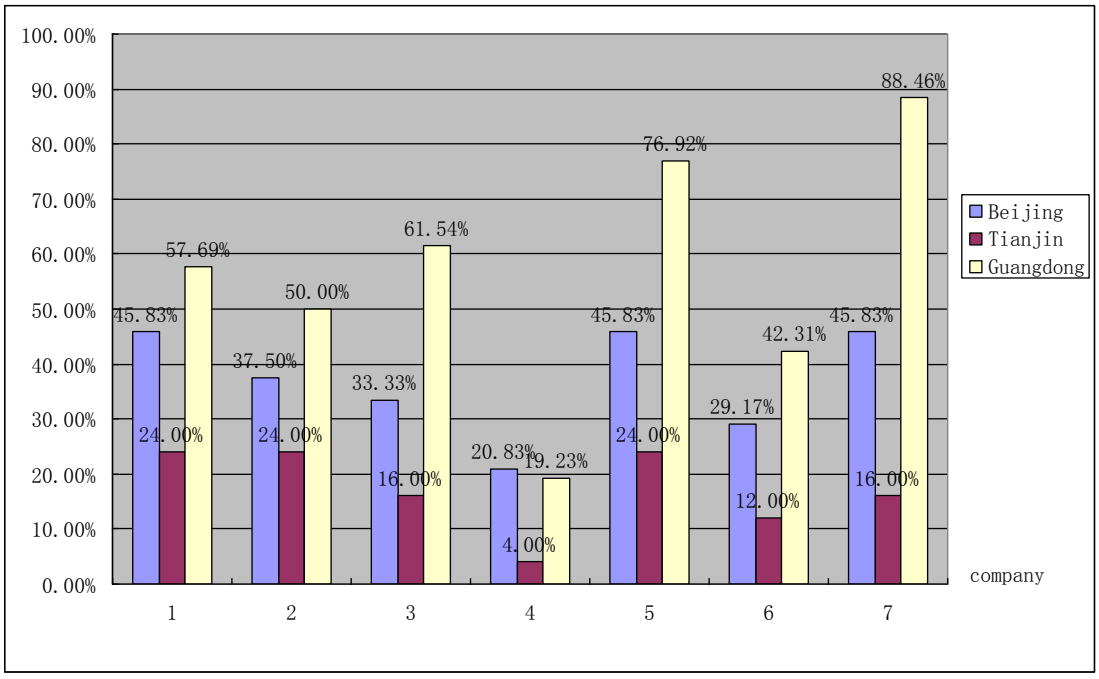

Figure 4.10 The percentage for each companies' standard within the 3 cities. (the performance of companies with different locations).

In Figure 4.10, the blue columns represent companies in Beijing, the red columns represent companies in Tianjin, and the yellow columns represent companies in Guangdong.

Column "1" denotes companies which have unofficial written regulations about sustainable design in the product or management system. Column "2"

denotes companies which have unofficial unwritten regulations about sustainable design in the product or management system.

Column "3" denotes companies which have a function department working with the Environment/Sustainable product design in both mid and base level Column "4" denotes companies which have a function department working with the Environment/Sustainable product design in base, mid, and base three levels.

Column "5" denotes companies which have purchased any sustainable design standards or an environment management system.

Column "6" denotes companies which invested 5%-10% of all investments on new technology of environment protection and/or sustainable product design. Column "7" denotes companies which have environmental requests about the supply chain.

It is obvious that Guangdong is the leading figure in every representative question, following them is Beijing and Tianjin ranks the least. These figures illustrate the aspects of investment, understanding and practical application of the surveyed firms. It is definitely related to economy development level difference.

4.2.6 Summary

Summary of key findings and recommendations

	Current Key Status of surveyed firms	Areas for Development
Part 1 Environmental acknowledgement and policy	a) Knowledge level on sustainable design overall is very low b) The detailed and profound understanding of sustainable standards, the investment of funds, function factors and human resources are very limited.	Most surveyed firms have a sustainable concept and also have the sustainable design awareness at the decision-making level. They need to bring the environmental awareness and ideas to the manufacturing level and end of life process.
Part 2: Environmental business prospects.	a) Most firms do not emphasize much on the sustainable development in production. b) Too little investment in the environmental aspect: education, manufacture, etc.	A large number of firms need to understand the long term and eco-efficiency profit by invest in the sustainable design and operating factor.
Part 3: Sustainable public relations	Most of the firms have insights into sustainable public relations and take measures to keep this.	Firms need to move positively in building sustainable design related common weal donation or financial aid.
Part 4: Environment information disclosure	The information disclosure on the environment is limited overall.	Firms need to know a good environmental information disclosure which can help the company's image to become more positive.

Table 4.2

Based on the above analysis, this research has found that within Chinese firms, the knowledge level on sustainable design overall is very low. Most firms do not emphasize much on the sustainable development in production. Most of the companies learn about the importance of investment in new technology and sustainable production flow, where there is limited investment compared to the total investments. The information disclosure on the environment also is limited. However, in some specific areas like Dongguan city of Guangdong, the firms are following quite high levels of environmental manufacture standards and operation systems. They not only understand the significance of implementing cleaner production standards but also embarked to introduce and operate those standards already. This imbalance of awareness of environmental standards is quite noteworthy.

As I noted in the earlier part of this paper, the sustainable design and environmental standards manifestation of surveyed firms indicated the regional difference. In the next chapter, I will analyze the chosen interviews to allow further research and understanding of this geographical discrepancy.

4.3 Conclusion of questionnaire research

As analyzed above, this questionnaire research has reached the following conclusions.

Firstly, the knowledge of business toward sustainable design standard is low. Most of the surveyed companies have no regulations toward the sustainable design in product and management systems. Only a limited number of companies have an education plan/system for staff training enhancing their awareness about sustainable product and environment protection. They have limited investment in the sustainable development technology and most of

them are in the primary stage of realizing and understanding a sustainable design and environmental standard.

Secondly, most of the companies surveyed have good sustainable public relations. These companies take measures in marketing and customer relations management. Most of the firms have insight toward the sustainable public relations and take measures to keep the sustainable public relations.

Thirdly, a limited number of companies have clear and complete information disclosures toward the environmental management within their companies.

4.4 Remapping of the Research focus based on the findings and analysis.

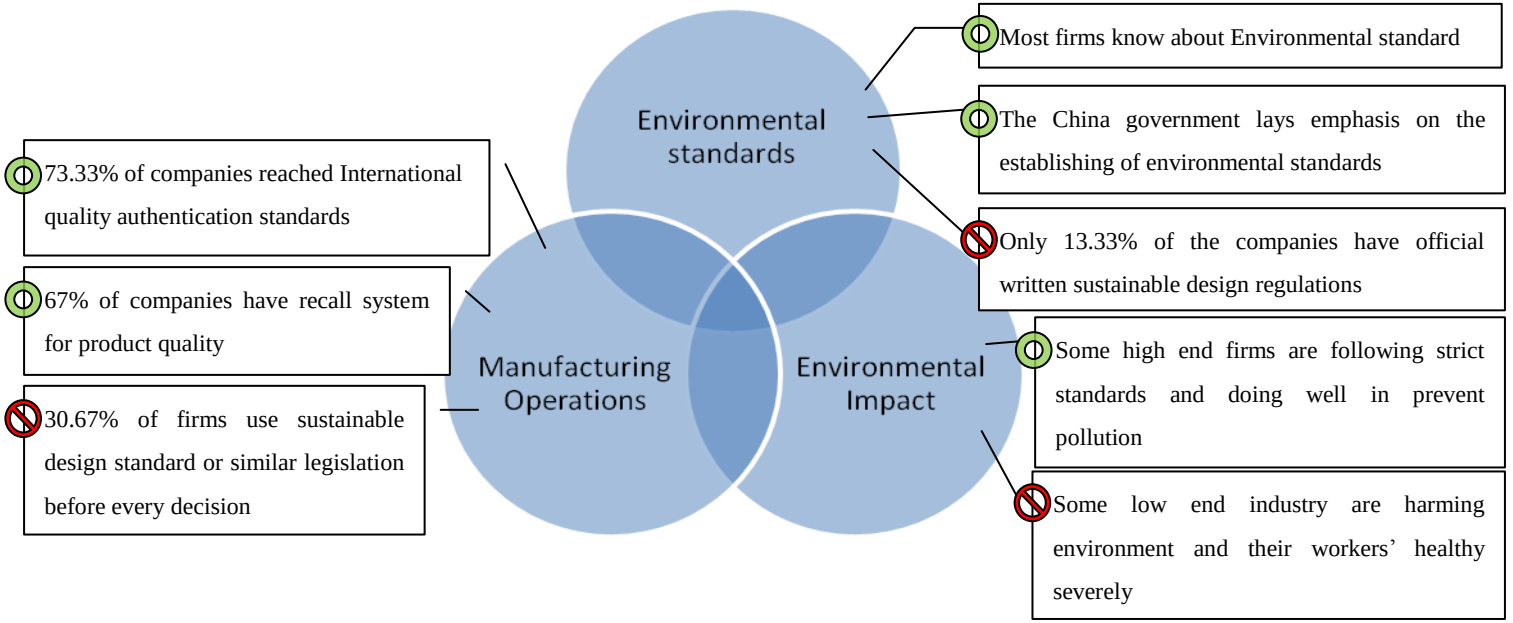

Figure 4.11 The research focus remapped.

Chapter 5 Field Research Interviews and Case Studies

This part is the synthesized data of interviews and analysis of case studies. The following figures show the general points of view of the interviews and the research focus.

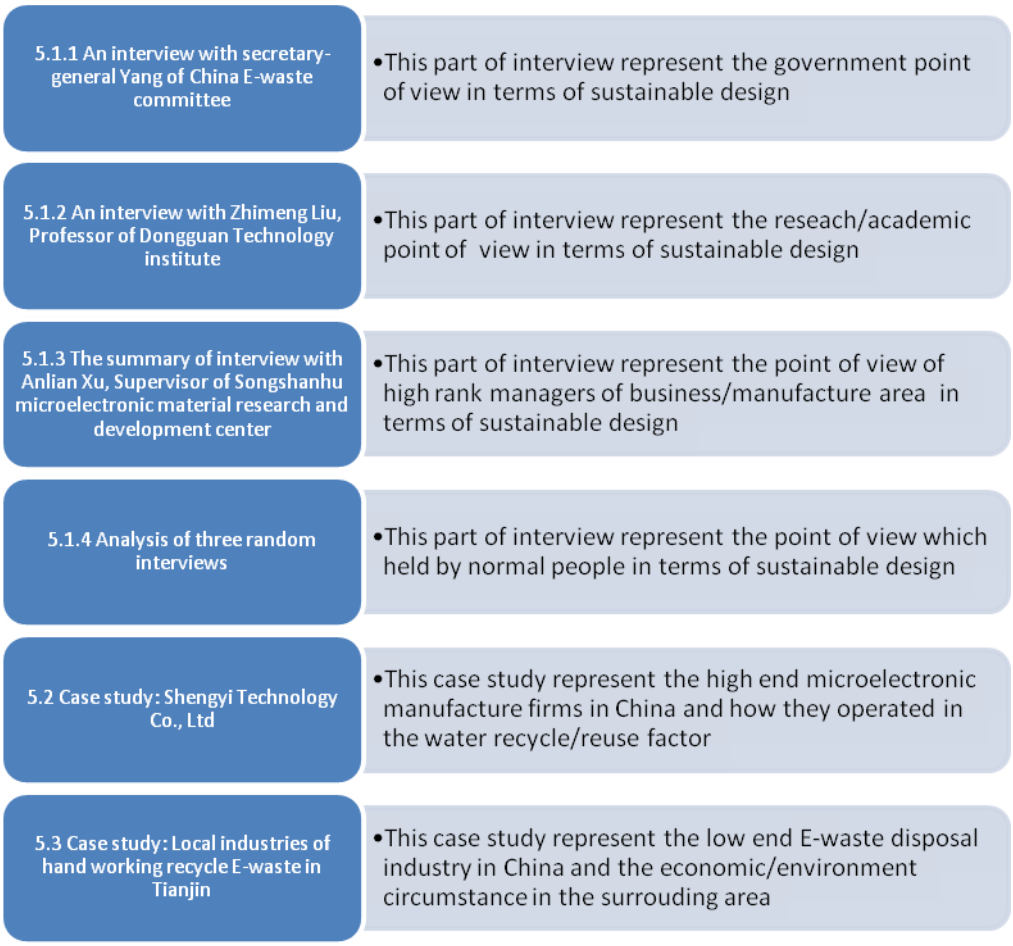

Figure 5.1 Introduction of the interview and case study.

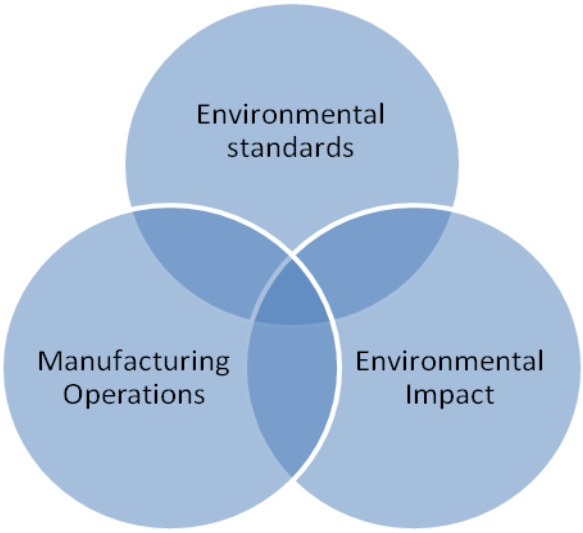

Figure 3.1 The research focus of this study.

The 5.1.1, 5.1.2 and 5.1.4 sections of the interviews link to the Environmental standards field of my research focus. The 5.1.3 and both case studies mainly link to the Manufacturing operation file. The 5.3 case study links to the environmental impact field.

5.1 Interviews

5.1.1 An interview with Secretary-General Yang of China, E-waste committee

The following content is a summary of the two interviews which were arranged in Beijing before my trip to Dongguan.

The electronic waste problem is rising in China, many retired products need to be dealt with. The rising slope of produced electronic waste is increasing.

In the 1980's, China's e-waste gradually increased, but over the recent decade, it has become explosive. More and more electronic products are produced, used and retired. The difficulties of dealing with E-waste are the expensive

labour costs and complicated processing methods. Also due to the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, the E-waste cannot be transported to other countries or areas without written permission.

China's population is large, with the evolution of economy and the process of modernization, the highly increasing demand of electronic products causes a huge amount of E-waste. The Secretary-General mentioned an opinion that the Chinese people prefer to have personal entertainment and household systems They choose DVD players rather than go to the cinema, buy a washing machine than go to the launderette – in my opinion the difference is based more on the population increase.

China is one of the largest export countries, and it has a high ranking in electronic export as well. The huge amount of exported electronic goods will cause part of the used product and E-waste recycling problems for the import counties or areas. The Secretary-General also stated that China may exceed the EPR (extended producer responsibility) in the near future. It is the demand of both sides, on the one hand, the E-waste requires high technology to deal with it, the import country may not have the willingness and ability to handle this, on the other hand, the export country (China) could use the recycled E-waste as product materials. The E-waste has a high percentage of metal content, which leads to the "urban mine" concept.

China is in its industrialization process and has also put forward the sustainable development policy. In the area of recycled E-waste, China has two main features as follows:

Technology: China actually has a decent reuse operating factor of the recycled E-waste, but it's mainly based on primitive handworks by the junkman or village. Due to the lack of technology, these kinds of processes cause severe

pollution problems. The Secretary-General considered this feature as a dual-blade sword.

Industry attributes changes: In the earlier industry of China, materials were mostly a simple substance, but because of the improvement of industrialization, the composite materials are more widely-used. This causes composited waste which is much harder to deal with.

Then the Secretary- General mentioned the international circle of the production – transportation – recycle, he also said it is a multipurpose use circle.

From the government's side, the establishment and perfection of the laws, regulations and standard system on environmental pollution, recycling of E-waste, and health hazards have a high priority. It needs the cooperation of administration departments due to the complicated areas which the establishment is involved. Those departments have different standpoints, so it's not easy to set them in one integrated framework.

From the government supported E-waste disposal industry side, the situation is complicate. The Chinese government has some encouraging and preferential policies for the E-waste disposal firms, like providing the E-waste which is recycled by the state, as raw materials (it's the main source for the whole industry) it also gives public subsidies and tax cut to the firms. But on the other hand, there is an idea called "let them eat their fill, but don't let them eat too well". I personally think it is because this industry is highly dependent on the government, but the funds are limited, also it may be considered unfair by other companies if the government provides too much support. The E-waste disposal companies cannot make a good profit, partly because of the insufficient raw materials supply – the government cannot collect enough E-waste from public recycling channels. In China, most of the E-waste is

recycled and collected by the junkman, which is private and personal. They may recycle the E-waste themselves or sell it to other private disposal organizations or companies. In the technological layer, the government supports companies mainly using major industry technology, it can only make a good profit if they dispose of enough E-waste and it has some flaws when dealing with some particular products like fridges – the company would lose 5 RMB for each fridge they've treated.

However, there are four pilot businesses which are helped by the Chinese government established at Beijing, Qingdao, Hangzhou and Tianjin. The government set threshold after some former companies abused the fund they'd obtained (used the fund on stock market), the threshold is 10 million RMB at the current time.

As I mentioned before, the private disposal area is a low economy cost, but a high environmental cost and how to resolve the opposition to economic efficiency is the key question. For a local area, handwork on the E-waste does not only produce some profit, but also makes the village rich. There is an example in the Guangdong province of China. A village called Guiyu is famous for its E-waste disposal. In the year 2006, the environment of Guiyu was an environmental disaster, 7/10 children were detected with an excessive amount of lead content in their blood. The whole village was covered with smoke and smelt of circuit wafer dissolving in acid. There was a pot in front of each house which had a smelting tin in it, that was for the removal the spare parts of the main board and mobile phone board. The assistant of the Secretary General informed me of the situation as he had visited the Guiyu village that year.

In my opinion, the people of the village must have known the harm of such

activities as it was their choice to let the village become a private E-waste industry organization due to the highly profit. The raw materials are not the only source from the junkman, but also international smuggling. It is hard to say whether the decision is right or wrong, but it did cause a serious pollution problem and health hazard in the local area. We have morality obligations to our later generations, that are for sure, but some local people believe it's better to let their children avoid hungry and poverty now. Personally, I can't say it's their fault. China doesn't have a perfect community welfare system, and the children are mostly dependent on their family – which maybe the only thing they can count on. Philosophically considered, Chinese society is highly motivated by money at present, the pursuit of wealth has already risen above the rest, especially morality and justice.

Nevertheless, the government needs to pay the bills after all, whether losing proposal or the pollution issue. The Secretary General mentioned that the Chinese government may try to change the framework, establish funds and systems for rewards and penalties. Then, transfer the responsibility to the production enterprise (EPR). But the problem is who will organize the process. China is carrying out the ministries and commissions / specialized department system, the branch routes and responsibilities are crossed so it would be hard to set up one department to be in charge due to this situation. In the meantime, the government is implementing new laws for environmental protection, encouraging the use of environmental protection renewable resources and strengthening the propaganda and education of environmental protection to enhance the public's environmental awareness.

5.1.2 An interview with Zhimeng Liu, Professor of Dongguan Technology Institute

This interview was arranged at Dongguan Technology Institute by a science factor officer of the local government. He also helped to arrange the following interviews and the Shengyi case study. I would like to express my gratitude to him now.

Professor Liu introduced the electronic production industry in Dongguan. As a member of the Dongguan Cleaner Production Standard committee, he also leads the Dongguan Cleaner Production technology center.

Dongguan is one of the biggest electronic circuit board production centers in Asia, thus many microelectronic companies are setting up their production-assembly industry in Dongguan. The classic treatment for E-waste is only dealing with the waste that the production industry already produce. The government administration organization only cares if the firms can reach the environmental discharge standard. The Cleaner Production focuses on the sustainable development progress– how to efficiently use the limited resources. In the year 2000, China's Energy Consumption per Unit of GDP was 11 times higher than Japan's ECUG, and now China's ECUG has decreased to 8 times higher than that of Japan. China's situation in ECUG is quite backward, however, it also reveals an exciting fact – there are many chances and possibilities for the Cleaner Production process – how much energy could be saved if China made more progress in the process?

In the conversation, Professor Liu introduced the Cleaner Production examination and verification system which is being carried out by the Dongguan government in the local industrial area. Compare to the ISO 14000 series standard, the Cleaner Production is not only about implementing an

environmental management system, but also focuses on general waste treatment efficiency. In theory, an industry can recycle all the wastes it produces, only in matter of cost. How to find the balance or in other words – how to find the most efficient way in the treatment of pollution is the Cleaner Production standard's highest priority. The microelectronics industry is Dongguan's most important industry, the government needs to provide good business concept of the enterprise for the city's development, at the same time, the government also needs to provide an appropriate environment for its citizen to live. There also exists only one balanced point in my opinion.

Professor Liu stated that there are 4 main aspect of Cleaner Production in Dongguan, which are listed as below:

1. Energy saving.
2. Consumption reduction.
3. Decreasing pollution..
4. Increasing benefits (or Efficiency improving).

As a matter of fact, China has carried out the Cleaner Production Standard Directive for standardization since 01/08/2008. Professor Liu introduced that there are two ways companies would implement the Cleaner Production standard, voluntary and forcibly. In 2010, to establish a national model city and district, Dongguan needed 500 local enterprises to pass the Cleaner Production examination and verification y system which has done. The qualification for Cleaner Production examination and verification needs government ratification at provincial level. The members of the Cleaner Production examination and verification organization need professional training. The plans would be implemented by the enterprise divided into 4

kinds, no cost, low cost, medium cost, and high cost. The no cost is mainly only changing the structures of company, as the ISO 14000 series to perform an environmental management system. The other 3 sorts of plans need more investment to purchase the equipment needed, for instance, a power-saving light system (low cost), water recycling system (med-high cost). The committee would produce an examination and verification report (which has come into legal effect) to help enterprises to find the most suitable plan for them.

The period of Cleaner Production examination and verification process normally takes 8-12 months, it's a needed time. Professor Liu stated that Dongguan Cleaner Production examination and verification committee had saved the local companies a huge amount of production cost in industrial process in the year 2008-2010. The amount in 2008 was around 49 million RMB, in 2009 it was 120 million and will be at least 120 million in year 2010.

Talking about specific implements of Cleaner Production, Professor Liu said the committee will help the firms to choose materials, optimize the production process, reduce the power consumed and recycle the waste. He gave a case example of a concrete manufacturing firm. The production process of the concrete needs to bake the materials for the force gypsum to turn to hemihydrate gypsum. The gypsum has 2 water molecules, to produce hemihydrate gypsum, the manufacturing flow needs to evaporate the 2 water molecules. It lifts the temperature to let the water evaporate which needs a lot of power, so the committee helped the firm to reduce the water contents of the materials, which significantly reduce the power consumption.

The Cleaner Production examination and verification process's normal execution flow is:

1. The committee sends a group of professional auditors to the company.
2. The auditors make joint contact with the company's specialists and managers.
3. The auditors examine the firm's production flow (MADE) then produce a feasibility plan.
4. After several rounds of discussions with the company's group, the auditors would present their final plan.
5. The company chooses the part or whole plan to put into practice (normally part of).
6. The committee would verify the result of the company's implementation of the plans.

5.1.3 The summary of the interview with Anlian Xu, Supervisor of Songshanhu Microelectronic Material Research and Development Centre.

The supervisor Xu is also a high rank manager of Dongguan Pusaite Electronic and Technology Co. Ltd. The research centre is located on the Songshanhu, a picturesque lake surrounded by grassland and small woodland hills, which is also a state-level science park.

The research centre focuses on 4 materials in research and development: scaling powders, cleaning agents, adhesives and soldering pastes. These products are a necessity within the microelectronics industry. The research centre mostly provides R&D support for Pusaite Co. Ltd. The manager introduced her company, explained the company's aim, its recent developments and long-range objectives.

The company's products are mostly sold abroad, Tyco is one of its clients. Some famous Chinese enterprises also purchase products from Pusaite Co. Ltd. Such as Haier, TCL, Hisense and Skyworth. The manager told us that her company seeks to manufacture the highest quality products. To improve the R&D ability and quick upgrade of its developing strength, Pusaite Co. Ltd invested and established the Songshanhu Microelectronic Material Research and Development Centre. The company's R&D input is surprisingly high 20% of its profit.

In the manufacture process, the company adheres to strict standards, its products are of first class quality and follow the ROHS standards, sometimes even stricter. In the recycling area, the company is trying to development some new kind of water-soluble soldering paste and wash free scaling powder to reduce the washing waste. .

5.1.4 Analysis of three random interviews

To facilitate the analysis and keep the privacy of the respondents this research uses respondent 1, respondent 2 and respondent 3 to refer the interviewees from Beijing, Tianjin and Guangdong in China. The 3 respondents are selected randomly in personnel that work in the firms that purchased ISO 14001 standard.

When being asked about their acknowledgement on the concept of sustainable design standards, the three respondents had different responses. Respondent 1 considers sustainable design standards as green design, which cuts emission and saves energy. Respondent 2 responded that he is confused with the concept of sustainable design since he only has ideas about sustainable development. Respondent 3 also think that sustainable design is new to

Chinese companies and only the staff with foreign study backgrounds have an idea about this concept. Therefore, it is clear that Chinese companies have no deep understanding toward the concept of sustainable design standards. They do however have some idea about the environmental standards of China but they do not know much about international sustainable design standards.

According to the responses of the respondents, all of their companies acquired the ISO 14001 certificate. When being asked the motivation for them to pass the certificate, they had different answers. Respondent 1 replied that to acquire ISO 14001 certificate could improve the competitive advantages for them. At the same time, since the company of respondent 1 is exporting electronic products, the foreign customers have high standards with regards to the products provided by them. This is another motivation for the company to improve. Respondent 2 answered that to acquire ISO 14001 could enhance the quality management in his company. ISO 14001 series standards can help improve their environmental performance. As a listed company on stock market of China, the company of respondent 2 considers the social responsibility of their practices more. Therefore, to acquire ISO 14000 could bring them more benefits. Respondent 3 answered that ISO 14000 is a must for them to survive in the industry since many other companies have acquired this certificate. Without this certificate, his company would be at a disadvantage. Therefore, most companies have different motivations but all of these motivations are contributing to the interest of the companies themselves.

When asked about the environmental standards in China, the three respondents have similar feelings on this issue. All of them argued that the environmental standards in China is much influenced by political factors. The environmental legislations in China have legal powers but have poor performance in practice. The companies in China have measures to treat the regulations of the Chinese government. Therefore, there is a poor performance of these standards even

though the government published many legislations on environmental protection. At the same time, economic development is also an influential factor of the environment standards in China. Respondent 2 claimed that the low income levels and irrational construction of industry in China has weaken the environmental management cause and also restricted the motivation of the public toward environmental protection.

5.2 Case study: Shengyi Technology Co., Ltd

This case study is based on the visit to the manufacturing area of Shengyi in the city of Dongguan, I interviewed two high ranked managers of the firm and one practical operator within the water recycling process system of the factory.

5.2.1 Background of Shengyi Technology Co., Ltd

As the biggest copper clad laminate company in China, Shengyi has an abundant technical source and employs many kinds of high-tech products which have achieved an advanced international level. Shengyi is the only one in Dongguan which has a research and development centre which achieved national level. The leading products have been approved by many well-known enterprises, such as Siemens, Motorola, Sony, Nokia, Samsung and Huawei. Products are exported to many countries and regions, such as the United States, Europe, Singapore, Malaysia, and Korea. The sales volume keeps 5 years No. 1 in mainland China. Shengyi was listed in the Shanghai stock market in 1998 and is the only copper clad laminate public company in China till year 2010. Shengyi has won various national, provincial and civic honors, such as the

National Advanced Export Enterprise, the Best in China (Manufacture Base of Copper Clad Laminate), Top 100 Chinese Electronic Components Enterprise, Top 500 Chinese Outstanding Enterprise in Composite Strength, Demonstration Enterprise of 863 Plan in CIMS Application and Dongguan Leading Industrial Enterprise.

5.2.2 Sustainable concept of Shengyi Technology Co., Ltd

Shengyi takes the lead in getting ISO9001, ISO 14001, IS0/TS16949 and BS7799 certificates in this industry. From the interviews with the two high ranked managers, I have learnt that Shengyi values the sustainable management and environmental standards very highly.

The Shengyi Company has taken on the mission of creating a model enterprise for energy conservation and emission reduction and is making a practical contribution to the cause of environmental protection one of its the social responsibilities. Shengyi committed to continue to prevent pollution, improve and control the risks to ensure the safety and health of its employees. At the same time, the aim is to adhere to the sustainable development of quality of the environment with legal operations and improving competitive advantages to meet the needs of customers by implementing environmental standards. In the Shengyi Company, every employee is required to be an advocate of environmental protection and environmental standards. At the same time, Shengyi also encourages its employees to innovate in energy saving and emission cutting.

5.2.3 The significance of clean production in the Shengyi Company

As a producer of microelectronic products, Shengyi faces many issues with

clean production. Not only the Chinese government but also the industry standard requires Shengyi to follow the cleaner production programme. The practice of Shengyi in clean production can verify that clean production can bring in good social, economic and environmental benefits. At the same time, the clean production programme can also enhance the economic benefits of the Shengyi company since energy saving, pollution cutting and emission cutting can reduce the costs. Furthermore, the clean production programme can improve the competitive advantage of Shengyi. Good quality, low cost and better service are the basis of many competitive advantages. Finally, clean production of Shengyi can also improve the living and working environment of employees, which keep sustainable development.

5.2.4 The process of Shengyi on sustainable standards management

The process was divided into four steps.

First step: Plan and organize. To have sustainable production, planning and organizing is the critical part. In this step, the company gives training to its employees and management team to introduce the aims and measures of Shengyi on clean production. The employees and management team can also propose suggestions. During this step, the directors of Shengyi put emphasis on much cleaner production. At the same time, Shengyi also built a special group to examine clean production in practice. The group takes the responsibility to examine the clean production works and resolves any problems faced.

Step 2: Preview evaluation. This step requires Shengyi to analyze the whole process of clean production and explore the potentials of clean production and possible opportunities. This step is mainly aimed to assess the consumption of

energy, material and pollution emission to set the goals of clean production.

Step 3: Assessment. This step requires Shengyi to achieve the international standard on clean production within this microelectronics industry. By comparative analysis between the data collected from within Shengyi and international standards, Shengyi can locate the problems and potential fields to be improved.

Step 4: Implementation of the clean production plan. Based on the analysis in step 3, Shengyi can work out the plan to improve clean production. In this step, Shengyi makes the plan to implement the plan. The financial department also needs to support the related projects in implementation. At the same time, Shengyi special group also has the responsibility to examine the clean production practice to detect any potential problems.

5.2.5 A field tour to Shengyi manufacturing water recycle & reuse system.

Under the guide of the two managers of the Shengyi Company, I visited the firm's water recycling workshop. The company has a long history of water recycling & reuse and the first set of equipment was installed at the end of the 1980's. The company has three sets of water recycling and reuse equipment now and they are all working in one workshop.

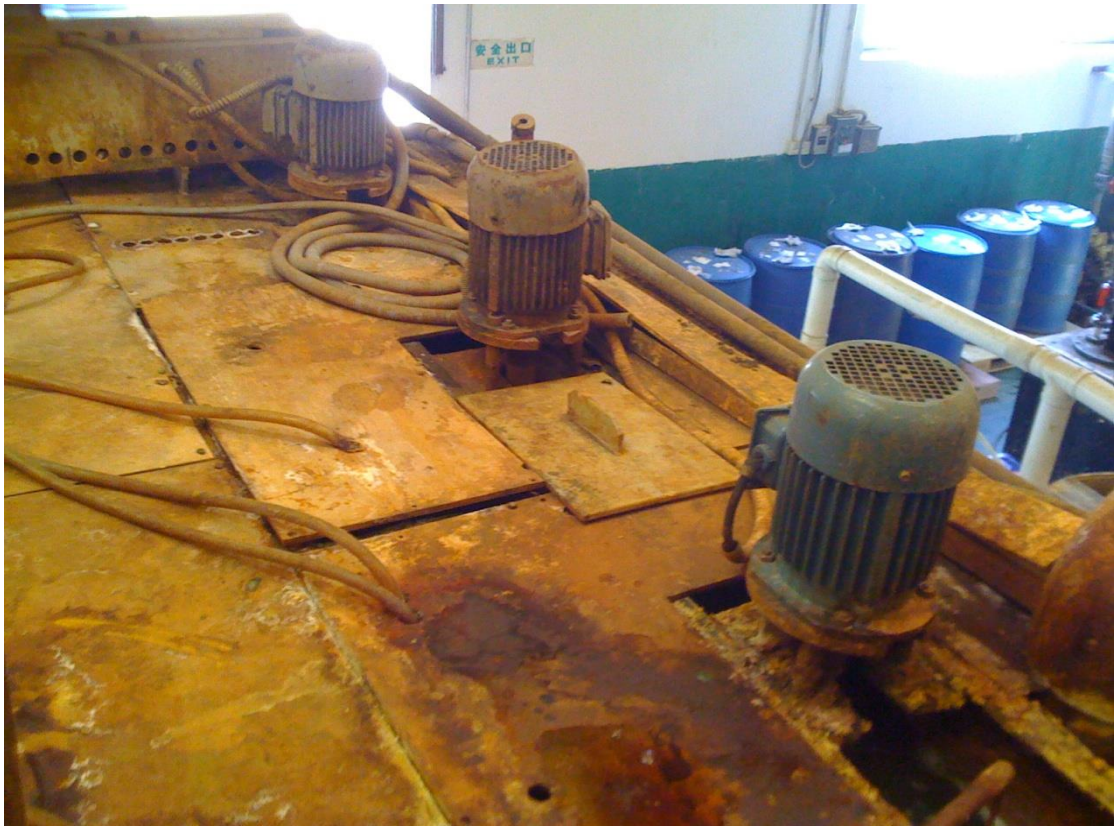

Figure 5.2 The first and oldest water recycle system of Shenyi manufacturing plant.

Figure 5.3 The second water recycle system of Shenyi manufacturing plant.

Figure 5.4 The third and newest water recycle system of Shenyi manufacturing plant.

As the mangers and the operator introduced, Shengyi has an outstanding water recycling utilization rate, up to 71%. The rest of the waste will be discharged to assigned channels after a purifying treatment. There was one thing the manager pointed out is that the government may need to implement a more specific sustainable standard according to different scales and circumstances of companies. She pointed out that the city government set a mark for the current Cleaner Production standard which the firm needs to improve by 5% in the water recycling utilization rate. It's easier for the firms which currently have the lowest water recycling utilization rate, but harder for those firms which have already achieved good results. Obviously it's quite easy to benefit from 0%-5%, but when you start from 70% it's a totally different story. I personally agree with her argument and will make some analysis later in my report.

5.3 Case study: Local industries using manual workers to recycle E-waste in Tianjin.

This case study is based on visits to several E-waste disposal firms of Jinghai County in the city of Tianjin.

The case study focuses on a small area of Tianjin, it is Jinghai County. Jinghai sits 40 kilometers away, southwest of Tianjin's urban district. The most important local industry is E-waste disposal, and mostly based on manual working.

Figure 5.5 The local workers are stripping cable under unsafe and poor work condition.

5.3.1 Background of local the E-waste disposal industry.

As one of the five directly governed city regions of China, Tianjin has its own brilliant history, whether political or economical. However, in recently years, Tianjin has become a depressed area compared to other directly governed city regions. It might be argued that the reason for this is Tianjin is too close to Beijing – the capital city of China – and Beijing consumes most of the adjacent resources.

Jinghai is a county of Tianjin. The local government announced the goal of the county is to "Become the National circular economy industrial zone and regional logistics centre." According to my field research and local personnel's introduction, Jinghai currently lives on the E-waste disposal industry. The E-waste disposal industry has already been the local economic pillar for many years. One local manager noted that some Taiwan companies started the investment in the mid 1980's. They built several firms and areas in Jinghai and recruited local manpower for the disposal of E-waste, mostly done by manual workers.

Figure 5.6 Two workers are treating waste metal.

5.3.2 Sustainable concepts of Jinghai's E-waste disposal industry.

Based on the introduction of the local manager, who welcomed my visit, the local government is trying to set up more restricted legislations for environmental protection in local area. However, most local people live a materially deprived life. It is hard to stop them joining the manual workers of the E-waste disposal business – which is the easiest job they can find and is well paid compared with the local living cost. The government measures are more focused on developing the local economy based on the current conditions. Correlated to the earlier part of this paper, the Guiyu case which was noted by one of my interviewees, my opinion has been further confirmed – people would prefer economy and household materials over safety and environment while they are living around poverty line.

Figure 5.7 The workers having lunch in their daily work area, the stock of E-waste.

Most of the local firms and workshops don't have any sustainable standards. They simply purchase E-waste and hire local people to dispose of the waste, and then sell the isolated raw materials and reusable parts. It is hard to implement any sustainable standards and environmental principles into the local industry when the workers are using a 'hands on' for the treatment of E-waste.

Figure 5.8 E-waste stock

5.3.3 A field tour to several E-waste disposal firms and grounds.

As I mentioned at the beginning of this case study, I visited several firms and disposal grounds in Jinghai. They were all different in their disposal objectives, some were dealing with scrap wire (workers remove the wires cover by tools manually and recycle the copper), and some were dealing with waste electrical devices. However, their technique levels were similar, using simple tools and manual labour.

I interviewed some local workers and they were honest, optimistic and proud-hearted. They were satisfied with the current life style but also willing to improve their living conditions. They believe the future will be better.

The local firm managers basically understand the sustainable concept and the

reasons to implement environmental standards in local industry, but as they pointed out, the competitive strength of local industry is inexpensive human resource costs, it would be less competitive if more sustainable standards were implemented and raised the base cost. In other words, the areas local increasing economy is built on this kind of manual work, disposing of electronic waste. In the future this form itself might change, but without economic growth there might be no future at all.

I did not interview any local government personnel so I am unable to summarize the government's point of view. I do not agree with the managers' opinion, however, I cannot say I am against it either.

Figure 5.9 The workers are dealing with E-waste (1)

Figure 5.10 The Workers are dealing with E-waste (2).

5.4 Conclusions on the field research.

Firstly, according to the interviews with the respondents from Beijing, Tianjin, Guangdong, this research finds that there were different understandings of the concept of sustainable design standards. Most of them think China has problems within the sustainable design standards. The case study of the Shengyi research finds that there is a complete environmental management system in Shengyi. At the same time, the environmental standards taken by Shengyi also brings them great benefits.

Secondly, according to this research, the Chinese government has already noticed the increasing need of sustainable standards in the manufacturing industry – especially in the micro-electronic production firms. In the year 2008, the Ministry of environmental protection of China published the Cleaner Production Standard directive for standardization as a guide for the sustainable standards' formulation in the manufacturing industry (Cleaner Production Standard Directive for Standardization, 2008). The government is also trying to set up a more effective E-waste recycling system - the EPR (extended producer responsibility) might be the next step.

Thirdly, there is a huge gap in the Chinese micro-electronics manufacturing industry between different companies, different areas and between people with different living standards in different geographical areas. . The different human and geographical conditions make a difference to the economy and political environment in many areas of China. -This difference makes the huge gap the very first thing to consider when any sustainable standard is to be formulated, or introduced in China.

Chapter 6: Conclusions

6.1 Conclusions.

According to the analysis and discussions, this research reaches the following conclusions:

Firstly, there are different definitions toward the sustainable design standard. Based on the literature review, this research argues that sustainable design is different from the traditional design concept, which ignores the resource waste and the impact on the environment. Therefore, sustainable design is the innovation and revolution toward the traditional design concept. Sustainable development concept is embedded in the product design, which linked the ecological environment to the economic development. This new design concept is aimed to make full use of the resources and energy to minimize the pollutions. Base on such primary research, this research proposes the definition of sustainable design standard here: The standards and formulations about both external and internal sustainable development of specific organizations.

Secondly, both the sustainable development and environmental standards stem from the values of ecological balance. In the implementation, both of these would be promoting each other. Environmental standards are the security of China to implement sustainable development. The sustainable development strategy of China requires the setting out of environmental law followed by the ecological concept and should make adjustments towards

current regulations and standards.

Thirdly, there are many different motivations for firms to take environmental management system (ISO 14001, EMS, or similar), or the manufacturing process of sustainable standards (BS 8887, Cleaner Production, or similar). The worsening of the environment brings a horrible conclusion for the organizations. Management teams generally accept that environmental performance of companies would take a large part of the investment and bring in satisfactory returns. Furthermore, with internet technology and other communication technology, the stakeholders can learn more about each company, so that the information can be widely spread.

Fourthly, the sustainable design standards of China are influenced by economic regime, public factor and an environmental protection concept. The situation can be totally different in diverse areas (Fig 4.10). With the overview of the economic development of China, the economic regime change brings damage to the environment while providing foundations for the competitive advantages of China. The environment protection bureau of China takes the role to plan, set and publish the environmental standards. Then China can begin to organize and plan research and set the environmental standard required. The environmental protection bureau should not only consider the domestic environmental standard but also consider the environmental standard of other countries. Although there is controversy toward the concept of environmental consciousness, the basic contents of this concept are similar: the relationship between humans and nature. Generally, the environmental consciousness includes the theories of environment, opinions, ethics, policies and values.

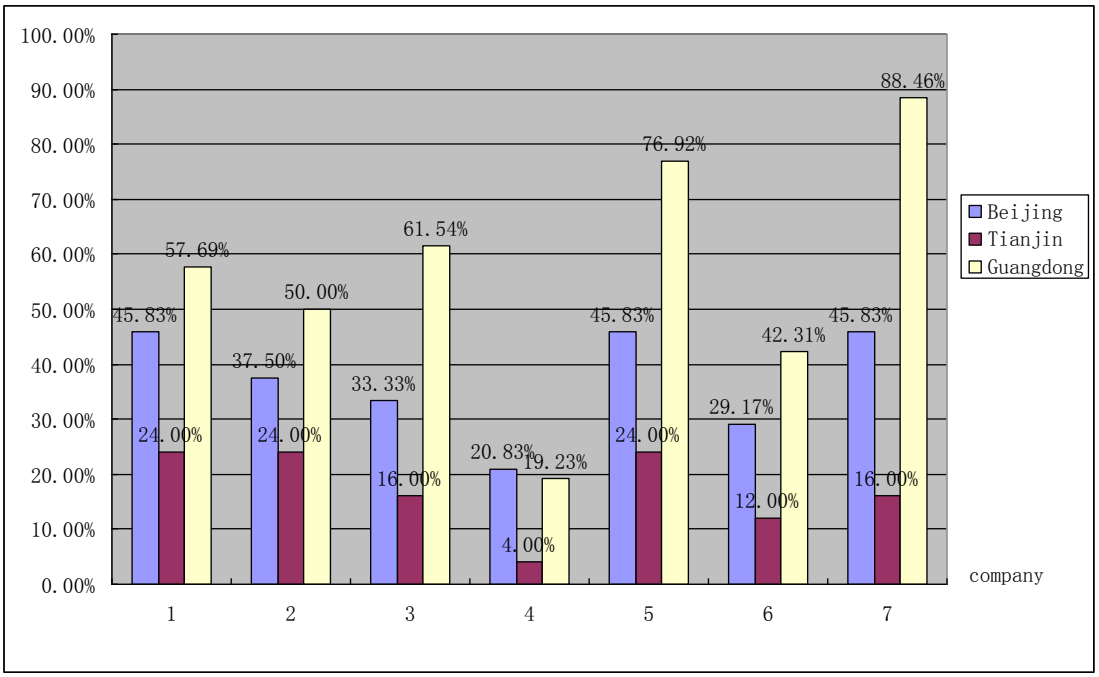

Figure 4.10 The percentage of companies which qualified for each standard occupied the total companies in each city (performance of companies with different location).

Fifthly, although China has developed well within the environmental management system in recent years, there are still many problems in the environmental management standards. The legislation feature of the environmental standard is not defined. The environmental standards in China are proposed by experts in the related fields. These standards themselves do not have the legal power to solve the legislation issues. The formulation of sustainable standards should bring people from government, firms and the public together, not only the experts. (Fig. 6.1 and Fig. 6.2)

Sixthly, there are many different needs of sustainable standards at different levels. Based on my case studies, the huge gap between highly developed industrial areas and developing industrial areas requires totally different sustainable standards to be formulated and put into to practice. The circumstances could be complicated in diverse regions, to carry out the sustainable standards needed for the specific local situations.

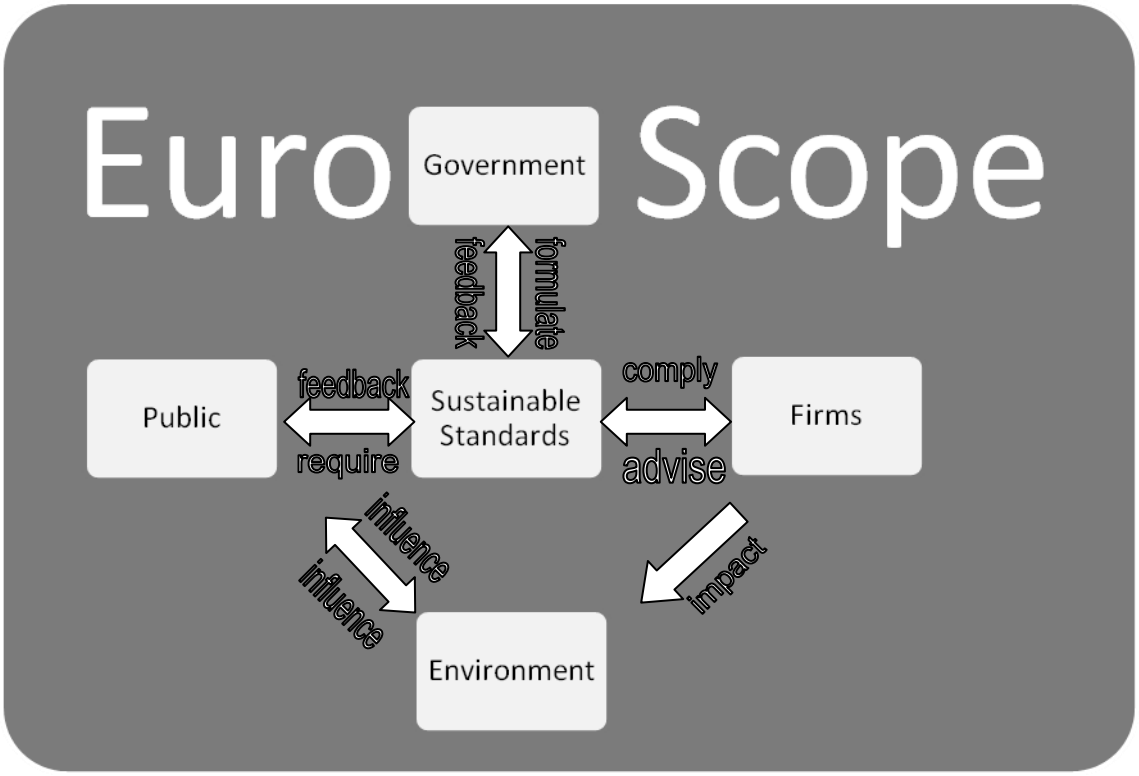

Figure 6.1 Euro scope of core elements related to the sustainable standards.

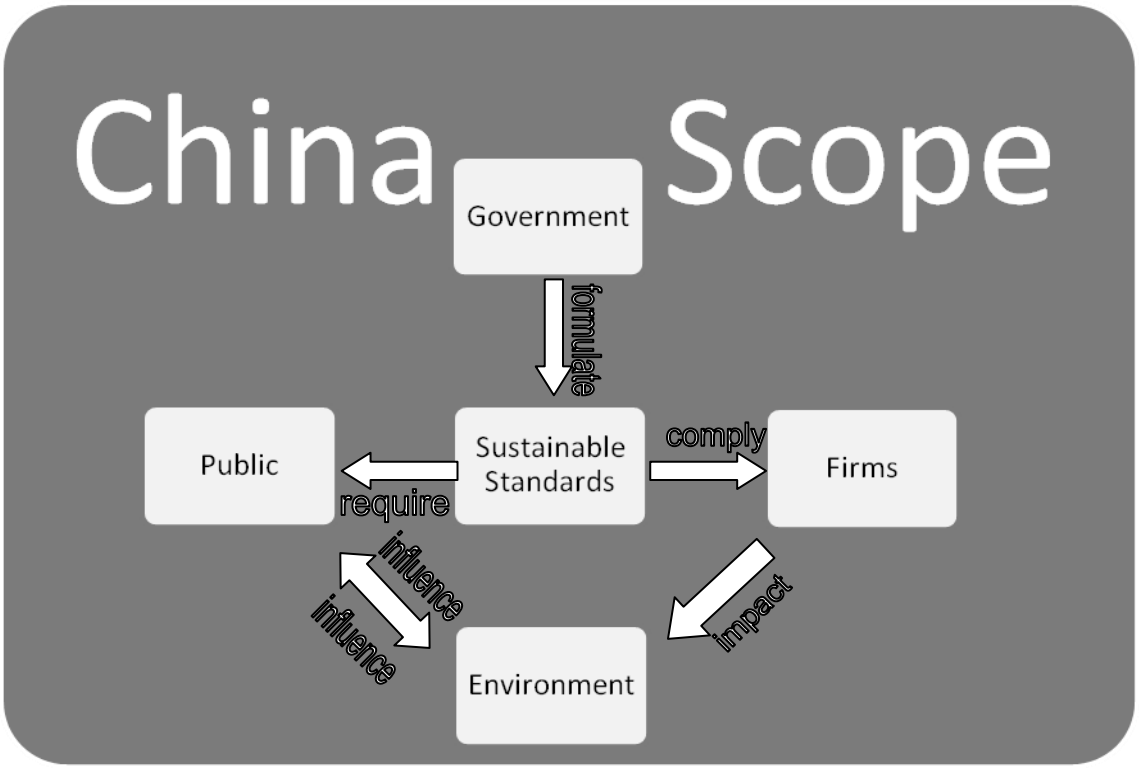

Figure 6.2 China scope of core elements related to the sustainable standards (the missing links)

The above figures shows there are three significant differences between Euro

and China scope of core elements related to the sustainable standards. The differences are all linked to lack of 2 -way communication when the core elements are affecting each other.

First difference: The Chinese governments' lack of feedback from the sustainable standards, the government has mainly formulated the standard, but reacts slowly when the circumstances change.

Second difference: The Chinese firms can only obey the standards and legislations which set by the government. The firms do not have unobstructed channels which allow them to join the formulations of sustainable standards or at least give advice.

Third difference: The people in China actually have need for the sustainable standard, but are only now just receiving such standards. Most people do not have any idea about how to give their own choices or speak their opinions in building process of the environmental standards.

6.2 Recommendations

Firstly, the theoretical foundation of the environmental management standards in China should be enhanced. The environmental management standard system in China includes the national environment quality standard, pollution emission standard, etc. Each standard should be quantified from five aspects: quality level, control requirements, analysis method, standard sample and scientific foundations. At the same time, the environmental protection bureau of China should work out the united directions for the implementation of the environmental management standards.

Secondly, the firms should take efforts to acquire an environmental management certificate. This certificate, such as the ISO 14000 or other certificates, could improve the competitive advantages for them. China has also currently introduced a certificate to regulate the firms in China. However, these certificates have a lower standard than that of the international environmental management organizations. Therefore, when the firms export

goods to other countries they may face barriers within the environmental management standards system. Therefore, the firms should make every effort to acquire the international sustainable design standards to enhance their competitiveness within the world.

Thirdly, the legislation feature of the environmental standards of China should be defined. Currently, the environmental standards in China are mainly proposed by the experts in the related field. However, most of these standards do not have the legal power to solve the problems in practice. Therefore, there are barriers for implementation of the environmental management standards.

Fourthly, the government of China should also give programmes to educate the public. The purchasing decision can affect the behavior of organizations. However, according to the above analysis, the environmental protection consciousness of Chinese is at a low level. The government should take measures to enhance the environmental protection practice.

Fifthly, China should adopt the experience from developed countries in developing sustainable design standards. As discussed above, there is a wealth of rich experience from developed countries, such as the U.K. and US. These experiences could reduce the cost of the establishment of sustainable design standards in China.

6.3 Limitations

Although the researcher in this study took sufficient efforts to meet the research aims and objectives, there are still limitations in this research due to personal research skill and time limits.

The sampling process although based on random principle, there is preference on the microelectronic companies. Therefore, the research results that come from the study may not fit other companies. At the same time, the sample size is only 90, which is relatively small compared to other researches. All these factors imitated the usefulness of the conclusions made by this research.

This research takes a mixed methodology. Although many scholars argue that the mixed method has advantages that both qualitative and quantitative

approaches have not, there still is difficulty in integrating both approaches. At the same time, due to the knowledge limits and research skills, it is hard to propose the professional recommendations on the sustainable design standards in China.

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Appendix

Questionnaire for Sustainable Standards in firms

Part 1: Environmental acknowledgement and policy

1. Does your company have regulations about sustainable design in product or management systems?
□ No
□ Have a non-official non-written regulation
□ Have a non-official written regulation
□ Have an official written regulation

2. What do your high level managers think about regular environmental problems, the particular risks and chances which your firm is facing?
□ Very clear
□ Average
□ Don't know
Have they received any related training or been consulted?
□Yes
□No

3. Does your firm have a defined responsible person for environmental problems? (High, mid and base level)
□ No
□ Only at base level
□ At both mid and base level
□ At all three level
□ At all three level and the high level responsible person is CEO or Chairman of the board

4. Does your firm have a functional department in charge of Environment/Sustainable product design?
□ No
□ Only at base level
□ At mid and base level
□ At high, mid and base level

5. Does your company have an accountability principle if any environmental problem occurs?
□ No
□ Yes

6. Does your company have an education plan/system for staff training teaching awareness about sustainable products and environmental protection?

□ No
□ Non-written
□ Written but non-official
□ Have official and written plans

7． Does your company adopt specific measures to encourage staff to participate in sustainable product design and environmental protection?
□ No
□ Have following measure: (Can have multiple choice)
◇Lectures
◇Competitions about related knowledge
◇Suggestions for action

8. Does your company have a reward and punishment system with regard to staff environment-related actions?
□ No
□ Only punishment
□ Only reward
□ Have both Evaluation of Environment/Sustainable influence

9. Does your company reach the maximum level of sewage discharge?
□ Over the level
□ Reaches the level
□Reaches the level but also has good recycling equipment and systems

10. Does your company reach the maximum level of harmful gas discharge?
□ Over the level
□ Reaches the level
□ Reaches the level but also has good recycling or cleanse equipment and systems

11.Do your company reach the maximum level of harmful metal or chemical discharge?
□ Over the level
□ Reaches the level
□ Reaches the level but also has good recycling equipment and systems

12． Has your company had their greenhouse gas discharge calculated?
□ Never
□ In progress
□ Done

13． Has your company a clear goal for reducing greenhouse gas discharge?
□ No
□ Relaxed goals
□ Clear goals including absolute quantity or percent, basic year and timetable

14. Does your company have any sustainable standards in product design, manufacture, assembly, disassembly and end-of-life sections?
□ No
□ In design
□ In MADE
□ In design and MADE

15. Have you ever heard about sustainable design standards and an environmental management system?
□ No, what are they?
□ Only design standards
□ Only environment systems
□ Purchase of both

16. Has your company purchased any sustainable design standards or an environmental management system?
□ No, what are they?
□ Purchased a design standard
□ Purchased an environment system
□ Purchased both

17. Has your company considered the implementation of any sustainable design standards and/or an environmental management system?
□ No, what are they?
□ Maybe a design standard
□ Maybe an environmental system
□ Both

18. Has your company signed and completed any documents about environmental liability with environmental protection and administration section from the government?
□No
□ Signed but didn't complete
□ Signed and completed

20. Does your company execute the evaluation of environmental influence before you start a new project?
□ No
□Yes

21. Does your company use a sustainable design standard or similar legislation in the decision-making process?
□ No
□ Sometimes
□ Frequently
□ Before every decision

22. Does your company have an environment risk management system?
□ No

□ No system, but have handling plan
□ Have such a system and works well

24．What is the proportion of environmentally friendly products or sustainable designed products that your company produces?
□ We do not have environmentally friendly products
□ Under 10%
□ Between 10% and 20%
□ Between 20% and 30%
□ Between 30% and 40%
□ Between 40% and 50%
□ Over 50%

25．Does your company use reproducible materials or environmentally friendly materials in prime products?
□ No
□ At planning stage
□ Yes

26．Do your company use simplified or recyclable packaging?
□ No
□ Under consideration
□ Yes

27．Does your company take any action to improve the type of shipping to reduce the costs and pollution caused by shipping?
□ No
□ Undertaking action
□ Yes

28．Does your company provide information of the product with regard to environment, energy consumption and recycling of your products?
□ No
□ One of the three
□ Two of the three
□ All

29．Does your company have a good working product recycling process system?
□ No
□ Planning to build
□ Yes

30．Does the workspace, manufacturing and storage areas of your company have energy saving measures or use a renewable energy source?
□No
□Planning to use energy saving measures
□ We have a renewable energy source

□ Yes

31. Did you know that sustainable design standards could help your company improve in all sections of the above mentioned areas in question 30?
□No
□Yes
□ Did not know before I read this questionnaire

Part 2: Environmental business prospects

32. What is the income from energy saving and/or environmentally friendly products of your company?
□ None
□ Under 1%
□ Between 1% and 5%
□ Between 5% and 10%
□ Between 10% and 15%
□ Over 15%

33. Has your company joined the formulation of new sustainable and environment protection standards of industry?
□ No
□ Yes
□ Yes and we do it in a positive attitude

34. Has your company invested new technology of environmental protection and/or sustainable product design?
□ None
□ Under 5% of all investment
□ Between 5% and 10%
□ Between 10% and 15%
□ Between 15% and 20%
□ Over 20%

Part 3: Sustainable public relations

35. Does your company have a plan of action to higher public environmental protection awareness, reasonable consumption, and attract the public to join in with the environmental action and funding environmental project?
□ None
□ Have such action：（multiple choice）
◇ public-interest advertisement
◇ education on reasonable consumption
◇ environmental lectures

36. Does your company emphasize the social responsibility and environmental protection value of your brand in the area of marketing?

□ No
□ Have such actions：（multiple choice）
◇Provide sustainable designed product
◇Energy saving in marketing action
◇Use an environmental protection method in marketing

37．Does your company have environmental requests about your supply chain?
□ No
□ Relaxed and general requests
□ Strict requests and have a reward & punishment system

38．Does your company follow the environmental law and legislation of your country?
□ No
□ Yes

39．What's the communication channel between your company and social organizations?
□ We do not have such channels
□ Have such channels：（multiple choice）
◇ Debating session；◇Hot line；◇Open day

40．Has your company co-operated with social organizations for response to environmental problems?
□No
□ Yes

41．Do you co-operate with the media for publicity and popularization of the environmental policy, purposes and efforts of your company?
□No
□ Yes

42. Does your company have environmental protection and/or sustainable design related common weal donation or financial aid?
□No
□Have such actions：（multiple choice）
◇ donate or financial aid to professional environmental group；
◇ donate or financial aid to other environmental subject held by other social organizations；
◇ donate or financial aid to technical environmental research and development

Part 4: Environment information disclosure

43. Is the environmental information of your company open to the public regularly and long term?
□ Only open within the company

□ Do not have a set timetable for open information but have done several times
□ Have a timetable and open information to public

44. How can the insiders and outsiders of your company acquire the environmental information of your company?
□ They can't
□ Only insiders can acquire the information
□ Outsiders can acquire the information by print or web text
□Outsiders can download the information as a complete report from the company website

45. What is the publicly announcement format of your company environmental information?
□ Unofficial reports
□ In an official finance report
□ In an official non-financial report
□ In an independent environment report

46. What is the quality of the publicity announcements of your company's environmental information?
□ Nothing substantive
□ Poor content
□ Reasonable content
□ Comprehensive content

Part 5: Social performance, Staff relationship, Customer

47. What is the quality control system of your company?
□ We do not have a quality control system
□ We take the following actions: (Multiple choice)
◇We have reached International quality authentication standards
◇We use advance quality detect technology
◇The quality of the product is linked to staff personal income

48. Does your company have a recall system for product quality?
□ No
□ Part and conditional
□ All and unconditional

49. Does your company have communication channels for customer?
□ No
□ Have such channels: (Multiple choice)

◇Complaint management
◇Degree of satisfaction survey
◇ Irregular bulletin

	company percent	company numbers						
Do your company have regulation about sustainable design in product or management system?								
No	6.67%	5						
Have non-official non-written regulation	37.33%	28						
Have non-official written regulation	42.67%	32						
Have official written	13.33%	10						
How do your high level manager think about regular environment problem, the particular risk and chances which your firm facing								
Very clear	26.67%	20						
Average	66.67%	50						
don't know	6.67%	5						
Have they received and interrelated training or consultation?								
yes	17.33%	13						
no								
Do your firm have definite responsible person for environment problems?								
No	20.00%	15						
Only in base level	28.00%	21						
In both mid and base level	37.33%	28						
In all three level	14.67%	11						
In all three level and the high level responsible person is CEO or Chairman of the	0.00%	0						
Do you firm have function department about Environment/Sustainable product design?								
No	26.67%	20						
Only in base level	24.00%	18						
In both mid and base level	37.33%	28						
In all three level	12.00%	9						
Do your company have purchase any sustainable design standards or environment management system?								
No, what are they?	38.67%	29						
Purchased design standard	18.67%	14						
Purchased environment	30.67%	23						
Purchases both	12.00%	9						
Do your company use sustainable design standard or similar legislation in decision-making process?								
No	9.33%	7						
Sometimes	25.33%	19						
Frequently	34.67%	26						
Before every decision	30.67%	23						
How's the income of energy saving and/or environment friendly products of your company?								
No	0.00%	0						
Under 1%	8.00%	6						
1%-5%	38.67%	29						
5%-10%	32.00%	24						
10%-15%	17.33%	13						
Over 15%	4.00%	3						
Does your company invest new technology of environment protection and/or sustainable product design?								
No	8.00%	6						
Under 5%	57.33%	43						
5%-10%	28.00%	21						
10%-15	4.00%	3						
15%-20%	2.67%	2						
Over 20%	0.00%	0						
Do your companywhich have plan or action about to bring up public environment protect awareness, reasonable consumption, and attract public to join environmental action and funding environmental project								
Have such action(multi								
Public-interest advertisement	46.43%	13						
Reasonable consumption education	50.00%	14						
Environment lecture	35.71%	10						
Do your company have environmental request about your supply chain?								
No	49.33%	37						
Relax and general request	34.67%	26						
Strict request and have reward & punishment system	16.00%	12						
How's the quality control system of your company?								
Reached International quality authentication standards	73.33%	55						
Use advance quality detect technology	69.33%	52						
The quality of product is linked to staff personal	81.33%	61						
Location	Beijing	Tianjin	Guangdong		Beijing	Tianjin	Guangdong	
1	Have non-official written regulation							
	45.83%	24.00%	57.69%		11	6	15	32
2	Have non-official non-written regulation							
	37.50%	24.00%	50.00%		9	6	13	28
3	Have function department about Environment/Sustainable product design in both mid and base							
	33.33%	16.00%	61.54%		8	4	16	28
4	Have function department about Environment/Sustainable product design in three level							
	20.83%	4.00%	19.23%		5	1	5	11
5	Have purchased any sustainable design standards or environment management system							
	45.83%	24.00%	76.92%		11	6	20	37
6	Invest 5%-10% of all investment on new technology of environment protection and/or sustainable							
	29.17%	12.00%	42.31%		7	3	11	21
7	Have environmental request about the supply chain							
	45.83%	16.00%	88.46%		11	4	23	38