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Extended Producer Responsibility and Design Change

A case study of the Japanese EPR prgrammes

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Abstract

Extended Producer Responsibility (EPR) aims to develop end-of-life product systems and reduce environmental impacts of product across entire life cycle. The empirical study of how EPR programmes have influenced design change is still few especially for complex and durable products such as EEE. Japan introduced EPR programmes in 2001 for four large home appliances (TV sets, air conditioners, refrigerators/freezers and washing/drying machines) and in 2003 for personal computers. This study takes Japanese EPR programmes for large home appliances and PCs as a case study to evaluate to what extent manufacturers improved design change of their products and how Japanese EPR programmes influenced on those attained design changes within the time frame from 2000 to 2010.

Keywords: Extended Producer Responsibility (EPR), design for environment (DfE), large home appliances, PCs

Executive Summary

Background and purpose

In the industrial society, the problem of waste management is getting significant because of the unsustainable patterns of consumer's consumption and producer's production. Consequently, waste management became problematic because of scarcity of area for landfills, cost, recycling technologies and the like along with problems of scarcity of material resources. To solve these problems and achieve sustainable consumption and production, Extended Producer Responsibility (EPR) has been introduced in several countries. In theory, EPR induces upstream change, that is, design change for more environmentally sound products by giving incentives and requirements to producers. However, the studies to examine whether EPR induced upstream change in reality are limited and thus these studies are necessary. This study conducted a case study of Japanese EPR programmes for large home appliances (TV sets, air conditioners, refrigerators/freezers, washing/drying machines) and personal computers to evaluate the effectiveness of Japanese EPR programmes. From this case study, this thesis seeks to contribute to the understanding of the role of EPR programmes for the promotion of overall environmental improvement of product systems.

Analytical framework

To evaluate the Japanese EPR programmes, this study investigated whether one of the intended outcomes of EPR programmes – design change – have occurred (*goal attainment evaluation*), and if so, what role the EPR programmes played in the occurrence of these outcomes (*attributed evaluation*). The study mainly examined influences from government interventions to obtain a clear linkage between EPR programmes and design change. However, other driving forces such as manufacturer's voluntary actions are also referred to when they took an important role for the improvement of design change in order to consider the generality.

Research methodology

This study analyses finding attained from the review of environmental business magazine and interviews with manufacturers, policy makers and experts. In total of 256 articles on design change of five products covering the period from 2000 to 2010 found in Nikkei Ecology, which is a monthly Japanese business magazine in the area of environmental business covers comprehensive national and international matters. The reason for this time frame is to examine influences of anticipation of the introduction and amendment of Japanese EPR programmes as well as its implementation phase. In addition to the review of Nikkei Ecology, open-ended interviews with 19 interviewees from nine manufacturers, two experts and two policymakers were also conducted to obtain insights of findings from the review of Nikkei Ecology. This study mainly observed designs in the areas of 3R, reduction of hazardous substances.

Findings and analysis

Findings attained from the review of Nikkei Ecology and interviews reveal that respective products, that is, TV sets, air conditioners, refrigerators/freezers, washing/drying machines and PCs have each feature of design change and influencing factors. Both manufacturers and experts have confidence in the progress of design change for 3R and reduction of hazardous substances. To achieve these improvements of design change, manufacturers have taken several tools such as product assessment, life cycle assessment, environmental accounting and the like. Moreover, all the interviewed manufacturers developed downstream and the feedback

system between upstream and downstream. These feedback systems have enhanced the improvement of design change especially for 3R and reduction of hazardous substances to close the material loop.

The factors induced these design changes could be attributed to Japanese EPR programmes, national regulations for chemical management, EU Directives and other international regulations. From analysis, it was found that Japanese EPR programmes have influenced design change to some extent. However, especially design for reduction of hazardous substances, the RoHS Directive and REACH have influenced significantly. Meanwhile, voluntary approaches by manufacturers such as company philosophy and their environmental management system have also influenced design change.

Conclusion

The effectiveness evaluation of the Japanese EPR programmes based on the review of Nikkei Ecology and interviews clearly showed the development of design change in the area of 3R, reduction of hazardous substances and energy efficiency. Moreover, design change can be interrelated with the Japanese EPR programmes during the time frame set in this study from both the review of Nikkei ecology and interviews. In addition to Japanese EPR programmes, EPR programes in other regions such as the WEEE Directive and the RoHS Directive, and national/international government interventions are also found to have influenced design change. Meanwhile, manufacturer's voluntary approaches are also founded as factors inducing design change with manufacturer's strong preferences. However, the role of EPR programmes with mandatory requirements imposed to manufacturers should be enphasised since manufacturers are mandated to meet target even though there are negative aspects such as high cost, a lack of demands from consumers, trade-off between design priorities and the like. Consequently, this study concludes that EPR programmes have induced design changes for more environmentally sound from total life cycle perspective. However, it should be noted that other governmental/non governmental supportive measures could generate synergetic effect on the improvement of product systems.

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Abbreviations

AEHA Association for Electric Home Appliances

CFC chlorofluorocarbon

CSCL Act on Evaluation of Chemical Substances and Regulation of Their Manufacture, etc (in short, Chemical Substances Control Law)

CRT cathode-ray tube

CSR cooperate social responsibility

ECCJ The Energy Conservation Center Japan

EEE electrical and electronic equipment

EPR Extended Producer Responsibility

EuP energy using products

DfE design for environment

DfD design for disassembly

HDD hard disc drive

HFC hydrofluorocarbns

JAMA Japanese Automobile Manufacturers Association

JAMP Joint Article Management Promotion-consortium

JBMIA Japan Business Machine and Information System Industries Association

JEITA Japan Electronics and Information Technology Industries Association

JEMA Japan Electrical Manufacturers' Association

JIS Japan Industrial Standard

J-Moss the marking for presence of the specific chemical substances for electrical and electronic equipment JIS C 0950

JRAIA Japan Refrigeration and Air Conditioning Industry Association

LCA life cycle assessment

LCD liquid crystal display

METI Ministry of Economy, Trade and Industry

MoE Ministry of Environment

NGO Non Governmental Organisation

OECD Organisation for Economic Co-operation and Development

REACH Regulation, Evaluation, Authorisation and Restriction of Chemicals

RoHS restriction of hazardous substances

PRTR Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof[1] (in short Law concerning Pollutant Release and Transfer Register)

SHAR Law Specified Appliance Recycling Law

WEEE waste electrical and electronic equipment

1 Introduction

In this section, the author presents basic information of this study including problem background, purpose and research questions, scope and limitation and outline of this study.

1.1 Problem Background

In the industrial societies, manufacturers have developed products for the better living and the consumers have consumed more along with the enhancement of their living standards. Consequently, consumer's consumption behavior and manufacturer's unsustainable production patterns induced environmental problems such as shortage of resources used for new products, usage of hazardous substances for more developed/complicated products, the inappropriate treatment of numerous discarded products, the shortage of the area for landfill and so on.

To reduce environmental impacts not only by diluting but also by preventative measures, the concept of life cycle thinking has been emerged over end-of-pipe approaches. For the products, manufacturers need to treat their products from the "cradle to cradle", that is, manufacturers need to treat their products till end-of-life properly. And for proper treatment of discarded products, manufacturer's efforts are required since governments including local governments had limited capacity for effective treatment of discarded products in terms of technologies, infrastructures and financial resources. Therefore, there were strong demands from the society that manufacturer had to take a responsibility for their products through their total life cycle. Additionally, for more effective collection of discarded products and cost for proper treatment of discarded products, retailers and consumers were to have a responsibility. To substantialise this structure that may change the structure of the existing society, a government intervention, notably called "Extended Producer Responsibility" has been developed and introduced in some countries.

Extended Producer Responsibility (EPR) aims to incorporate incentive mechanisms for industries to continuously improve their products and processes by having them bear responsibilities for their products.

According to Lindhqvist (2000, p.154), EPR is understood as:

> *…a policy principle to promote total life cycle environmental improvements of products systems by extending the responsibilities of the manufacturer of the product to various parts of the product's life cycle, and especially to the take-back, recovery and final disposal of the product(Lindhqvist, 2000).*

According to the OECD, the EPR policy is characterised by:

> *(1) the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities; and (2) the provision of incentives to producers to take into account environmental considerations when designing their products (OECD, 2001).*

The extension of the responsibilities can be categorised as liability, economic responsibility, physical responsibility and informative responsibility (Tojo, 2004). Chapter 2 will explain details about the EPR programmes.

The EPR programmes are to date mostly extending producer's responsibility to the end-of-life management of products, which is the "weakest link" for the producers in the products chain

(Kroepelien, 2000, cited by Tojo, 2004). Shifting end-of-life management to producers may lead to multiple, inter-related benefits for the society by affecting the various phase of the product's life cycle. The EPR programmes, can in theory, induce various changes such as upstream (design change), downstream (development of infrastructures for sorted collection and recovery) and between (development of feedback mechanism between upstream and downstream) (Tojo, 2004). The design changes of products for more environmentally sound product development is the art of balancing a great number of competing and often conflicting demands regarding function, size, design, raw materials, production properties, product quality, durability, price and the like (Lindhqvist, 2000). Design strategies for products incorporating with environmental concern could be found in the 1980s, however, the systematic Design for Environment (DfE) strategies and approaches were a new feature of the 1990s (Lindhqvist, 2000).

However, it is challenging to measure upstream changes after the introduction of legislation by the achieved reuse and recycling rate (Tojo, 2004). The achieved collection/reuse/recycling rate may not clearly relate to the achievement of upstream changes since they could be induced by both upstream and downstream changes (Tojo, 2004). This fact reflected the limitations of setting up targets concerning upstream changes within the EPR programmes and thus it is difficult to grasp and communicate upstream changes achieved by the EPR programmes. Further, it would be difficult to measure in short period of the implementation such as less than five years since technological developments on new products would take several years. It may be possible to measure around ten years past after the EPR programmes introduced. Moreover, there are few researches on the product developments induced by the EPR programmes despite it is important to measure to see the effectiveness of the EPR programmes as the policy instrument.

Japan introduced an EPR programme for four large home appliances (air conditioners, TV sets, refrigerators, wash machines), called the Specified Home Appliance Recycling (SHAR) Law, which was enacted in 1998 and fully came into force in 2001. It is the second EPR programme in Japan that legally assigns part of the responsibility for the end of life management of products to manufacturers. Under the SHAR Law, responsibilities are distributed among actors; consumers pay expenses for collection and recycling, retailers collect products and manufacturers treat collected discarded products properly and achieve required reuse/recycling rate targets.

Additionally, an EPR programme was introduced for personal computers (PC) in 2003 under the Law for Promotion of Effective Utilization of Resources. Under this programme, the responsibility to collect and dispose/recycling discarded PCs is shifted from municipalities to manufacturers. Consumers have the responsibility to pay the expenses for the proper treatment of discarded PCs.

1.2 Purpose and research questions

The purpose of this thesis is *to contribute to the understanding of the role of EPR programmes for the promotion of overall environmental improvement of product systems by evaluating of the effectiveness of EPR programmes for large home appliances and personal computers (PCs) in Japan in inducing design changes.*

The effectiveness of the Japanese EPR programmes for large home appliances and PCs is investigated by seeking answers for the following questions:

- *What measures have been undertaken by manufacturers in order to reduce environmental impacts from the end-of-life phase of their products?*

- *What kind of government interventions and other factors affected design change for the reduction of environmental impacts?*

Finally, the thesis will also seek to explore *whether design change have been continued after the amendment of the Japanese EPR laws.*

1.3 Scope and limitation

The EPR programmes are different from country to country with various implementation mechanisms. Thus an in-depth study of the experience in Japan may provide useful insights on how EPR policies influenced on the upstream changes. The reason to select the Japanese case is that the country has a huge industrial sector and several well-known worldwide manufacturers on EEE. In addition, as mentioned in section 1.1, two EPR programmes have been introduced.

In Japan, under two EPR programmes for four large home appliances and PCs, the design changes to be investigated are mainly from 2000 to 2010 since the Japanese EPR programmes for both large home appliances and PCs came into force and was amended in during this period. The reason of stating 2000 is that design change may have been induced during the preparation period before the SHAR Law came into force. Actually, in 1999, two years before the legislation came into force, manufacturers had already started to re-design their products to ease their end-of-life management (Tojo, 2004). Additionally, to compare the measures of design changes after the amendment of the SHAR Law, design changes is investigated till 2010.

Various factors influenced manufacturer's behavior regarding design change. This research mainly focuses on government interventions. However, the author will also mention other factors when they appeared to play important role.

Concerning Japanese laws, the author uses the translation published by the government. The author will add explanation when it is needed.

Detailed limitations regarding the contents of analytical framework, methodology including data collection for this study will be provided in the respective sections.

1.4 Outline of the thesis

After this chapter, Chapter 2 describes the general explanation of the EPR policy and an analytical framework of this thesis. This section provides criteria for evaluation of development of design change and the linkage between design change and Japanese EPR programmes.

Chapter 3 describes methodological approach taken in this study to get findings to answer the research question.

Chapter 4 briefly presents the Japanese EPR programmes for large home appliances and PCs.

Chapter 5 briefly describes measures taken by manufacturers for end-of-life product management. Additionally, findings of the review of Nikkei Ecology and interviews are also provided.

Chapter 6 provides the analysis of findings from Chapter 5 by using an analytical framework provided in Chapter 2.

Finally, Chapter 7 presents a conclusion of this thesis.

2 Analytical Framework

This chapter develops an analytical framework for investigating the research question set in Section 1.3. The author firstly provides a short description of the concept of Extend Producer Responsibility followed by its relation with design change.

2.1 What is EPR?

Extended Producer Responsibility is firstly introduced as a defined policy strategy in a report to the Swedish Ministry of the Environment in 1990 by Thomas Lindhqvist (Lindhqvist, 2000). One implication of EPR is to shift responsibility which were traditionally assigned to consumers and authorities for the waste management to the producers of products (Lindhqvist, 2000).

The first report to the Swedish Ministry of the Environment by Thomas Lindhqvist already emphasised as an issue of design change as follows.

> *A successful model should give a strong incentive for developing the product in question in such a way that it minimizes the total life-cycle environmental impact.*
>
> *(Lindhqvist, 2000)*

All the stage of the life cycle of products was stressed and it was mentioned that the product should be designed for an environmentally adapted end-of-life treatment, including easy repair, longevity, good recyclability and possibility for reuse (Lindhqvist, 2000). A formal definition of EPR was presented later to the Ministry of the Environment and Natural Resources, which reads as follows.

> *Extended Producer Responsibility is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product. The Extended Producer Responsibility is implemented through administrative, economic and informative instruments. The composition of these instruments determines the precise form of the Extended Producer Responsibility.*
>
> *(Lindhqvist, 2000)*

The concept of EPR was further developed and in 2005, Lindhqvist and van Rossem clarified two main environmentally related goals of EPR based on the definition of EPR provided in the OECD Guidance Manual and experiences from studies conducted at IIIEE:

> *Goal1. Design improvements of products – the EPR system should provide incentives for manufacturers to improve the environmental performance of products and the systems surrounding the life cycle of the products.*
>
> *Goal2. High re-utilisation of product and material through effective collection and re-use or recycling. This goal can be further divided into three sub-goals.*
>
> *2a. Effective collection – A primary goal with an EPR policy is to ensure a high collection rate of the product in focus in order to avoid littering and abandoned products in nature. A related goal is to divert selected discarded products from the general waste stream in order to facilitate a more proper end-of-life treatment and utilissation of the product and its material.*

2b. Environmentally sound treatment of collected products – Before being further processed many products need a pre-treatment in the form of dismantling and/or sorting. The aim of this can be to secure special treatment of hazardous components and materials, and to improve the possibilities for re-use and recycling.

2c. High re-utilisation of products and materials in the form of re-use and recycling – The EPR implementation should secure that products or their components, when appropriate, can be re-used, and that the materials are recovered and used for substituting the use of virgin materials, thus saving raw materials and avoiding the environmental impacts related to the extraction and processing of these materials.

(van Rossem, 2008)

2.1.1 Different forms of responsibilities

Along with the development of the concept of EPR as section 2.1, a model of EPR is distinguishes with different form of responsibility as Figure 1 below. However, the concrete allocation of these responsibilities is different from one programme to other (Tojo, 2004).

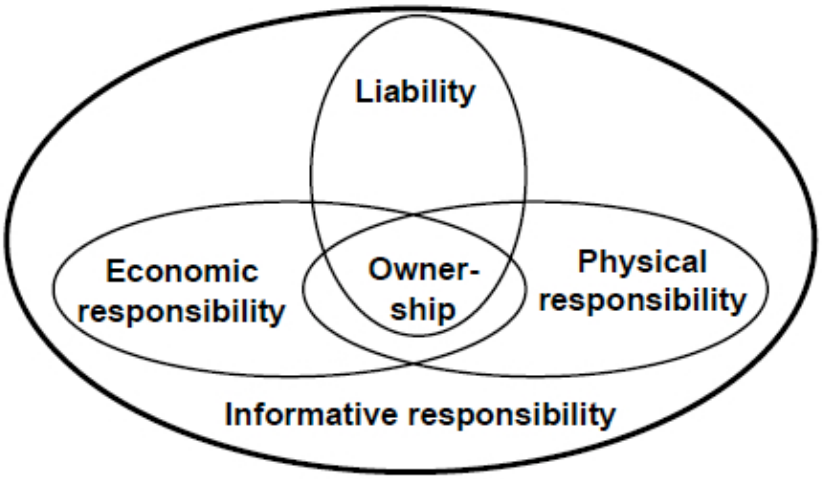


Figure 1: Models for the Extended Producer Responsibility (Lindqvist, 2000)

Liability *refers to the responsibility for proven environmental damages caused by the product in question. The extent of the liability is determined by legislation and may embrace different parts of the life cycle of the product, including usage and final disposal.*

Economic responsibility *means that the producer will cover all or part of the expenses, for example, for the collection, recycling or final disposal of the products he is manufacturing. These expenses could be paid for directly by the producer or by a special fee.*

Physical responsibility *is used to characterise the systems where the manufacturer is involved in the physical management of the products and/or their effects.*

The manufacturer may also retain the ownership of his products throughout their life cycle, and consequently be linked to the environmental problems of the product.

Informative responsibility *signifies several different possibilities to extend responsibility for the products by requiring the producers to supply information on the environmental properties of the products he is manufacturing.*

(Lindhqvist, 2000)

2.1.2 EPR Multiple policy instruments

The EPR principle can be implemented through administrative instruments, economic instruments and informative instruments depending on EPR programmes (Lindhqvist, 1992; Tojo, 2004; van Rossem, 2008). Usually a mix of administrative, economic and informative instruments is found in the EPR programmes (van Rossem, 2008). Tojo and van Rossem categorised EPR-based policy instruments as found in Table 1. The EPR programmes are mainly based on legislative measures, however, manufacturer's voluntary approach as a part of their business strategy can be found (Tojo, 2004)

Table 1: Example of EPR-based policy instruments

Administrative instruments (command and control regulation)	Collection and/or take-back of discarded products, substance landfill restriction or ban, landfill/disposal bans, achievement of collection, reuse (refill) and recycling target, fulfillment of environmentally sound treatment standards, fulfillment of minimum recycled material content standards, product standard, utilization mandates
Economic instruments	Material/product taxes, subsidies, advanced disposal fees or advanced disposal fees, deposit-refund systems, Tradable permits, upstream combined tax/subsidies, tradable recycling credits
Informative instruments	Reporting to authorities, marking/labeling of products and components, consultation with local governments about the collection network, information provision to consumers about producer responsibility/source separation, information provision to recyclers about the structure and substances used in products

(Source: Tojo, 2004; van Rossem, 2008)

2.1.3 Individual and collective responsibility

To implement imposed responsibility related to the downstream operation such as take-back, there is a notable distinction referred to as individual versus collective responsibility (Tojo, 2004). This can be distinguished depending on the degree of cooperation among the producers in fulfilling their responsibility (Tojo, 2004). Tojo described individual and collective responsibility as following.

> *In essence, if a producer takes responsibility for the end-of-life management of their own products (individual responsibility) or producers in the same product group together fulfil their responsibility for the end-of-life management of their product regardless of the brand (collective responsibility).*
>
> *(Tojo, 2004)*

There are diverse understandings of collective and individual responsibility, and it is difficult to define individual or collective responsibility in actual manner, for instance, Japanese case has both elements. Thus the author will not describe details of individual versus collective responsibility in this thesis to avoid the complication.

2.2 EPR and design change of products

As the concept of EPR, the goal is to develop design change for the reduction of environmental impacts from end-of-life product systems. And for better management of

product systems, producers are in the position to take a role for preventative solutions at source among different actors in life cycle of products.

The concept of EPR has potential to induce design change by providing incentives to producers even though the introduction of an EPR programme requires a significant change of social system involving many actors (Tojo, 2004). For instance, the introduction of an EPR programme would change the system for collection of discarded products, collection of cost to recycle, infrastructure and the like involving all sectors, that is, business, household and government sector. Further, even though the EPR programme can in theory induce improvement on upstream, downstream and between upstream and downstream, measuring those improvement in the entire life cycle is difficult especially when the implementation period of EPR progammes is short (Tojo, 2004). Further, it is difficult to evaluate the improvement of design change of products and the linkage between those development and the EPR programmes especially for durable, complex products such as EEE and vehicles. Because it is difficult to grasp all the various kinds/types of materials contained in products and also these durable/complex products will come to recycling plant 10-15 years after consumers bought them (Tojo, 2004).

These difficulties make the evaluation of the EPR programmes complicated (Tojo, 2004). Further, study of EPR programmes and design changes are little apart from EPR programmes for packaging (Tojo, 2004). Van Rossem conducted extensive review of empirical research on EPR programme implementation for vehicle, EEE and package and found that effects of EPR programmes on design change varies depending on the studies (van Rossem, 2008). His study showed that the anticipation of the EPR legislation affected more on producers than the implementation of the programmes (van Rossem, 2008). However, empirical studies that evaluate how EPR programmes influenced corporate strategy and design change are far from extensive even in 2008 when van Rossem did his research (van Rossem, 2008). Table 2 shows empirical studies for EEE evaluating the impacts of EPR programmes on corporate strategy and design changes he researched.

Table 2: Empirical Studies Evaluating the Impacts of EPR Programmes on Corporate Strategy and Product Design for Electronics

Author(s)	Product group	Geographic Region	Main Findings
Furuhjelm, J, 2000	Electronics	Sweden	Anticipation of WEEE Directive led to new end-of-life consideration, Customer requirements (Japanese B2B customers)
Hosoda, K, 2004	Packaging, Vehicles, Electronics	Japan	Example of design change of packing attributed to the EPR system including phase out of coloured PET, light-weighting, reduction of composites in PET bottles. Similarly, for the 4 household appliances under SHAR Law the following design changes were noted; design for ease of disassembly & uniformity of plastic resins
Hafkesbrink, J, 2004	Electronics	Germany	Anticipation of Draft WEEE Ordinance led to downstream development of recycling technologies
Tojo, N, 2004	Electronics Vehicles	Sweden Japan	Design changes (hazardous material reduction, improved recyclability) and downstream infrastructure development attributed to pending EPR legislation: Anticipation
Roine, K & Lee, C-Y, 2006	Electronics Agricultural	Norway	No observed direct impact, but influences organizational innovation that indirectly influenced

	Film		technical change
Gotteberg, A et al., 2006	Electronics (Lamps)	European Union	Take back obligation for lamps has not led to design improvements in the lamp sector
Yu, J et al., 2006	Electronics	China	Investigated Chinese firm's response to the WEEE & RoHS Directives. Efforts more focused on RoHS than WEEE, with little evidence to suggest that Chinese firms or their foreign customers (OEMs) are influenced by the WEEE Directive requirements.

(Source: van Rossem, 2008)

From these situations, it is important to examine further whether an EPR programme can indeed provide a incentive for producers to undertake improvements of design change that enhance environmental performances of entire product systems.

2.3 Analytical framework – evaluation of environmental intervention

To answer the research question, the author uses the effectiveness evaluation as an analytical framework, which was developed by Naoko Tojo (2004).

Regarding the evaluation of environmental intervention, there is a discussion of evaluation itself and evaluation criteria, that is, "substantive" criteria (*effectiveness* and *efficiency*), and "procedural" criteria (*legality* and *democracy*), *legitimacy of political acceptability* and *relevancy* criterion (Vedung, 1997; Bemelmans-Videc, 1998, cited by Tojo, 2004). However, the author will only look at effectiveness criterion, which is the most dominant criteria in evaluation practice concerns whether and by how much the goal of the intervention have been attained. This can be considered from two viewpoints: 1) whether the outcomes are in accord with the goals (*goal-achievement measurement*), and 2) whether the outcomes are produced by the intervention (*attributability assessment*) (Vedung, 1997).

Concerning outcomes of EPR programmes to examine to what extent producers developed upstream change, this study mainly focuses on design change. Therefore, downstream change and development between upstream and downstream will be referred to only when these changes are related to upstream change. Considering attributability assessment, factors facilitated the occurrence of these design changes will be discussed. Figure 2 shows the effectiveness evaluation adapted from Vedung (1997) combined with the model for the evaluation of an EPR programme based on its intervention theory developed by Tojo (2004).

Figure 2: Analytical framework used in this thesis (adopted from Vedung and Tojo)

3 Methodology

This chapter describes the methodological approach applied to this research work. This study seeks to examine whether outcomes intended by policies was actually attained by the intervention incorporating the EPR principle with the effectiveness (*goal-attainment*) evaluation and what is the linkage between that outcomes and governmental interventions (*attributability assessment*).

3.1 Data collection

This work started with the literature review of the Japanese EPR programmes for large home appliances and PCs to provide the basic information on how these programmes were implemented as policy intervention. Data for this review were academic articles, documents published by the government, industrial associations and the like.

3.1.1 Primary data for the review of design change for products

After obtaining an overview of the Japanese EPR programmes for large home appliances and PCs, the author investigated how designs of these products became more environmentally sound and how such changes happened. To see design change in a comprehensive manner, the author observed with the time frame between 2000, which is one year before stated the SHAR Law, and 2010. This time frame was chosen since the author assumed that design change would be conducted before the EPR programme for large home appliances started to be implemented. The SHAR Law was amended in 2008 and the author sought to review design change until 2010 to see how this amendment influenced product design. Regarding the EPR programme for PCs, the programme was started in 2003 and thus the design changes of PCs can be examined with the same timeframe 2000-2010 as for large home appliances covered by the SHAR Law.

To collect information on design change of products from 2000 to 2010, the author chose the Nikkei Ecology, which is a monthly environmental business magazine covers comprehensive national and international environmental matters. Nikkei Ecology is published by the Nikkei Business Publications, Inc. and targeted reader is business person including management layer of companies. Nikkei Ecology has been published since 1999 and could cover the whole timeframe the author set. Additionally, an expert who has researched in the field of EPR policies and cleaner production suggested Nikkei Ecology as a worth reviewing magazine. The reason not to select daily industry newspaper but this monthly magazine is that there are too many articles to observe for 10-year-period within the time allocated for this thesis. It was also difficult to access a daily industry newspaper since very limited libraries have that a whole set of newspaper published in 2000-2010. In the end, the author collected 256 articles about design change from the review of Nikkei Ecology by following criteria below.

The following two types of articles in Nikkei Ecology were selected for review:

- An article about the design change of newly released TV sets, air conditioners, refrigerators/freezers, washing/drying machines and PCs with environmental specific features.

- An article about the new technology used in the aforementioned products, including both what was already released and was to be released.

After the selection of articles, the author read each article carefully, and checked if it stated anything about the reason of the respective design changes. The stated reason can be national or international regulations, organization or manufacturer's voluntary actions, and demands from consumers. If an article does not mention any reason for design change of newly released products, the author considered that article as "the article without stated reason". The author's criteria for considering as a reason for design change are followings:

- If an article mentioned that "because of X, design change of YZ happened", "X affected a manufacturers to make an effort for developing a new technology/design of products…", "manufacturers changed design for new products to deal with X", the author considers X as a reason for design change.

- If an article mentioned that "a new product achieves the standard of X with Y%…", the X is not considered as reasons for the improvement of design change since the achievement can be regarded as not a reason but a result.

After the review of the articles based on these criteria, the author sorted the articles.

When an article about the design changes mentioned only "large home appliances", without specifying the product, the author counted that article as the "design change for large home appliances".

In addition to articles about design change, the author reviewed articles about EPR programmes in general, the development of technologies at recycle plants, the development of the communication between manufacturers and recycle plants and design changes of products other than the large home appliances and PCs. These information were used for better understandings of a background of design changes and matters which can be related to EPR programmes. The author will mention about these matters in the sections where the review of the Nikkei Ecology is summarized (Section 5.2).

3.1.2 Interviews with manufacturers and experts

To get insights in addition to the result from the review of Nikkei Ecology, open-ended interviews were conducted. Interviews with manufactures were conducted in July 2011 in Japan. The author interviewed with 19 interviewees from nine manufacturers. Regarding interviews with Hitachi and Toshiba, the author could have interviews with affiliate companies since they divide production depended on products. Except for two interviews with manufacturers via e-mail, all interviews were conducted in person. Interviewed manufacturers are selected with criteria whether they have relatively high share in the market and produce four large home appliances covered by the SHAR Law except manufacturers mainly produce PCs. Thus, other well-known manufacturers, for instance SONY who is a notable audio instrument manufacturer, were not interviewed. Contacts with manufacturers are attained from experts of the EPR policies and cleaner products. The list of interviewee can be seen at Appendix1. Before having interviews, the author passed a list of questionnaire to contact persons of manufacturers via e-mail. General questions are provided in Table 3, however, the author changed the question slightly according to contents of interview.

In addition to interviews with manufacturers, the author also interviewed with two experts in the field of the EPR prgorammes and cleaner products, and two policy makers who worked on the amendment of the SHAR Law. Except for one policy maker whose interview was conducted via skype, all interviews were also conducted in person in July 2011 in Japan. All interviews with manufacturers and policy makers were conducted in Japanese.

Table 3: The list of general questions for manufacturers

- What kind of design consideration for environmentally sound product development has been conducted for large home appliances, especially TV sets, refrigerators/freezers, air conditioners, washing/drying machines?
  - How have these designs been changed?
  - Who took initiatives to promote those design changes?
  - DfE can be decided in to the area of 3R, reduction of hazardous substances and energy efficiency. How did you worked on them?
  - What do you think of the trade-off between DfE and or other factors?
- What are driving forces and barriers for the promotion of DfE?
- How did you deal with the EPR programmes when the SHAR Law came into force in 2001? And after the amendment of the SHAR Law, how did you deal with the higher reuse/recycling rate and expanded covered products?
- What do you think of recycling costs?
- How do you communicate about design changes with other manufacturers?

3.2 A Method to analyse information attained from the review of articles and interviews

Data attained from the review of the Nikkei Ecology and interviews are analysed in accordance with the analytical framework provided in Chapter 2. Then, from analysis, the author will conclude whether and how an EPR programme provides incentives for environmentally conscious design for the manufacturers.

4 EPR Programmes in Japan

This section describes details of existing Japanese EPR programmes for large home appliances and PCs. As mentioned earlier, the ultimate aim of EPR programmes is to improve upstream change. The author chose the Japanese EPR programmes for EEE as a case to seek for an answer to the purpose of this thesis. This chapter briefly describes contents of two EPR programmes for EEE in Japan.

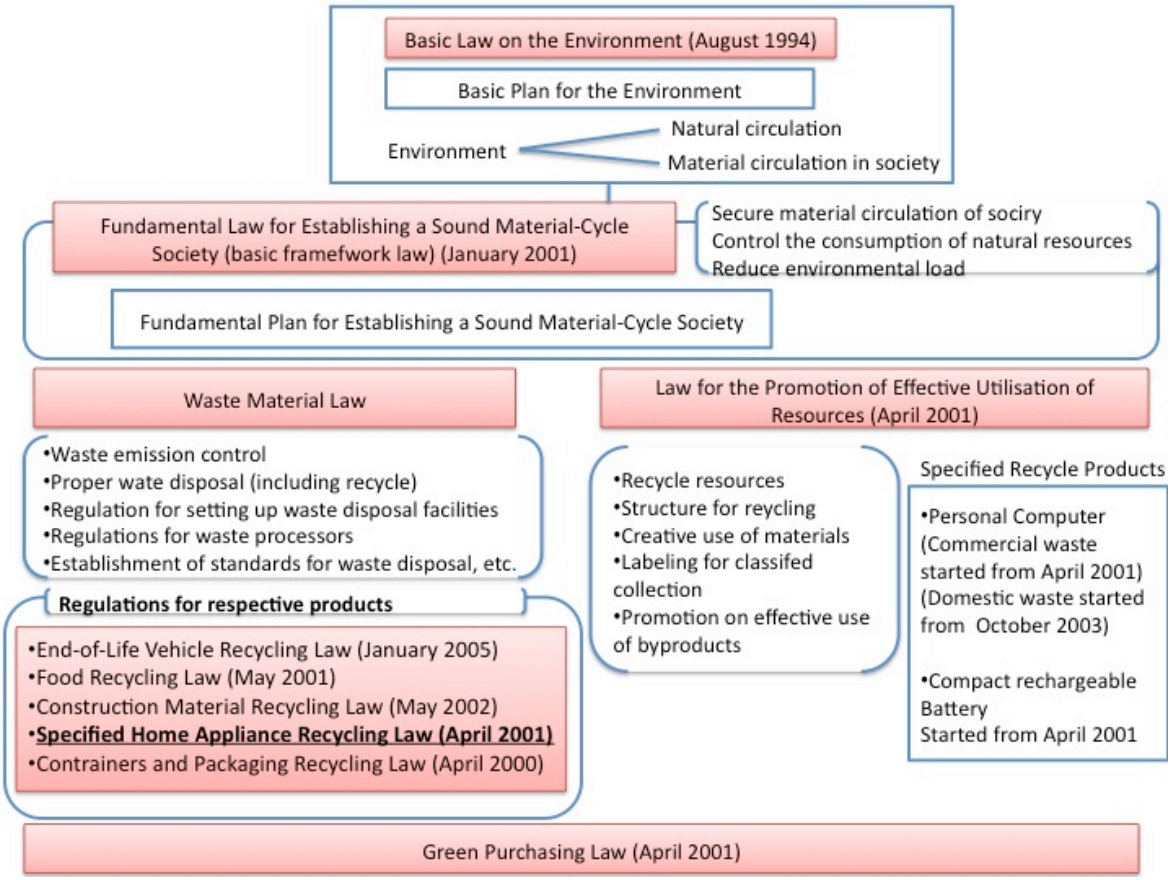
4.1 The Specified Home Appliance Recycling Law for large home appliances

In Japan, Specified Home Appliance Recycling (SHAR) Law was enacted in 1988 and fully came into force in 2001. This is the second EPR programme in Japan that legally assigns part of responsibility for end-of-life management of four large home appliances to manufacturers. Main driving forces to introduce this EPR programme were scarcity of final disposal sites increase of large home appliances in waste stream and inadequacy of existing treatment plants for handling those products (Tojo, 2004).

4.1.1 System of laws for a sounds material-cycle society

Figure 3 shows a legislative system to promote a 3R-oriented society in Japan. To construct a system for a sound material-cycle society, it was necessary to develop from existing recycle (1R) polity to reduce/reuse/recycle (3R) policy (METI, 2010). With this background, the Fundamental Law for Establishing a Sound Material-Cycle Society came into force in January 2001. Under this Fundamental Law, laws such as the Law for the Promotion of Effective Utilisation of Resources and laws for specific product groups, which account high rate of waste generation, were enacted. The SHAR Law, which is an EPR programme for four products (TV sets, air conditioners, washing machines and refrigerators), is one of such laws. PCs are covered by the Law for the Promotion of Effective Utilisation of Resources (in short, the Recycling Promotion Law). The Green Purchasing Law came into force in April 2001 to induce demands of green products. Under this law, the governments are required to purchase green products (local governments need to make efforts to purchase) and business sector are required to provide appropriate data of environmental impacts of their products (MoE, 2011).

Figure 3: Legislative system for the creation of a 3R-Oriented Society



(Source: METI, 2010; AEHA, 2007)

4.1.2 Products categories covered by the SHAR Law

Product categories covered by the SHAR Law are followings:

1. It is difficult to recycle under existing facilities and technologies possessed by local governments.

2. There is not significant economic restriction for recycling.

3. Manufacturers can exert great influence on the recycling through their selection of designs and components of products.

4. It is rationale that retailers collect discarded products smoothly since products are delivered by retailers when consumers purchase them.

(Article 2.4, the SHAR Law)

From those requirements, the SHAR Law covers the products such as air conditioner, TV sets (cathode-ray tube (CRT), liquid crystal display (LCD) and plasma TV), refrigerators, freezers, and washing/drying machines. Among those products, LCD, plasma TV sets and drying machine were added in April 2009 (AEHA, 2011)

4.1.3 Reuse/Recycling target set by the SHAR Law

Under the SHAR Law, "recycling" is defined as:

1. "Removing parts and materials from discarded products and reusing them as components or raw materials of new products".

2. "Removing parts and materials from discarded products and assigning them, with or without charge, to those who will reuse them as components or raw materials of new products".

(Article 2.1, the SHAR Law; METI, 2010)

"Recycling" could include thermal recycling, but it is currently not added as recycling target imposed on manufacturers from the view that material recycling should be prioritized over thermal recycling (Article 2.3, the SHAR Law; AEHA, 2011).

With this definition of "recycling", reuse/recycling target is set for respective product groups as Table 4.

Table 4 Recycling level required under the SHAR Law

	Reuse/recycling target till 2008	Reuse/recycling target from 2009
Air conditioners	More than 60%	More than 70%
TV sets	More than 50%	For CRT; more than 55% For LCD and plasma TV; more than 50%
Refrigerators/freezers	More than 50%	More than 60%
Washing machines and Drying machines	More than 50%	More than 65%

(Source: METI, 2010; AEHA, 2011)

4.1.4 Allocation of the responsibilities

Under the SHAR Law, manufacturers, consumers, retailers, the government and local governments bear different responsibilities for promoting recycling of home appliances properly.

End-users bear a responsibility of covering the cost for the end-of-life management of the products they discard. They are also required to hand-in discarded products to retailers adequately (Article 6, 11, 19, the SHAR Law).

Retailers bear the responsibility of taking back old products when;

1. They are required to take back the old products they sold before.

2. They are required to take back the old products when they sell similar new products.

(Article 9, the SHAR Law)

Adding to this collection requirement, retailers are required to pass the old products they collect to manufacturers who produced them. If a manufacturer of a product is unclear/disappear (orphan products), retailers transport it to designated legal entities. (Article 10, the SHAR Law; AEHA, 2011)

Manufacturers including importers are required to take back their discarded products (take-back requirement), dismantle them and recover components and materials that can be reused or recycled (recovery requirement) (Article 17, 18, SHAR Law). Manufacturers are also required to collect CFCs used as refrigerants for air conditioners, refrigerators/freezers and washing/drying machines, and CFCs in the heat insulator of refrigerators/freezers (METI, 2010). Manufacturers are required to recycle or decompose these collected CFCs (AEHA, 2011).

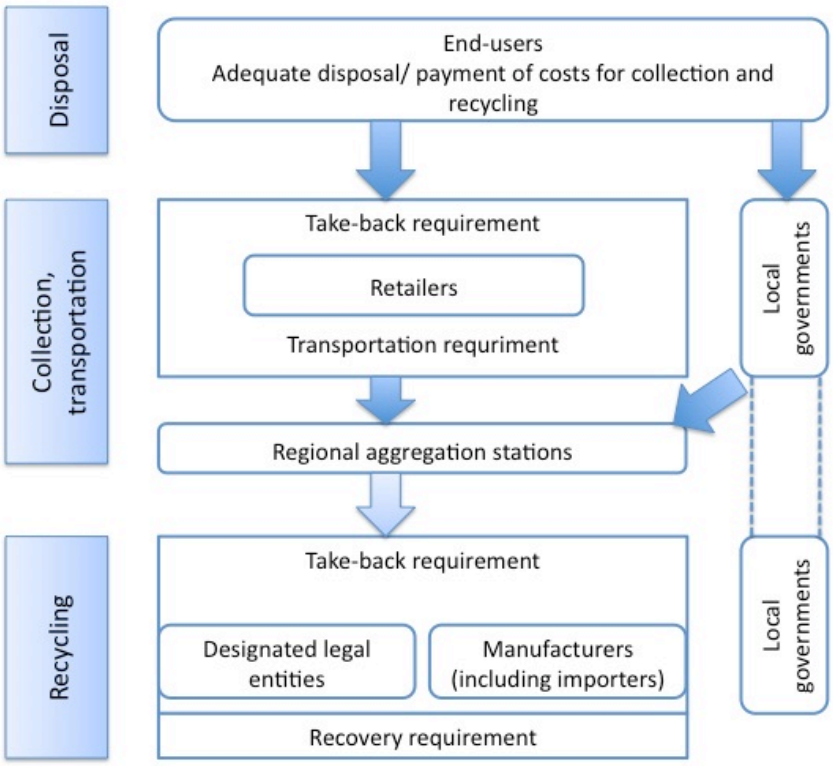
Manufacturers should also establish regional aggregation stations, where the discarded products collected by retailers and other actors such as local governments and designated legal entities are brought in (Article 17, the SHAR Law).

The national government should collect information and utilize them as well as promote R&D for collection, transportation and recycling (Article 7, the SHAR Law). The national government also should provide information of the amount and the cost of recycling and so on (Article 7.2, the SHAR Law). Promoting communication with citizens for further understanding is also the task of the national government (Article 7.3, the SHAR Law).

Local governments should make efforts to take necessary measures to promote collection and transportation of the old products. For instance, local governments (and designated legal entities) collect the products came from remote areas or whose retailers disappeared (Article 8, 33.1-33.3, SHAR Law). When local governments collect the old products, they can transport them to manufacturers or designated legal entities. Or they can recycle them by themselves.

Figure 4 shows a picture of the allocation of responsibilities

Figure 4: A picture of the allocation of responsibilities.



Source: (AEHA, 2011; METI, 2010)

4.1.5 Systems supporting the SHAR Law

To assure that discarded products are transported to manufacturers via retailers, a manifesto system was established. Retailers issue the "manifesto" and they pass a copy of a manifesto to end-users when they take-back the old products. Retailers pass the old products to manufacturers with a copy of a manifesto. Both retailers and manufacturers are required to keep this copy for three years. Association for Electric Home Appliance (AEHA) founded the RKC to operate and manage manifestos and recycling fee from end-users to support retailers (AEHA, 2011).

As mentioned at section 4.1.4, designated legal entities could also be regarded as a support of the SHAR Law.

4.1.6 The systems established for the Collection and Recycling

Manufacturers have grouped themselves into two – often referred to as Group A and Group B – and operated a recycling system of the discarded products covered by the SHAR Law. The main reason of dividing into two groups is to enhance the competition for the reduction of recycling costs based on market mechanisms. However, it costs a lot if each manufacturer establishes his/her own recycling centers across the country and thus manufacturers are working together within two large groups. Also, it is more convenient for retailers and local governments to have regional aggregation stations from a view of the transportation of collected products (AEHA, 2011). As of May 2011, there are 379 regional aggregation stations

in Japan (AEHA, 2011). These regional aggregation stations had been operated by group A or B, however, these stations were merged on 1st October 2009 to enhance the convenience for retailers (AEHA, 2011).

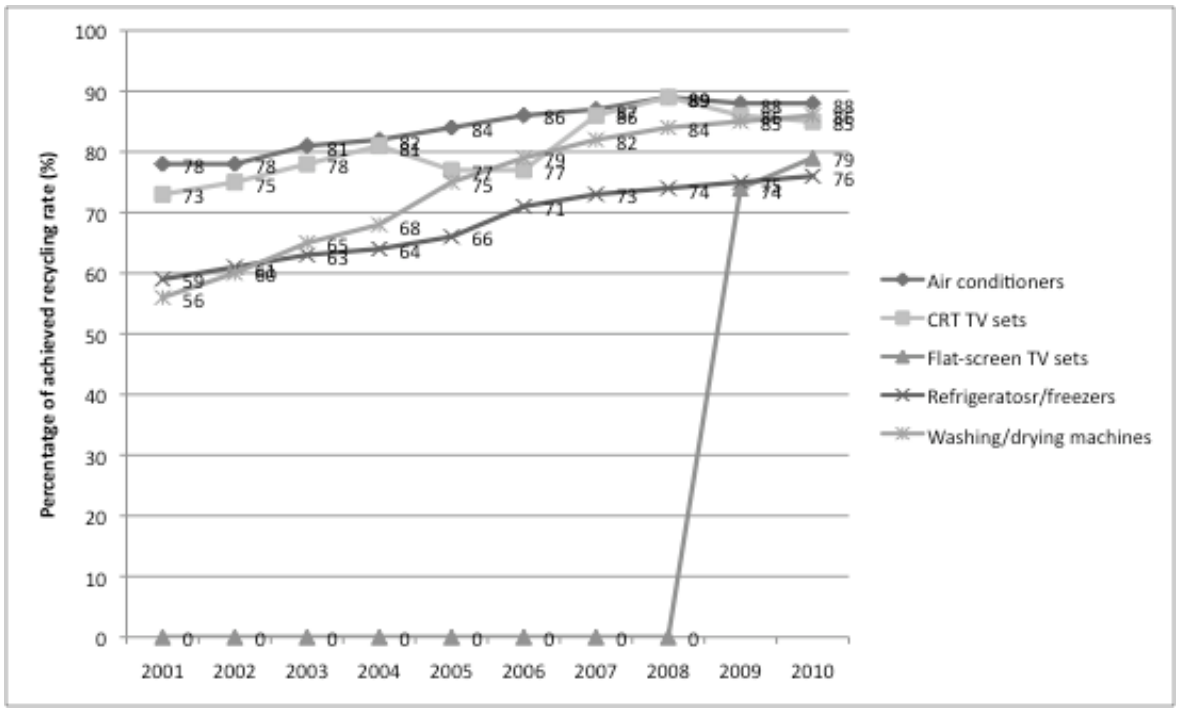
Manufacturers subsequently receive collected old products at 49 recycling plants in Japan (as of may 2011). Among them, 31 plants are operated by Group A, 16 plants are operated by Group B and 2 joint plants are operated by both groups (AEHA, 2011). There is a significant differences between group A and B about recycling plants, that is, Group A mainly cooperates with existing recycling entities, while Group B establishes new recycling plants for home appliances themselves (AEHA, 2011). However, manufacturers participated in Group A often have his/her recycling plant as well.

4.1.7 Status of Recycling

Since the SHAR law came into force, 73.08 million units of air conditioners, 113.15million units of TV sets (CRT, LCD and plasma TV), 42.81million of refrigerator and 44.62 million units of wash machine (including drying machine) have been put in the market (AEHA, 2011). A significant transition is that the CRT TV has been reduced year by year but the flat-screen TV (including LCD and plasma TV) is boosting in the contrary. For example, in 2010, the number of CRT TV put in the market was zero while flat-screen TV was 25.68 million (AEHA, 2011). It is because that the analog broadcasting was finished in July 2011 in Japan.

Meanwhile, over 130 million of products have been recycled since the SHAR Law came into force. In 2010, the total amount of old products manufacturers collected is about 8.9 million ton and it can be translated as about 6.9 kg per person in Japan (AEHA, 2011). The number of recycled products is growing and in 2010, it was 25.79 million (AEHA, 2011). The recycling rate of respective products in 2010 was as follows: air conditioners: 88%, CRT TV sets: 85%, flat-screen TV sets: 79%, refrigerators/freezers: 76% and washing machines/drying machines: 86% (AEHA, 2011). A recycling rate of CRT TV sets was decreased among 2007-2008 and 2009-2010 since some grass with CRT cannot be sold and in the contrary, producers need to pay to have them treated (AEHA, 2011). Figure 5 shows that the recycling rate is growing since downstream technologies have been developed at recycling plants, and plastics and other valuable materials have been more recycled (AEHA, 2011). Most manufacturers are also promoting the closed-loop recycle to use recycled materials for components of new products (AEHA, 2011).

Figure 5: Percentages of achieved recycling rate for four large home appliances from 2001 to 2010



(Source: AEHA, 2011)

4.2 The Law for Promotion of Effective Utilisation of Resource and recycling of PCs

The Law for Promotion of Effective Utilisation of Resources (in short, the Recycling Promotion Law) was enacted in 1991 for the promotion of various measures to improve recycling (Tojo, 2004). Under the law, manufacturers of specific product groups are advised to take various types of measures such as facilitating design for ease-of-disassembly and recycling for large electrical home appliances, facilitating separate collection of steel cans, material recycling of glass bottles, papers and the like. A revision of the Recycling Promotion Law came into force in April 2004 for more promotion of the 3R (reduce, reuse, recycle) principle (METI). Under this law, manufacturers and importers of PCs have been required to set up a system for the collection and recovery of PCs used in business (since April 2001) and personal (since October 2003) (PC3R). Manufacturers can charge for the cost to recycle old PCs their customers, that is, both business and personal customer. Especially for the households, an advance disposal fee system was adopted (METI, 2010). That is, the recycling mark for PCs was sealed for products for households put in the market after October 2003 and with this mark, consumers are not required to pay additional costs when they pass old PCs to manufacturers (PC3R). Regarding the recycling fee, manufacturers set respectively for their products (PC3R). Each manufacturer who is a member of the PC3R Promotion Association introduced the recycling mark (PC3R). As of April 2009, the PC3R Promotion Association has 47 manufacturers producing PCs as their member and this number covers almost all major manufacturers producing PCs in Japan (PC3R). Regarding the products without the recycling mark, which consumers bought before September 2009, consumers are required to pay the recycling fee when they pass to manufacturers (PC3R).

Unlike the SHAR Law, the wording of the Recycling Promotion Law stipulates that producers collect and recover their products in voluntary basis (Tojo, 2004). To facilitate the collection of discarded PCs, the Japan Electronics and Information Technology Industries Association (JEITA) announced the voluntary action plan for the joint-collection system in January 2004 and manufacturers participated in this plan (Nikkei Ecology, April 2000). Regarding the collection and recycling rate for both office and personal PCs, each manufacturer is required to provide their data (METI, 2001). Meanwhile, the PC3R Promotion association provides data of integrated collection and recycling rate covering manufacturers participated in the PC3R Promotion Association every three months (PC3R).

5 Findings from the review of Nikkei Ecology and interviews

This section presents an analysis of measures taken by manufacturers for large home appliances covered by the SHAR Law and PCs covered by the Recycling Promotion Law. Firstly, the author provides the description of design change for the reduction of environmental impacts from the end-of-life management from the products mainly introduced by manufacturers, which is aggregated by the AEHA for large home appliances.

Secondly, the author describes the actual upstream measures taken by manufacturers as well as other measures mandated by/ envisioned in the EPR programme to date from the review of Nikkei Ecology and interviews with manufacturers, experts and policy makers. Other measures include the development of downstream infrastructure, the development of feedback mechanisms between downstream and the upstream and the like. As mentioned earlier, the rationale of the EPR programmes is to extend the responsibilities of manufacturers to the end-of-life management of their products in order to provide the manufacturers with incentives to take into account environmental impacts generated from the end-of-life management of their products. Therefore activities occurring downstream or between downstream and upstream are also discussed for further understandings of upstream changes. A methodological approach for the review of Nikkei Ecology and interviews are described in Chapter 3.

5.1 Design for Environment in general taken by Japanese manufacturers

When examining what manufacturers assess their products in relation to environmental impacts, three common areas can be identified, that is, 1) energy efficiency, 2) reduction of hazardous substances and 3) resource efficiency and recyclability. To evaluate environmental performance of products from different angles, each manufacturer uses the combination of different tools such as life cycle assessment (LCA), checklist, design guideline, recyclability assessment, environmental account and the like. Some manufacturers have their standards for green products within assessment areas mentioned above and increase the percentage of green products among their whole products. This could be categorized as Type 2 eco-label, that is, the self-declaration without an independent audit. However, these manufacturer's own standards take into consideration of existing and anticipated legislations, Type 1 eco-label criteria (label with independent audit and approval to seal), environmental performance of suppliers, superiority to competitors, access to information, company's own environmental policy and the like (Tojo, 2004). The contents of standards and the process of making decisions differ from company to company based on their own policy.

In addition to the product assessment conducted by respective manufacturers, AEHA published a product assessment manual. As Table 5 below, AEHA published the first edition in October 1991 and since then they have made revisions along with the development of national and international policies (AEHA, 2007).

Table 5: The assessment guidelines published by AEHA

	Publish	Focused problems by the electric home appliance industry	Features/changes	Relevant regulations
1st edition	October 1991	The problem of waste materials in electric home appliances	Focus on the reduce/recycling Integration of the material labeling of plastics	The Recycling Promotion Law (1991)
2nd edition	October 1994		In addition to the evaluation of each item, promote the general evaluation of products assessment Include the labeling of equipment using nickel cadmium battery	
3rd edition	March 2001	Environmental impacts from the whole life cycle of products	Support 3R Add evaluation criteria considering the life-cycle Promote the quantitative evaluation Describe the legal aspect of energy saving	The SHAR Law (2001) Top runner standards (1998)[2] The Recycling Promotion Law (2000) The Green Purchasing Law (2000) The WEEE Directive[3], the RoHS Directive [4](2003) The EuP Directive (2005) J-Moss (2006) REACH (2007)
4th edition	May 2006		Revise the checklist of product assessment Describe various design guidelines relevant to marking and labeling	

(Source: AEHA, 2007, translated by the author)

Manufacturers conduct the product assessment at different phases of product development such as design, prototype and mass production as their responsibility. This assessment guideline provides 14 evaluation criteria (See Table 6), which are further divided into 47 sub-criteria. Evaluation standards/methods are described for each criterion. By using this checklist, manufacturers can check improvements of their products with each point of each criterion as well as total points of new product with that of similar old product (AEHA, 2011)

[2] The Top Runner Program is the requirement imposed on manufactuerers to improve energy efficieny of their products (METI, 2010).

[3] The WEEE Directive (Directive 2002/96/EC) promotes the collection and recycling of EEE. With the collection scheme under the WEEE Directive, consumers return old products free of charge. The collection target is four kg per person (EC).

[4] The RoHS Directive (Directive 2002/95/EC) restricts the use of hazardous materials (heavy metal such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) in EEE (EC).

Table 6: 14 Evaluation criteria of product assessment guideline

No.	Evaluation criteria	Purpose
1	Weight/volume reduction	Reduce the consumption of resources Control the generation of waste materials
2	Usage of recycled materials and parts	Promote recycling of resources
3	Improvement of possibilities for reuse/recycling	Promotion of recycling/reuse by using recyclable materials
4	Promotion of durability	Utilise resources and reduce waste materials by improving the durability of products
5	Efficient collection/transportation	Efficient collection/transportation of old products
6	Ease of manual disassembly/separating process	Efficient reuse/recycling of old products
7	Ease of crush/classification process	Prevent damages for crushing machines from hard components, oil leak or magnet of discarded products Sort mixed materials after crushing
8	Packaging	Promote resource-efficiency and recycling of packaging materials Reduce environmental impacts by reducing weights and volume of packaging materials for transportation
9	Safety	Assure safety of work environment and reduce risks of burn from explosion and injury and the like
10	Environmental protection	Prohibit, reduce and manage the use of chemical substances regulated by law, industry's voluntary standards and the like.
11	Conservation of energy and resources during usage phase	Reduce/control electricity consumptions and green house gas emissions Reduce the use of consumable materials
12	Communication	Provide necessary information in appropriate manners
13	Reduction of environmental impacts from production phase	Reduce hazardous substances, waste materials, electricity consumptions during production phase
14	LCA	Evaluate life cycle environmental impacts of products quantitatively in advance and make changes at the design phase

(Source: AEHA, 2011, translated by the author)

Regarding energy efficiency, the result of LCA studies conducted with CO2 emissions as a proxy for total life cycle impacts are used to evaluate impacts of the life cycle. Especially large home appliances and PCs induce high CO2 emissions at the use phase and thus the energy saving can be connected to the consumer's direct economic interests. These factors urge manufacturers to improve energy efficiency for their products. Other promoting factors are the Kyoto Protocol to the UN Framework Convention on Climate Change, followed by a revision of a national legislation on energy efficiency. It is based on the so-called "top runner approach" which was included in the amendment of the Energy Conservation Law in 1998 (Tojo, 2004). Energy-saving labeling program was also introduced in August 2008 based on JIS (Japan Industrial Standard) along with the top runner approach to inform consumers the energy efficiency performance of products clearly. Additionally, from October 2006, the "Uniform Energy-Saving Label" that shows various information including the classification of energy-efficiency and the approximate amount of annual electricity bill has been started for air conditioners, TVs, refrigerators, electric toilet seat and fluorescent lumps. The Energy

Conservation Center Japan (ECCJ) informs data registered by manufacturers to retailers and consumers. For Energy Star, which is the international energy programme, ECCJ also registers products and provides information to the public (ECCJ).

5.1.1 Management of chemical substances

Regarding the chemical substances used in products, regulations restrict the use of specific hazardous substances. The "Act on Evaluation of Chemical Substances and Regulation of Their Manufacture, etc."[5] (in short, CSCL (Chemical Substances Control Law, entered into force in 1974, amended in 2003 and 2009) and the "Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof[6]" (in short, PRTR (Law concerning Pollutant Release and Transfer Register), entered into force in April 2001, amended in November 2008) have urged manufacturers to manage chemical usage of their products (METI).

The Recycling Promotion Law was amendment in March 2006 (put into force on 1st July 2006) and manufacturers and importers are obligated to provide the information of the use of chemical and label so-called "content label" showing its content on the product, packaging and catalogues if seven products specified by the law (TV sets, refrigerators, wash machines, drying machines, air conditioners, microwaves and PCs) contain the following six substances; lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyl, polybrominated diphenyl ether (AEHA, 2010). This label is based on the JIS C 0950 which is a Japanese Industrial Standard titled "The marking for presence of the specific chemical substances for electrical and electronic equipment", often referred to as J-Moss, it can be regarded as Japanese RoHS (JEITA, 2011). The JIS C 0950 was originally issued in 2005 and revised in January 2008 (JEITA, 2011).

In addition to the "content label", the J-Moss Green mark was introduced for the same specific product groups and chemical substances. This green mark can be labeled if the use of six chemical substances is less than standards. The guideline for this green mark was issued by the three industry association; JEITA (Japan Electronics and Information Technology Industries Association), JEMA (Japan Electrical Manufacturers' Association) and JRAIA (Japan Refrigeration and Air Conditioning Industry Association) in January 2008 (JEITA). Manufacturers of large electric home appliances are working on the management of chemical content of their products by cooperating with each other on their supply chain management and providing information on their websites (AEHA, 2011).

In addition to these regulations, international regulations such as the RoHS Directive and REACH also influenced on the chemical management and whole supply chain. To support the chemical management of the products, the Joint Article Management Promotion-consortium (JAMP) was established in September 2006 by more than 15 companies and as of August 2011 JAMP has 387 member companies(JAMP).

5.1.2 Resource efficiency to promote 3R (Reduce, Reuse, Recycle)

Main areas included in the 3R could be weight/volume reductions, improvement of durability of products, ease of manual disassembly process, improvement of packaging reduction,

[5] This translation was found at the web page of METI about chemical management (METI).

[6] This translation was found at the web page of METI about chemical management ((METI).

utilization of recycled materials. These were also aforementioned in the evaluation criteria for products assessment provided by AEHA (See Table 6).

Especially for the ease of disassembly, manufacturers have been working on the marking and labeling of materials used in their products. AEHA provides the guideline called " Marking on Products and Labeling on Packaging Materials" for recyclers as well as manufacturers to improve the design for disassembly (AEHA, 2007). This guideline provides the information on plastics, marking symbols and abbreviations specified in JIS, and marking methods including the size and location. This guideline also covers the use of recycled plastics and plastics, which do not include flame retardant materials. Recycling marks are also introduced for more efficient recycling and manual disassembly, for instance, a mark indicate that metal was inserted into plastics, hole puncture location and direction of compressor's refrigerant enclosing pipe. To establish these recycling marks, AEHA did a questionnaire for 16 recycling plants of home appliances and took into account requests from those recycling plants (AEHA, 2007). The aforementioned "content mark" and "green mark" as the labeling of the chemical management can be also utilized for the disassembly of the products (AEHA, 2007).

Regarding the package, "Guideline of electric appliances industry relevant to containers and packaging identification labeling etc – 2nd Edition – " was issued by the container packaging recycle law expert committee of AEHA in April 2005, cooperating with the packaging committee of the Japan Electrical Manufacturer's Association (JEMA) and the packaging technology small committee within the Japan Business Machine and Information System Industries Association (JBMIA) (AEHA, 2007).

5.1.3 Information sharing of improvements on products

To provide the information of product assessments manufacturers have performed, the AEHA issued the document of "Case Examples of Products Assessment of Electric Home Appliances – Toward Environmentally Conscious Products –" in March 1997. This document describes examples of implementation of product assessment provided by AEHA and design change for respective manufacturer's products. Additionally, AEHA has been introducing these examples of product assessment on their website since October 2002 (AEHA, 2007).

5.1.4 International standardization

The International Electrotechnical Commission (IEC) founded the committees so called "TC 111" for the environmental standardization for electrical and electronic products and systems in October 2004. Under the TC 111, there are three working groups about 1) material declaration for EEE, 2) test methods of hazardous substances and 3) GHG. Additionally, there are four project teams, three ad-hoc Groups and one validation team (IEC). To deal with these topics in Japan, a national committee was founded in JEITA in March 2005 and for WG2, JEMA takes charge as a secretariat (AEHA, 2007). At the WG2 in TC111, Japanese proposal about the creation of environmentally conscious design standard was accepted in May 2005 and this work is still in the process (AEHA, 2007).

The EuP Directive (Directive for a framework for the setting of ecodesign requirements for Energy-using Products) was enacted on 22 July 2005 and came into force on 11 August 2005. The EuP Directive takes into account IPP (Integrated Product Policy) for the legislation of DfE (AEHA, 2007). IPP is the main EU strategy developed by the European Commission

focusing on the life cycle performance of products (Dalhammar, 2007)[7]. The EuP Directive covers products, which use, generate, transfer or measure energy (electricity, gas, fossil fuel), such as boilers, computers, televisions, transformers, industrial fans, industrial furnaces etc (EC). For other energy related products (ErPs) which do not use energy but have an impact on energy and can therefore contribute to saving energy, such as windows, insulation material, shower heads, taps etc. were also covered from 2009 (EC). Manufacturers in Japan work with Japan Business Council in Europe for following up discussions in EC.

5.2 Factors influencing measures related to design change for end-of-life

This section analyses the different factors influencing the manufacturers' undertaking of the measures discussed in the previous section and discusses how/to what extent manufacturers have worked on design change of their products before and after of the amendment of EPR programmes.

To analyse this, the selected articles from the Nikkei Ecology (2000-2010) was reviewed as the primary data. To get additional insights, open-ended interviews with manufacturers are conducted. Additionally, interviews with experts and policy makers are utilized to triangulate the information attained from interviews with manufacturers.

As aforementioned at methodology, the author selected the articles written about the design change of products covered by EPR programmes, that is, TV sets (including CRT, LCD and plasma TV), air conditioners, washing/drying machines, refrigerators/freezers and PCs. The types of design change reviewed were energy efficiency, 3R designs and reduction of hazardous substances. 3R designs including the reduction of weights and size, resource efficiency, longevity, recyclability, ease of disassembly, new materials for resource efficiency such as plant-based plastics and the like.

The author subsequently categorised them according to the reasons why design change were induced. The number of articles which did not write about the reason for design change for the new products were counted as well This is to see to what extent the governmental intervention influenced on the design changes from the articles. Some articles in the Nikkei Ecology are relatively small and these articles tend to describe only about the new functions such as the energy consumption per hour and the reduction of specific hazardous substances without any reason. The author counted these articles and thus the number of articles without stated reasons sometimes represent higher portion of the total articles.

In the following section, the author firstly shows the article about design changes with or without stated reason in the areas of the 3R, reduction of hazardous substances and energy efficiency.

Secondly, the author provides the graph showing what governmental regulations and other reasons influenced on the design for the 3R and reduction of hazardous substances. The factors of the design for energy efficiency were not examined since the energy efficiency is not the primary intended purpose of the EPR programmes.

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[7] IPP is still under development and it could fade away since there are critiques that the Commission's IPP can be applyed to a varying extent and thus different European countries are in different stages. Further, EU does not have the most advanced IPP strategy and it would be hard to develope IPP in Europé (Dalhammar, 2007). For more insights about IPP, see Dalhammar (2007). An Emerging Product Approach in Environmental Law. pp. 60-69.

There are articles that contain description of several design changes and factors inducing design change. The author counted all these design changes and factors separately and thus a figure of "the number of total articles" and a sum of figures of respective design changes are not equal. Likewise, there are differences between a figure of "with stated reason" and a sum of figures "the factor inducing design change" for each design change since some design changes are attributed by several reasons.

Each graph provides the comparison between 2000-2005 and 2006-2010 since discussions of the amendment of the SHAR Law started in 2006 by MoE and METI (Ecology, 2006b). Thus whether design change has taken care continuously even after the amendment of the EPR programmes could be examined.

The author describes from graphs of four large appliances and PCs and subsequently a graph of TV sets, air conditioners, washing/drying machines, refrigerators are respectively.

5.2.1 Four large home appliances and PCs

This section shows findings about four large home appliances and PCs from the review of Nikkei Ecology.

Figure 6: The number of articles about design change for areas of 3R, reduction of hazardous substances, energy efficiencies for large home appliances and PCs with or without stated reasons (2000-2005: 157 articles, 2006-2010: 99 articles)

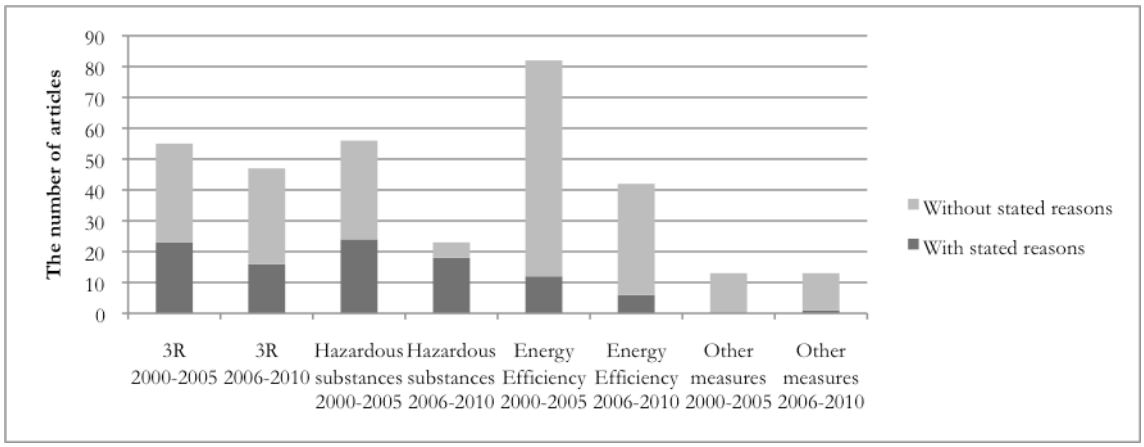


Figure 7: Government interventions and other stated reasons inducing design change for 3R

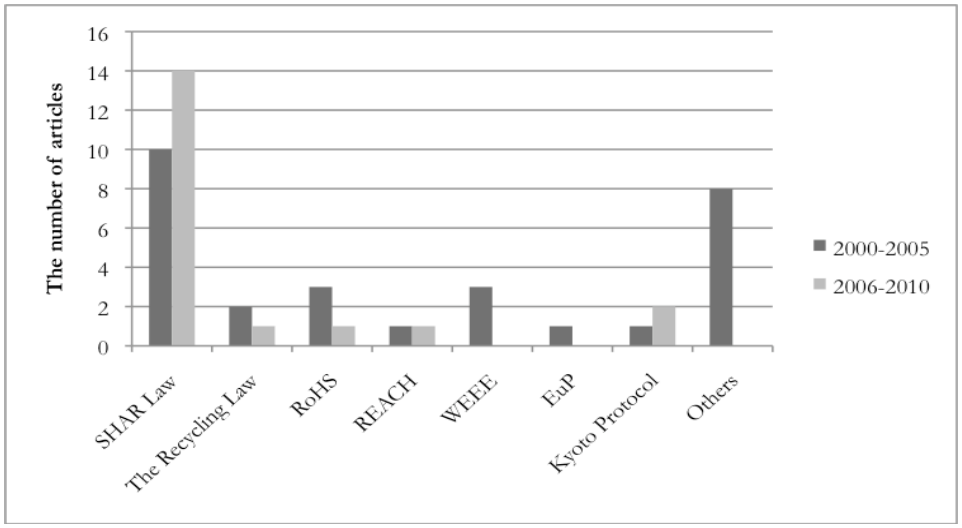
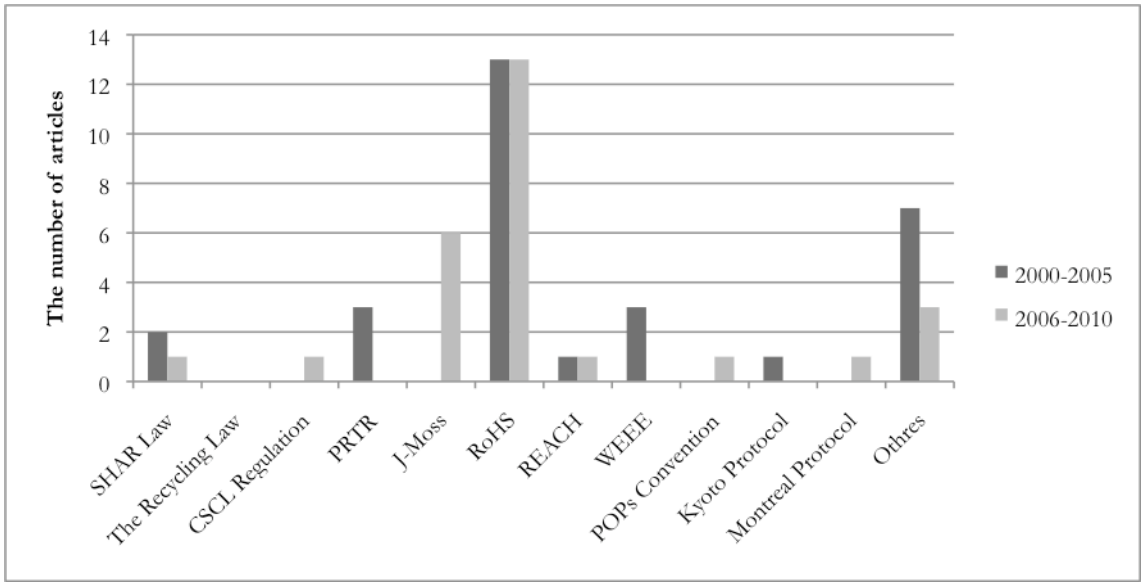


Figure 8: Government interventions and other stated reasons inducing design change for reduction of hazardous substances



As found in Figure 6, the total number of articles decreased after 2006 in all areas of design change. Also the percentage of the number of articles with stated reason is less than half except the design change for the reduction of hazardous substances. However, concerning design change for 3R and reduction of hazardous substances, percentages of the number of articles with stated reason are slightly less than half. Therefore, stated reasons attained from articles could be regarded as the influencing factor of design change for at least 3R and reduction of hazardous substances.

Concerning governmental intervention and other factors inducing design change, EPR programmes influenced design changes related to 3R. It is quite clear with the high number of articles. For the reduction of hazardous substances, the RoHS Directive was the highest as an influencing factor among other governmental intervention including national regulations such as the CSCL regulation and PRTR.

Other stated factors include company's own environmental management, for instance, including environmental product assessment in their ISO14001 and promoting the improvement of DfE as a whole company's strategy. Green purchasing, manufactures' own green label (Type II), CSR and manufacturer's action plans are also included. For the tool of product assessment used for improvement of product design, LCA, Factor X[8] and manufacture's own products assessment and the like were used.

Although the number of articles about energy efficiency is the highest among three areas, strong reasons for change could not be found. Nevertheless, one of noticeable stated reason is the top runner programme based on the Energy Conservation Law. In addition to the top runner programme, design for energy efficiency is quite effective to appeal to consumers how manufacturers are working on the environmental matters. Especially, with the "Uniform Energy-Saving Label", consumers can easily see how they can save the money and this also contributes on the acceleration of design change for the energy efficiency.

Among design change for 3R, it was interesting to note that many changes took place around 2000-2001 influenced by the SHAR Law. For instance, Mitsubishi reduced the kinds of plastics used for their products to one over thirty, from 300 to 9, to deal with the SHAL Law(Nikkei Ecology, 2000d). Manufacturers also select and reduce the number of suppliers producing components of products for the environmental management of whole supply chain around 2002 (Nikkei Ecology, 2002a). Regarding the communication between designers and recycling plants, Matsushita started to have a feedback system by making product designers have experiences of recycling at their plant in 2001 to improve the recyclability of products (Nikkei Ecology, 2001b). Each manufacture has developed technologies of recycling (including recycling of CFCs) and established a code of conduct for their suppliers and standard for green purchasing since the SHAR Law came into force.

Meanwhile, regarding the reduction of hazardous substances, manufacturers started chemical management around 2000 and for instance, Matsushita declared to abolish solder that contains lead till 2002 (Nikkei Ecology, 2000e). Each manufacturer has constructed a supply chain management for chemical use to deal with especially the RoHS Directive and REACH and some manufacturers sell tools useful for supply chain management.

5.2.2 TV sets (CRT, LCD and plasma TV)

This section describes findings from the review of Nikkei Ecology about TV sets.

[8] Some manufacturers established their own factor X that manufacturers developed Factor 4 or 10 approaches as their environmental management strategy.

Figure 9: The number of articles about design change for areas of 3R, reduction of hazardous substances, energy efficiencies for TV sets with or without stated reasons (2000-2005: 30 articles, 2006-2010: 29 articles)

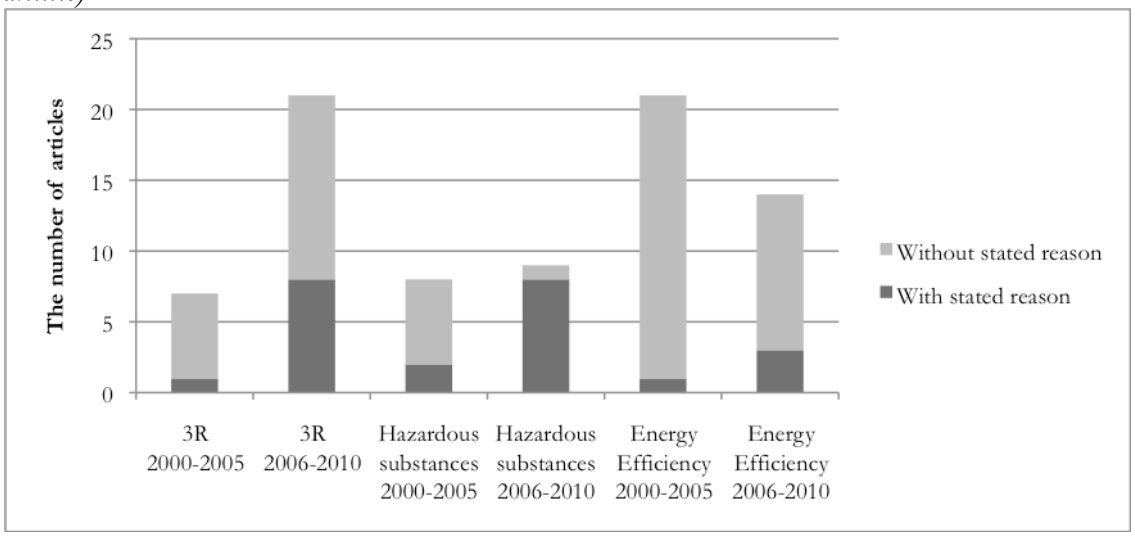


Figure 10: Government interventions and other stated reasons inducing design change for 3R

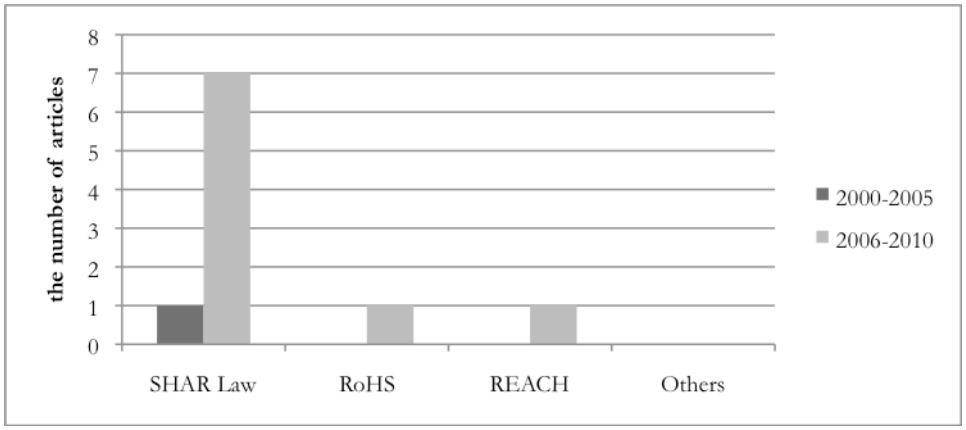


Figure 11: Government interventions and other stated reasons inducing design change for reduction of hazardous substances

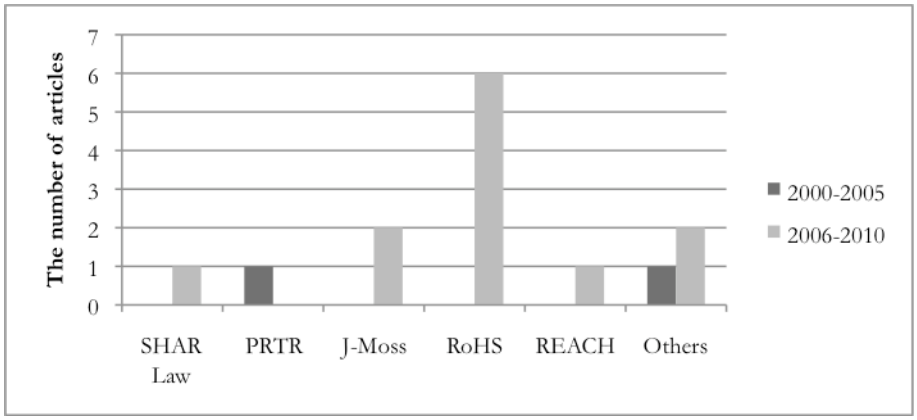


Figure 9 indicates the design changes related to TV sets. Although the total number of articles is bit reduced, the number of articles of the design for 3R and reduction of hazardous substances is increased. Though the number of articles with stated reasons for design change

is low except for design for reduction of hazardous substances, the number of articles with stated reasons is increased after 2006 in all design categories. Figure 10 indicates that among the reasons of design change for 3R, it could be said that the SHAR Law influenced on design change mainly from 2006. Regarding design changes for reduction of the hazardous substances, Figure 11 indicates that the PRTR influenced before 2005, and after 2006, in addition to the RoHS Directive, the SHAR Law, J-Moss and REACH influenced the design change for the reduction of hazardous substances. Regarding "Others" of stated reasons, manufacturer's voluntary action plan and requirements of information disclosure from NGOs were mentioned.

Figure 9 indicates that design changes for energy efficiencies also share substantial design change of TV sets. The main sated reason of these design change found in Nikkei Ecology is the top runner programme based on the Energy Conservation Law. Voluntary actions such as ISO14001 and the Energy Star[9] also affected the design changes to improve the energy efficiency.

Regarding the reduction of hazardous substances, since 2005, the restriction of hazardous substances have become more stringent because of the RoHS Directives and REACH and thus manufacturers are required to manage chemical usage on their products from whole supply chain. For example, some manufacturers stopped using lead for plasma display panel of plasma TV sets in 2006 since there was a fear that the RoHS Directive would restrict them (Nikkei Ecology, 2007a). In the end, the usage of lead for plasma display panel was exempted from the RoHS Directive, however, manufacturer had worked on since the early 2000 because the European market is quite important for Japanese manufacturers. In terms of reduction of hazardous substances, from around 2000, manufacturers started to reduce the use of halogenated flame retardants for a printed-circuit board to avoid the emission of dioxin when they are incinerated (Nikkei Ecology, 2000b). Also from around 2000, halogen free, which means not including chlorine and bromine, design was also started with the incentives from their environmental management system based on ISO14001 and PRTR (Nikkei Ecology, 2000c). The vinyl chloride has also been considered to be reduced/abolished, however, it is difficult to find alternatives and thus the attitude differ depended on respective manufacturers (Nikkei Ecology, 2009a).

Meanwhile, regarding 3R design, manufacturers have worked on the reduction of weights/size, longevity, ease of disassembly and recyclability continuously. Because the market of LCD TV sets has been getting bigger since the early 2000, efforts to make them thinner, lighter were continued as well. Organic electroluminescence started to be used from around 2004 to improve both resource efficiency and energy efficiency. Since LCD and plasma TV sets was added to the object of SHAR Law in April 2009 and it could be anticipated that the reuse/recycling rate will be higher, manufacturers started to recycle materials from collected flat TV sets and also work on the "closed material recycling", that is, to reuse collected plastics from old products as a part of their own new products (Nikkei Ecology, 2009b). And manufacturers have expanded the use of PP (polypropylene) by developing technologies such as the selection useful plastics from mixed plastics and improve the strength of PP (Nikkei Ecology, 2010). Additionally, some manufacturers started to develop the recycling technology for collecting rare metal from liquid crystal panel in 2009 and they are working for the practical use (Nikkei Ecology, 2009b).

[9] Energy Star is a joint programme of the US Environmental Protection Agency and the US Department of Energy for labeling energy efficient products and practices (DOE and EPA).

5.2.3 Air Conditioners

This section describes findings from the review of Nikkei Ecology about air conditioners.

Figure 12: The number of articles about design change for areas of 3R, reduction of hazardous substances, energy efficiencies for air conditioners with or without stated reasons (2000-2005: 27 articles, 2006-2010: 16 articles)

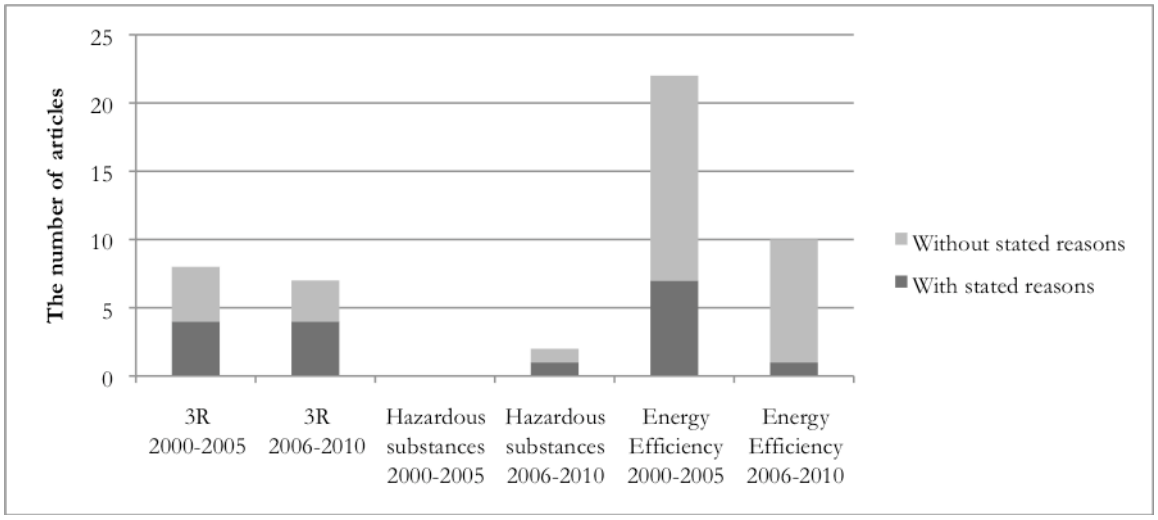


Figure 13: Government interventions and other stated reasons inducing design change for 3R

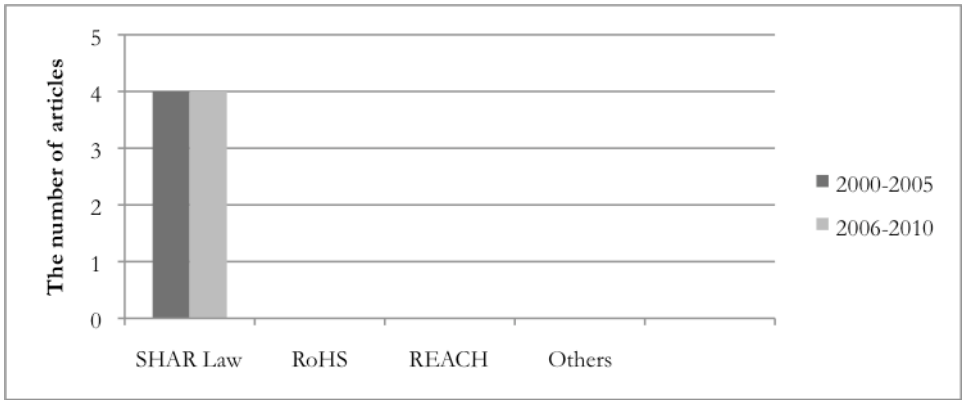


Figure 14: Government interventions and other stated reasons inducing design change for reduction of hazardous substances

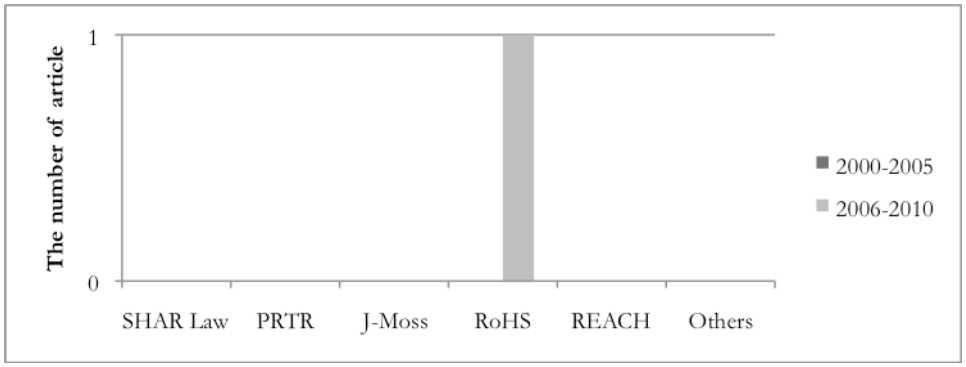


Figure 12 indicates the design changes related to air conditioners. For the air conditioners, the number of articles itself reduced from 2000-2005 to 2006-2010. In total, articles about design change of energy efficiency were mostly found. The number of articles about the 3R and energy efficiency decreased. However, percentages of the number of articles with stated reason about 3R and reduction of hazardous substances are almost half, while a percentage of the number of article about energy efficiency is low. The only stated reason found in articles in design change for 3R was only the SHAR law. Similarly, the only stated reason found in articles in design changes for reduction of hazardous substances was only the RoHS Directive. Especially for the 3R design, material recycling such as recycling old plastics has been performed since around 2004 and some manufacturers have already started "closed-loop material recycling" since then (Nikkei Ecology, 2004b). Another unique design change is that the system of self-cleaning/ease of cleaning of a filter to increase energy efficiency and longevity.

Regarding design for energy efficiency, stated reasons for design change were the top runner approach based on the Energy Conservation Law, CSR, LCA and manufacturer's own Factor X[10]. An article found Nikkei Ecology mentioned that the amended Energy Conservation Law made manufacturers stop producing the cheap, energy inefficient air conditioner since they might fail to achieve the target required by the law (Nikkei Ecology, 2000a).

5.2.4 Washing machines and drying machines

This section describes findings from the review of Nikkei Ecology for washing/drying machines.

Figure 15: The number of articles about design change for areas of 3R, reduction of hazardous substances, energy efficiencies for washing/drying machines with or without stated reasons (2000-2005: 15 articles, 2006-2010: 20 articles)

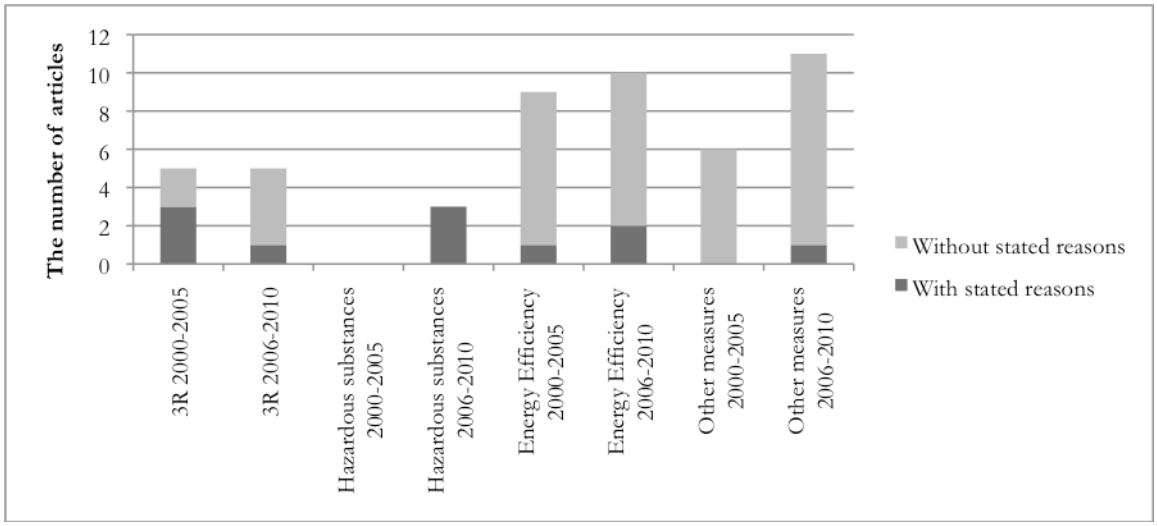


Figure 16: Government interventions and other stated reasons inducing design change for 3R

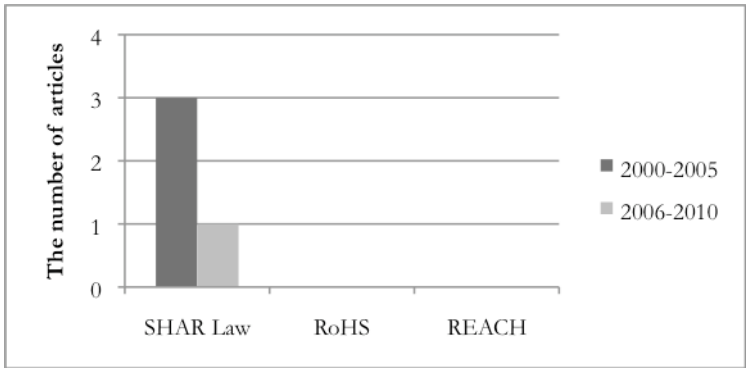


Figure 17: Government interventions and other stated reasons inducing design change for reduction of hazardous substances

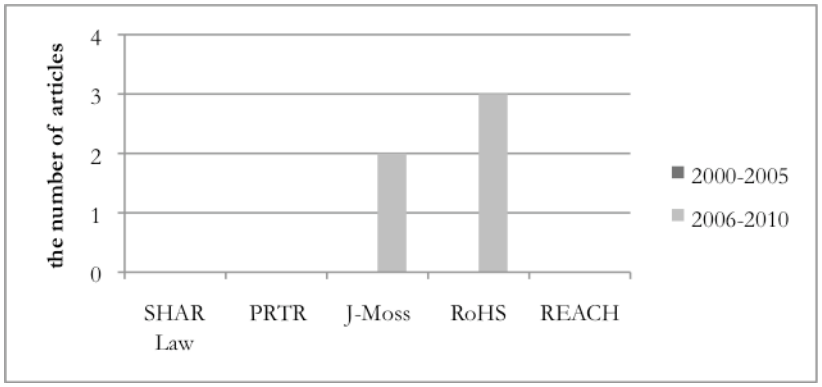


Figure 15 indicates that design change related to washing/drying machines and the number of articles itself is increased after 2005. The number of articles about design change of energy efficiency is higher than 3R and reduction of hazardous substances. However, for the design of 3R and reduction of hazardous substances, percentages of articles with stated reasons are relatively high for the 3R and reduction of hazardous substances except the 3R design change from 2006 and reduction of hazardous substances till 2005. Although the number of articles with stated reasons for 3R was decreased after 2006, stated reasons for 3R design were only the SHAR Law (Figure 16). For reduction of the hazardous substances, stated reasons are J-Moss and the RoHS Directive (Figure 17).

A main other stated reasons for design change was water saving, but also include demands from consumers, manufacturer's own concept for their products and the cooperation with other companies to develop their technologies.

Design for water saving seems to be a main driving force for manufacturers because of washing machines use much water for cleaning. Other design improvements found in Nikkei Ecology include noise reduction and reduction of use of detergents. One example of design change for energy efficiency, manufacturers adopted a heat pump for the drying system instead of a heater to increase energy efficiency in 2006 (Ecology, 2006a). Notably, because a drying function is added to washing machines, the weight of washing machines increased and manufacturers are working for the reduction of the weight of washing/drying machines. Similarly to other products, manufacturers have been worked for the closed material recycling.

5.2.5 Refrigerators and freezers

This section describes findings from the review of Nikkei Ecology for refrigerators and freezers.

*Figure 18: The number of articles about design change for areas of 3*R*, reduction of hazardous substances, energy efficiencies for refrigerators/freezers with or without stated reasons (2000-2005: 30 articles, 2006-2010: 12 articles)*

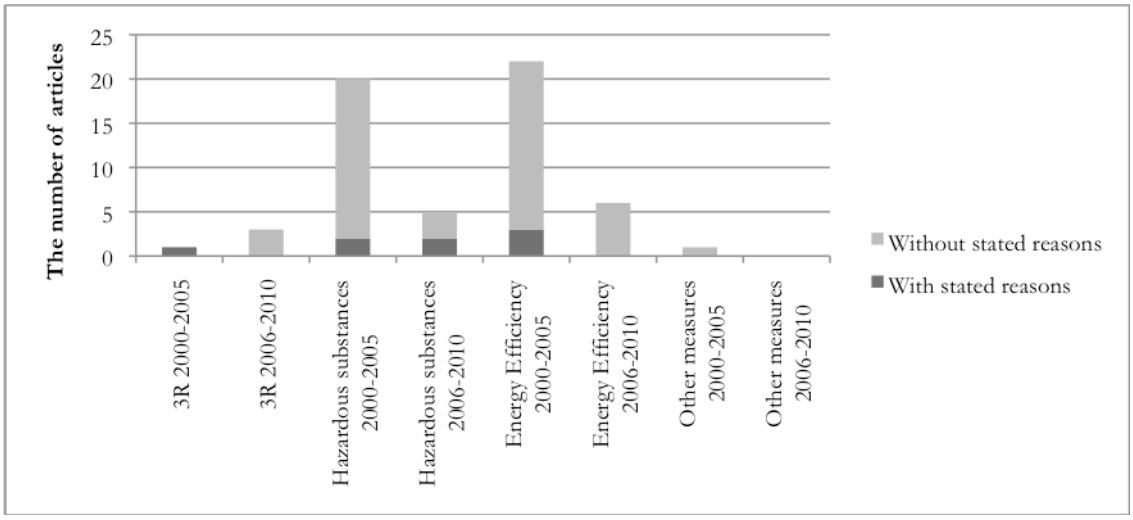


*Figure 19: Government interventions and other stated reasons inducing design change for 3*R

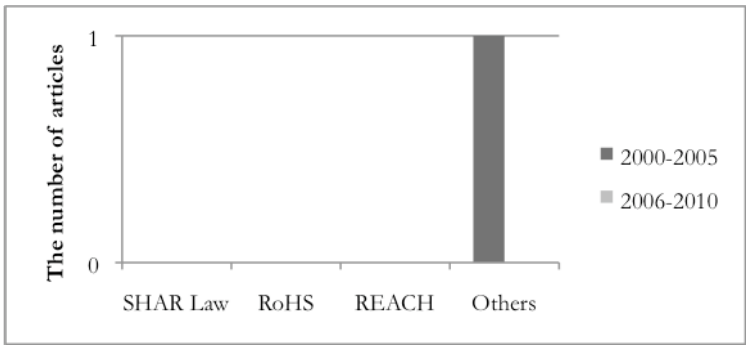


Figure 20: Government interventions and other stated reasons inducing design change for reduction of hazardous substances

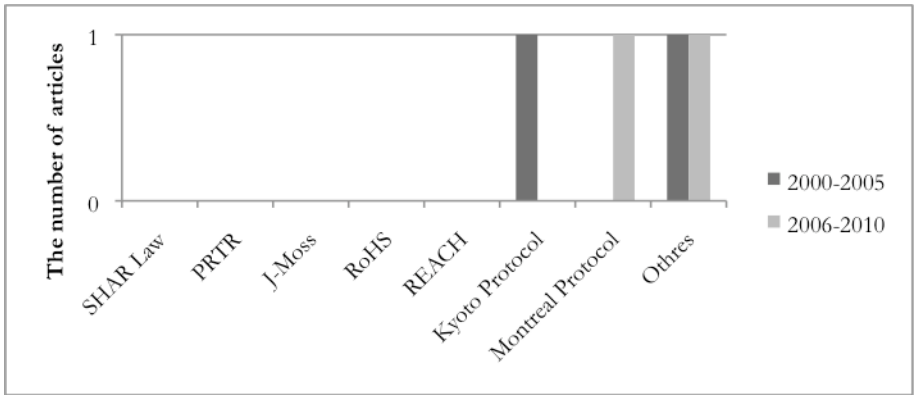


Figure 18 indicates that design change related to refrigerators/freezers and the total number of articles about design change significantly decreased after 2006. Among three areas of design change, the number of articles about design change for hazardous substances and energy efficiency especially till 2005 is high while the number of articles about design for 3R is a few. Another type of design change found in Nikkei Ecology is to increase storage spaces of refrigerators due to consumer's needs. Considering the percentage of articles with stated reasons for each design change, the number is quite small and it would be difficult to interrelate design change for 3R/the reduction of hazardous substances and the SHAR Law (Figure 19). However, manufacturers actually improved design change before the SHAR Law obligated manufacturers to collect and handle CFCs used as insulation agents in 2004. That is, manufacturers started to deal with CFCs before 2004. In addition to insulations, manufacturers already released the CFCs-free refrigerators, for instance, by using isobutene (R600a) as a cooling medium at least in 2002 (Nikkei Ecology, 2004a).

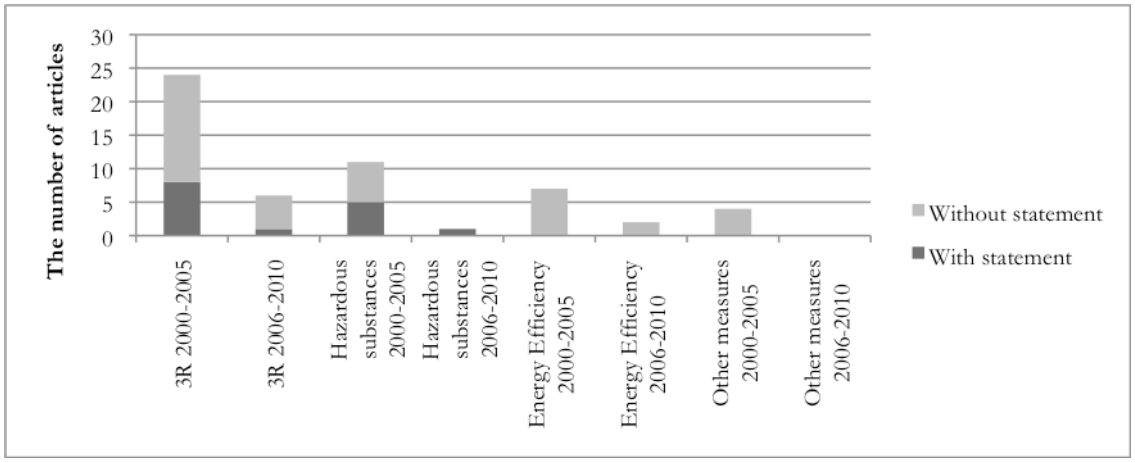
Meanwhile, Figure 20 shows that for design of reduction of hazardous substances, international conventions such as the Kyoto Protocol and the Montreal Protocols[11] mainly influenced design change. The Kyoto Protocol also influenced the abolition of the HFC from the refrigerator since the HFC are regarded as the greenhouse gases (Nikkei Ecology, January 2003). Not only governmental interventions such as the Kyoto protocol and the Montreal Protocol, actions from NGOs to reduce hazardous substances especially for HFC was also found in articles (Nikkei Ecology, 2007c). In addition to CFCs, manufacturers have worked for the reduction/abolition of vinyl chloride, lead and the like.

Regarding design change for 3R, for instance, the miniaturization of compressors, closed material recycling and the like have been conducted by manufacturers as well. Concerning stated reasons for design changes for 3R found in Nikkei Ecology, LCA was also a reason for the downsizing of refrigerator.

5.2.6 PCs

This section describes findings from the review of Nikkei Ecology for PCs.

Figure 21: The number of articles about design change for areas of 3R, reduction of hazardous substances, energy efficiencies for PCs with or without stated reasons (2000-2005: 30 articles, 2006-2010: 6 articles)



[11] The Montreal Protocol on substances that Deplete the Ozone Layer is the international agreement stipulates that the production and consumption of compounds that deplete ozone in the stratosphere – chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform – are to be phased out (UNEP).

*Figure 22: Government interventions and other stated reasons inducing design change for 3*R

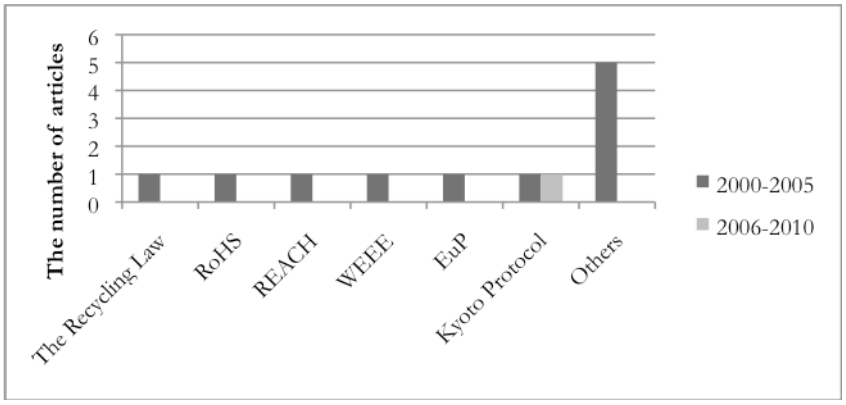


Figure 23: Government interventions and other stated reasons inducing design change for the reduction of hazardous substances

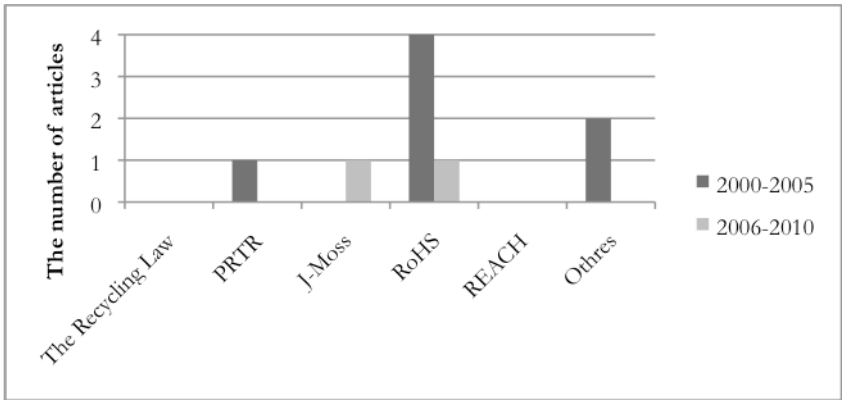


Figure 21 indicated design change related to PCs. The number of articles decreased after 2006. One explanation for this decrease could be that the EPR procramme for PC was started in 2003 and thus between 2000 and 2005 manufacturers worked on design change harder especially for design for 3R and reduction of hazardous substances.

Considering 3R designs, stated reasons found in Nikkei Ecology include the Recycling Law which is the base of the EPR programme for PC, the RoHS Directive, the EuP Directive Directive, REACH and the Kyoto Protocol (Figure 22). Other stated reasons about design change for 3R founded in Nikkei Ecology include establishment of a feedback system between recycling plants, manufacturer's own product assessment manual and manufacturer's own eco label (Type II). Other designs for 3R founded in Nikkei Ecology include reduction of the weight and size of PCs, improvement of longevity, resource efficiency, disassembly, recyclability, use of plant-derived plastics and reuse of old PCs. Among design for 3R, use of plant-derived plastics has been increased mainly since around 2005 in practical use.

Regarding the reduction of hazardous substances, stated reasons were PRTR, J-Moss and the RoHS Directive (Figure 23). Especially the influence of the RoHS Directive seems to be larger than national regulations in terms of the number of articles. Other stated reasons are the manufacturer's own assessment manual and product differentiation in the markets. Manufacturers also started the management of chemical use of their products by making database and abolished one of halogenated materials from around 2000-2001 and they started to stop using the lead for components of PC at least in 2003 to implement requirements in the RoHS Directive prior to the enforcement (Nikkei Ecology, 2000b, 2001a, 2003c).

Manufacturers also started to unite the standard for miniaturized fuel cells and seek to diffuse those use in PCs and mobile phones (Nikkei Ecology, 2003d). The Green Purchasing Law also influenced on the improvement of green products since this law induce the demand of the green products (MoE, 2011). Additionally, manufacturer's environmental strategies such as ISO14001 influenced the improvement of design change for their products.

Other design changes found in Nikkei Ecology include the development of nanotechnologies for devices. These technologies appeared to have various possibilities such as super energy efficiency and resource efficiency and manufacturers have worked for researches at least since 2000 (Nikkei Ecology, 2002b). Additionally, another interesting system, which is not included in graphs, is that some manufacturers started to reuse the components of discarded PCs for the repair of PCs. The market of secondhand PCs is growing and some manufacturers started refurbish old PCs and sell them as secondhand PC to retailers, or sometimes manufactures sell these refurbished PCs themselves(Nikkei Ecology, 2003b). NEC started the business to sell refurbished old PCs that they buy back from consumers in 2003. They started to establish this business in 2002 since the EPR programme for PC was to be started from 2003 (Nikkei Ecology, 2005b). To promote the reuse of PC, the REITA (Refurbished (Reuse) & Recycle Information Technology Equipment Association) was founded in 2006 and they are working on the promotion of the market of secondhand PCs and established guidelines for secondhand PCs (Nikkei Ecology, 2006c; REITA, 2011). It is interesting that in addition to the design changes of new products, the improvement of secondhand products was derived from the EPR programmes.

5.3 Findings from interviews

In addition to the review of articles, interviews with manufacturers policy makers and experts were conducted to gain insights and for the triangulation of written information. A summary of interviews is provided in this section. All the information in this section was attained from interviews.

5.3.1 Overview of the progress of DfE for large home appliances and PCs

Regarding the progress of overall DfE by manufacturers, all interviewed manufacturers mentioned that they did make effort more than requirements from regulations including EPR programmes. Actually, experts also mentioned that major manufacturers in Japan have already finished to develop DfE to some extent and they are waiting the proper timing for further development. Additionally, from the policy makers' point of view, the progress of DfE was not regarded as problem during the discussion of the amendment of the SHAR Law.

All the interviewed manufacturers have been making efforts and some manufacturers already have started since 1998-9. Most manufacturers are using their own products assessments, which are utilised the guideline published by AEHA. All the interviewed manufacturers have their own symbol for green products and they are making efforts to increase the percentage of these green products among their products. Some manufacturers include the product assessment in their environmental management system based on ISO14001 and work on as their environmental management policy. As a tool to assess a product, all manufacturers conduct LCA when they design a new product. An expert mentioned that manufacturer's concerns of DfE have been increased since the ISO 14040, which describes the principles and framework for LCA and then the life cycle thinking became an important concern for a

product's competition at the market. Factor X is also used as a tool, but currently it is difficult to use as the promotion tool since it is too complicated for consumers.

A manufacturer describes the process of the development of DfE activities as follows. The first step was the assessment of products by making a products assessment manual and calculating theoretical recycling potentials, the second step was the utilization of data at recycling plants and making a guideline for design change from actual experiences at recycling plants, the third step was the utilization of LCA, Design for Disassembly (DfD) and the closed-loop recycling system including the use of recycled materials from products to products. According to a manufacture, considering three areas of design improvements discussed in this thesis, that is, design for 3R, reduction of hazardous substances and energy efficiency, first step was 3R to increase recyclability, second step was reduction of hazardous substances and third step was energy efficiency. Although design for energy efficiency mainly focused at third step, improvement of energy efficiency has been constantly developed during the first and second step.

Among the DfE, there are a trade offs and all manufactures have some sorts of dilemma. For instance, if manufactures want to increase energy efficiency of air conditioners, one method is to make a heat exchanger bigger. This is the retrogression from the point of view of resource efficiency. Moreover, when manufacturers put new functions to meet consumer's demands, for instance a drying function into washing machines, the size/weight may increase. In addition to these cases of trade off, problems of the cost and the assurance of the quality of recycled plastics and the like disturb the progress of DfE. All manufacturers mentioned that consumers do not always demand green products and it is difficult to match demand and supply. Further more, it is difficult to appeal consumers about DfE of products, especially for 3R and hazardous substances since it does not directly connect to the consumer's benefit; it is different from design for energy efficiency what can reduce electricity costs at each household. However, the eco point system[12] increased consumer's consciousness towards green products and with this system these products sold well. Some manufacturers and experts anticipate that DfE products would occupy the market and there would be no choice but DfE products for consumers in the near future. The Green Purchasing Law also influenced the sales of DfE products and that leads to manufacturer's incentives for improvement of DfE. However, it worth noting that a policy makers pointed out that manufacturers spent a large amount of cost for R&D for development of design change instead of decreasing recycling fee.

5.3.2 Design change for 3R and the reduction of hazardous substances

Though manufacturers have dilemma with consumer's demands, governmental interventions make them work on promoting other design changes, which are not directly connected to the consumer's benefit.

Regarding 3R design, some experts mentioned that recyclability has already developed quite well by now and it seems there is no need to improve more since there are not enough receivers of these recycled materials, moreover, it would be better to recycle by unit. As the driving force of 3R design, Japanese 3R laws, not only the SHAR Law, influenced manufacturers. For instance, a manufacturer founded their own recycling plant and started the

[12] The eco points system is a programme to increase demands of "green home appliances" by giving eco points which can be changed as products/services to consumers. For more details, Matsumoto, Numata, Tasaki and Tojo published a report in 2010 (Matsumoto, Numata, Tasaki, Tojo, 2010).

communication between upstream and down stream since they anticipated a regulation for recycling from the Recycling Promotion Law. The requirements based on the SHAR Laws strictly band manufacturers to increase reuse/recycling rate and all the interviewed manufacturers have confidences that they are doing more than that the law requires.

Regarding the reduction of hazardous substances, an expert mentioned that almost all manufacturers achieved requirements by the RoHS Directive and REACH and an expert mentioned that matters of security for working environment would be more important for manufacturers. The SHAR Law also contributed to the collection of CFC and a policy maker mentioned that is one of successful things of the SHAR Law. All the interviewed manufacturers mentioned that the reduction of hazardous substances was the "must" thing for manufacturers since J-Moss and the RoHS Directive restricted use of hazardous substances. To achieve the management of the hazardous substances, manufacturers established a management system overarching supply chain since manufacturers outsource the production of components to components manufacturers.

5.3.3 Communication between upstream and downstream

All the interviewed manufactures mentioned that they are communicating well with recyclers in several ways. For instance, most manufacturers make designers of products take practical trainings at recycling plants. Among group A, which was described at Section 4.1.6, representatives of respective manufacturers gathered and make an annual action plan and guidelines for disassembly, including a targeting time for disassembly of old products based on actual practices. Meanwhile, among group B, which was described at Section 4.1.6, manufacturers have established their own recycling plant respectively and effected on the improvement of design change for their products. Further, some manufacturers founded a recycling plant near from a production plant to enhance communication between designers and recyclers/dismantlers. Some manufacturers mentioned that it is difficult to anticipate effects of the present design since large home appliances would be discarded 10-15 years later after consumer purchased. However, they are making efforts to improve the disassembly.

The positive change induced by the SHAR Law is that since recycle plants have lines for each product group and thus feedback on design change is more effective. Comparing to the WEEE Directive, focusing on only four products by the SHAR Law makes manufacturers disassemble more carefully. An expert mentioned that the SHAR Law significantly contributed to the establishment of the recycling system of group A and B, and it can be evaluated that the SHAR Law made a framework for the recycling system in Japan based on the common rule.

5.3.4 Anticipation of the amendment of the EPR programme

Regarding the reuse/recycling rate, all manufacturers mentioned that they could achieve the amended reuse/recycling rate without problems. However, manufacturers mentioned that high recycling rate does not always mean a good recycle since sometimes discarded products should not be disassembled into very small parts in the process of making recycled materials. Moreover, the recycling rate is affected by the market price of oil and thus these things should be considered if the SHAR Law is amended to raise the reuse/recycling rate.

Meanwhile, regarding to the objective of the SHAR Law, some manufacturers assume that the scope will be expanded. Actually the government started the discussion about the EPR programme for small home appliances. Toshiba already conducted the LCA for cleaners and microwave ovens as representatives of small home appliances since cleaners mainly contain plastics and microwave ovens mainly contain metals. Meanwhile, regarding environmental

design of small home appliances, some manufacturers mentioned that they share the technical know-how for design change for products among a whole group. Both experts and policy makers mentioned if an EPR programme for small home appliances is to be developed, that programme might be separated from the SHAR Law for large home appliances. This is because the collection system, method to charge a recycling fee and recycling system would be different because of the different character of products.

5.3.5 Other efforts conducted by manufacturers

As other efforts, some manufacturers started to take voluntary actions for products which are not covered by the EPR programmes. For instance, Hitachi started to collect information devices such as HDD, although the collection is not going well since there is no regulation. Moreover, some manufacturers assume a possibility of new business model for the future that is to sell service with added value instead of products.

6 Analysis

In this section, the findings from the review of Nikkei Ecology and the interviews with manufacturers and experts are analysed based on the analytical framework provided at Chapter 2. The study investigated whether outcomes on design change have occurred (*goal attainment evaluation*), and if so, what roles of the EPR legislation played in the occurrence of these outcomes (*attributability evaluation*).

6.1 Goal attainment evaluation

To evaluate goal attainment, the author considered the following questions: have the manufacturers improved upstream change in order to reduce environmental impacts from end-of-life management of their products? If so, how are designs improved? How are developments of downstream infrastructure and development of feed back mechanism inter-related to upstream change?

Upstream change of new products to decrease environmental impacts from the end-of-life management of their products concerns 1) reduction of hazardous substances and 2) design change that facilitate resource efficiency, increased reuse/recycling of products, components and materials. From the review of Nikkei Ecology and interviews, it can be said that manufacturers improved the design changes of all products examined in this study, that is, TV sets, air conditioners, washing/drying machines, refrigerators and PCs.

Regarding reduction of hazardous substances, as experts, all manufacturers and a number of articles mentioned, manufacturers already achieved the reduction or elimination of the use of hazardous substances covered by national and international regulations. Further, many manufacturers have confidences for their management system of whole supply chain regarding what chemicals are actually included in their products. Manufacturers mentioned that it was a formidable task for manufacturers to manage entire supply chain, but cooperation through industry associations such as JAMP contributed to the establishment of management system. In addition to the improvement of reduction of hazardous substances, manufacturers and experts also have confidences that design for 3R have been improved quite well. Moreover, a number of articles mentioned about improvement of design change for 3R and reduction of hazardous substances could prove their opinions.

Among five products covered by this study, there are different features of design change depending on respective product's functions. Followings briefly describe features of each product's design change obtained from findings.

TV sets: The review of Nikkei Ecology reveals that design change of TV sets was mainly on 3R and energy efficiency. Especially after 2005, the improvement of design in the area of 3R is significant from the review of Nikkei Ecology. Resource efficiency from thinner designs with the growing market share of flat TV sets is one of features since the transition from analog to digital broadcasting was completed in 2011. Additionally, use of new materials such as organic electroluminescence has been developed and contributed on the improvement of design change for more environmentally sound.

Air conditioners: In the case of air conditioner, the majority of design change found in Nikkei Ecology was energy efficiency. However, 3R design such as miniaturization, recyclability for closing material cycle and reduction of hazardous substances are also mentioned. However,

from interviews, it became clear that there is dilemma of designers in trade off between the energy efficiency and resource efficiency in terms the size of heat exchanger.

Washing/drying machines: The review of Nikkei Ecology shows that design change of washing/drying machines was mainly on water saving and energy efficiency from features of washing machines. Regarding 3R design, there also is a dilemma of designers: adding a function of dryer increases size and weight of products. However, from both the review on Nikkei Ecology and interviews, manufacturers have made efforts to reduce size and weight as well as improving recyclability of washing/drying machines to close material loop. These efforts have been made continuously between 2000 and 2010.

Refrigerators: The review of Nikkei Ecology indicates design change of refrigerators was mainly in the area of reduction of hazardous substances especially CFCs and energy efficiency in 2000-2005. Although design change of 3R was not found as many as other areas of design change from the review of Nikkei Ecology in whole time frame, manufacturers have improved design for recyclability to close material loop have been developed.

PCs: The review of Nikkei Ecology indicates that design change of PCs took place mainly in the area of 3R especially in 2000-2005. Additionally, reduction of hazardous substances was improved mainly in 2000-2005. Manufacturers work on the improvements of longevity, recyclability, use of plant-derived plastics and the like.

To achieve design changes mentioned above, manufacturers utilize various types of environmental product assessment tools to decrease the overall environmental impacts from the product's life cycle. Design tools are utilized to identify focused areas including design guidelines published by industrial associations and manufacturers, LCA, Factor X, environmental accounting such as material flow cost and databases of chemical use on components of their products. Some manufacturers make businesses by selling these tools.

In addition to these various design tools, all manufacturers are clearly making efforts on the development of downstream infrastructure, including dismantling/disassembly, reuse/recycling of components/materials. Recycling technologies have been developed to reuse/recycle old plastics more in order to increase reuse/recycling rate, and to reduce recycling fee for consumers. Further, communications between recyclers and manufacturers is frequent and designers take feedback from recyclers into account well on design of products in both group A and B. For example, a manufacturer established recycling plant very near from a production plant, and this location enhanced a communication between downstream and upstream more effectively. These developments have continued during whole timeframe of this study.

From the practice found from research so far, the author concludes that design for end-of-life management is considered for the total life cycle improvement of product system in the given time frame continuously. However, there are differences of focused area of design change and timing to make design change practical depended on features of products.

6.2 Attributability evaluation

The author subsequently analyses linkages between those achieved upstream change and EPR programmes. To analyse the linkage, the author observes the number of articles with the stated reason with EPR programmes and interviews with manufacturers.

From the result of the review of Nikkei Ecology, the linkage between Japanese EPR programmes and all areas of design change, that is, 3R, reduction of hazardous substances, energy efficiency and other design changes can be showed as percentages. Table 7 below shows percentages of articles which clearly stated the Japanese EPR programmes as reasons for design change in the area of 3R and reduction of hazardous substances. This table excludes EPR programmes in other regions as reasons for design change since the author intends to see the effectiveness of Japanese EPR programmes. Before start to describe findings from Table7, it should be noted that the author considers that an article without clear linkage with Japanese EPR programmes does not necessarily mean that it was not influenced by Japanese EPR programmes. Even though the author looks at the number of articles objectively, articles cannot totally exclude media persons' subjective point of view. Thus, there are difficulties to interpret numbers in Table 7, however, the author found a meaningful result that at least not so small proportions of articles, which clearly linked design change with Japanese EPR programmes are gained from the review of Nikkei Ecology.

Table 7: Proportion of articles on design change in the area of 3R and reduction of hazardous substances in which Japanese EPR programmes are stated as reasons for design change

Product	Articles with+without stated reason 2000-2005	Articles with+without stated reason 2006-2010	Articles with stated reason 2000-2005	Articles with stated reason 2006-2010
Four large home appliances and PCs	12.6%	20%	30%	67%
TV sets	8%	26%	33%	50%
Air conditioners	50%	44%	100%	67%
Washing/drying machines	60%	13%	100%	25%
Refrigerator/freezer	0%	0%	0%	0%
PCs	3%	0%	7%	0%

From the figure shown in Table 7, the author observes that Japanese EPR programmes has had influence on design change in the area of 3R and hazardous substances to some extent. However it would not be said that the Japanese EPR programmes is the main driving force for these design changes since percentages of articles clearly linked with respective changes are relatively low within all articles about design change of 3R and reduction of hazardous substances. On the other hand, if looking only at the number of articles with stated reasons, percentages of articles that indicate Japanese EPR programmes as a reason for design change are relatively high. Especially, from a line of four large appliances and PCs, design change was mainly happened after 2006. However, lines of air conditioners and washing/drying machines showed that design change influenced by Japanese EPR programmes was conducted more during 2000-2005.

However there are differences in percentages for respective products. The author observes that these differences links to features of respective products. For example, the reason why articles in refrigerators/freezers did not refer to Japanese EPR programmes can be said that the main design change was taken place in the area of reduction of hazardous substances influenced by international regulations. Meanwhile, the reason of low percentages for PCs is that not only Japanese EPR programmes, but also EPR programmes in other regions such as the WEEE Directive and the EuP Directive were stated as reasons for design change. Thus, if

the scope of this study includes EPR programmes in other regions as well, the result would change as well.

In addition to the observation of the review of Nikkei Ecology, insights obtained from interviews with manufacturers and experts showed positive regards about influences of Japanese EPR programmes on design change as discussed at Section 5.3. That is, mandatory requirements from EPR programmes forced manufacturers to meet those requirements such as reuse/recycling target which links to the development of design change. This means that mandatory measurers based on EPR policies influenced manufacturers to work on improving their product system. Additionally, manufacturers worked on their product systems when they anticipated a new legislation such as Japanese EPR programmes including amendments, national and international regulations such J-Moss, the WEEE Directive, the RoHS Directive, REACH, the EuP Directive and the like.

In addition to Japanese EPR Programmes, most manufacturers commented on their strong preferences of voluntary approaches and internal drivers of companies such as their philosophy, promotion of CSR and environmental management system. These are also perceived to facilitate the undertaking of upstream change. However, as some experts mentioned, voluntary measures without any enforcement are often limited because of barriers such as costs, lack of demands, competing design priorities and the like.

Nonetheless, as all the interviewees, that is, manufacturers, policy makers and experts, mentioned that Japanese manufacturers are in general considerably earnest and they prepare well for upcoming legislations. Thus, when the SHAR Law was amended and reuse/recycling rates were raised, manufacturers achieved those rates higher than what the law required. Reuse/recycling rate might become even higher in the future as some manufacturers anticipate. However, some manufacturers mentioned it should not be regarded that reuse/recycling rate always connected to 3R design change. For example, unless materials are to be sold/taken for free, the recovered materials would not be counted as reused/recycled materials. Therefore required targets should be taken into consideration issues such as the situation of society, market of materials/recycled materials and the like.

Regarding the scope, the existing EPR programmes in Japan covers four large home appliances and PCs. However, EPR programmes for smaller home appliances such as microwave ovens have been discussed and MoE and METI already have meetings with manufacturers. Policy makers, experts and some manufacturers mentioned that the EPR legislation for the small home appliances should be covered under a different law from the SHAR Law since products' features are completely different. Thus methods for recycling would be differ from large home appliances. However, from these discussions, some manufacturers already started to think of smaller home appliances and conducted LCA and recycling.

In sum, the author observes that Japanese EPR programmes influence manufacturers to some extent with legal binding forces even though there are other factors such as manufacturer's own preferences. Especially anticipation of regulations seems to be significant for manufacturers working on design change.

Consequently, from both the review of Nikkei Ecology and interviews, the author could observe that to some extent Japanese EPR programmes had impacts in manufacturer's efforts for more environmentally sound product system during the time frame of this study, 2000 to 2010. It is difficult to define in which time frame design change was happened more from both percentages obtained from the review of Nikkei Ecology and interviews. In addition to

the Japanese EPR programmes, it should be noted that manufacturer's voluntary approaches, national and international government interventions have influenced the improvement of end-of-life management of product system as well. Especially for other government interventions, it could be said that a level of importance of government interventions is different from product to product depended on the situation of society in terms of introduction of new regulations, amendment of regulations and so on.

7 Conclusion

This section provides answers of research questions of this study from the analysis by applying the effectiveness evaluation observing goal attainment and attributability.

Firstly, the author can conclude that manufacturers have improved design for more environmentally sound on their products with the consideration of features of respective products. To develop design change, manufacturers took and developed/improved various measures such as product assessment, LCA, Factor X, environmental accounting, communication between designers and recyclers/dismantlers and the like.

Secondly, government interventions influencing design change vary with respective areas of design change. For instance, main reasons for 3R are the Recycling Promotion Law and the SHAR Law. Meanwhile, J-Moss, PRTR, the RoHS Directive and REACH have influenced design for reduction of hazardous substance and the Energy Conservation Law has influenced design for energy efficiency. Considering the interrelation between design change and Japanese EPR programmes, from the attributability evaluation at Section 6.2, the review of Nikkei Ecology and interviews provided empirical evidence that an EPR programme have induced upstream change that would lead to reduce environmental impacts from total life cycle of the products system during 2000-2010, which is a given time frame in this study. Importantly, anticipation of the introduction of EPR programmes also urge manufacturers to deal with implementation of EPR programmes. Moreover, even around ten years past after the introduction of the SHAR Law, upstream change has been progressed step by step along with the situation of society. Moreover, manufacturers have improved design of products, recycling technologies, communications between designers and recyclers/dismantlers and the like quite well prior to further requirements of EPR programmes with the anticipation.

As the evaluation of Japanese EPR programmes, reuse/recycling rate requirement could be said as an important factor for the improvement of upstream change, downstream change and development of feedback mechanism between upstream and downstream since that requirement is mandatory. However, there are barriers to improve upstream changes such as a lack of consumer's demands, high costs, trade-offs in design priorities and the like. Taking into consideration these barriers, roles of legislations could be said to induce design change even though there are difficulties such as a lack of preferences of consumers. Additionally, supportive policies such as the Green Purchasing Law could change a trend of market.

Finally, the author concludes that from the empirical study of a Japanese case for large home appliances and PCs, EPR programmes can influence the promotion of design change as well as overall environmental improvements of product systems. However, other measures such as governmental/non governmental supportive measures can be interrelated to EPR programmes for synergetic effect on the improvement of product systems for more environmentally sound.

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Appendix 1: List of interviewees for the study presented in Chapter 4

Manuracturers/Organisation	Time & setting	Name and position of the interviewee
Manufacturers		
Hitachi Appliances, Inc.	11:00-, 15 July 2011, In person	Mitsuo Satoh, Senior Engineer, Environment Promotion Department
Hitachi, Ltd.	13:00-, 19 July 2011, In person	Masayuki Ichinohe, Manager, Environment Promotion Center, Environmental Strategy Office Manabu Hirano, General Manager, Environment Planning Center, Environmental Strategy Office
Toshiba Corporation Digital Products & Service Company	14:00-, 22 July 2011 In person	Takashi Nagashima, Environment Management Group, Business Administration & Support Div. Tooru Takechi, Chief Specialist, Environment Management Group, Business Administration & Support Div. Hiroshi Kishibe, Specialist, Environment Management Group, Business Administration & Support Div.
Fujitsu Laboratories Ltd.	10:00-, 25 July 2011 In person	Masahiro Miyo, Green Product Engineering Dept., Environmental Engineering Div., Corporate Environmental Strategy Unit Tomoko Konichi Ph.D., Researcher, Environmental Technology Laboratory, Environment & Energy Research Center
Toshiba Corporation Digital Products & Service Company	10:00-, 26 July 2011 In person	Daijiro Ueyama, Senior Manager, Home Appliance Recycling Promotion Office, Customer Satisfaction Div., Toshiba Corporation Kyoya Matsuda, Chief Specialist, Environment Management Group, Business Administration & Support Div., Digital Products & Service Company Toshiyuki Nakano, Specialist, Environment Management Group, Business Administration & Support Div., Digital Products & Service Company Takashi Nagashima, Environment Management Group, Business Administration & Support Div., Digital Products & Service Company
Mitsubishi Electric Corporation	14:00-, 26 July 2011 In person	Katsumi Fujisaki, Recycling system group, Engineering Department, Living Environment and Digital Media Equipment Group
Toshiba Consumer Electronics Holdings Corporation	10:30-, 28 July 2011 In person	Yukihiro Matsuzono, Group Manager, Environment Planning Group, Technology and Quality Management Center Yoshiyuki Yokoe, Group Manager,

		Environmental Protection & Equipment Power Service Group, Engineering Dept., Technology Div. Toshiba Home Appliances Corporation Tadayuki Kouya, Environmental Protection & Equipment Power Service Group, Engineering Dept., Technology Div. Toshiba Home Appliances Corporation Yuichi Mukai, Engineer, Environmental Protection & Equipment Power Service Group, Engineering Dept., Technology Div. Toshiba Home Appliances Corporation
Sharp Corporation	18 August 2011 E-mail	Maki Mizuno, Environmental Protection Group, Green Product Planning Department
Sanyo Electric Co., Ltd.	24 August 2011 E-mail	Takashi Yanai, Environmental Management H.Q., Corporate Environment Center, Environment Products Department
Policy Makers		
Ministry of Economy, Trade and Industry (METI)	10:00-, 27 July In person	Masato Koie, Deputy Director, Mineral and Natural Resources Division, Agency for Natural Resource and Energy
OECD	11 August 2011 Skype	Hirofumi Aizawa, Administrator, Environment, Health and Safety Division, Environment Directorate, OECD
Experts		
National Institute of Technology and Evaluation (NITE)	15:00-, 14 July 2011, In person	Itaru Yasui, President, Professor Emeritus, The University of Tokyo
Japan Environmental Management Association for Industry	15:00-, 21 July 2011, In person	Hiroshi (Harvey) Yokoyama, vice president, Department of Environmental Business and Technology